

EXPLORE CRAFTS AND MAKING · EXPERT

Track 7 of the Explore Tracks, Expert level: four trails for students who like to make things by hand. They cover sewing, knitting and needlework, paper and hand crafts, and making, pricing and selling a small line of goods.

First edition

Them hath he filled with wisdom of heart, to work all manner of work, of the engraver, and of the cunning workman, and of the embroiderer, in blue, and in purple, in scarlet, and in fine linen, and of the weaver, even of them that do any work, and of those that devise cunning work.

Exodus 35:35 (KJV)

COURSE GUIDE

Explore Tracks are for students who want more of what they love. Each track is a set of short stops. At every stop the student reads a true account, studies a great picture, makes something by hand, plays a game and adds a page to a Field Notebook. At the Expert level each stop also gives primary sources, real numbers and measurements, and a “Go deeper” list of books, museum collection pages and a second video. Each stop ends with a “Goes deeper in” link to the matching School Launch course: Art, History, Small Business & Economics, Arithmetic, Literature, Gardening & Animals, Geography, Life Science or Earth Science.

The Crafts track has four trails of eight stops. Trail A covers hand sewing, from the sewing box and the backstitch to reading a commercial pattern and working a sewing machine, and ends with a lined drawstring bag. Trail B follows wool from the fleece to the needle and covers knitting, the classic embroidery stitches, the samplers children stitched for centuries and the American quilting bee. It ends with a knitted scarf and a cross-stitched verse. Trail C traces paper from Egyptian papyrus to the paper mill and covers origami, calligraphy, quilling, pressed flowers and beading, ending with a hand-sewn, case-bound notebook. Trail D begins with Bezalel and Aholiab, the first craftsmen named in Scripture. It then takes the student through a real small business: choosing a product, costing materials and labor, setting a fair price, checking quality, designing a label, running a table and keeping the books.

WHO IT IS FOR

Written for students ages 14 and up who read on their own and work with little supervision. Younger siblings at the Scout and Ranger levels can do the same stops alongside them, so a family can share one sewing box and one craft table. No earlier sewing or knitting is needed. Trail D uses arithmetic through percentages and is easier after a little of Small Business & Economics, but it does not require it.

HOW TO USE THIS COURSE

1. **One stop at a time.** The reading and picture study take 15–25 minutes. At this level the hands-on part often runs longer: a scarf, a sampler or a bound book can take several sittings. Two or three stops a week works well, with projects carried on between them.
2. **Any order, with one exception.** The four trails are independent. Within Trail A, do A1–A3 before the projects. Within Trail D, do the stops in order, since each builds on the last.
3. **Field Notebook.** Every stop adds a notebook page: a stitch sample taped in, a measured diagram, a source note or a cost sheet. Each trail builds toward a finished piece: a drawstring bag, a knitted scarf and verse sampler, a hand-bound notebook, or a product line with a price list and a profit sheet. A parent signs each trail certificate.

4. **Go deeper.** Each stop lists primary sources (Scripture, period manuals, museum catalog records), a few numbers to work with, and further reading. These are optional. Use them when a student wants more.
5. **Badge quizzes.** Each trail has a short, optional written quiz. They are for practice, not grades.

SCOPE AND SEQUENCE

Trail 1: Crafts and Making ✕ **Trail A: Sewing** (Self-paced)

Trail 2: Crafts and Making ✕ **Trail B: Knitting and Needlework** (Self-paced)

Trail 3: Crafts and Making ✕ **Trail C: Paper and Hand Crafts** (Self-paced)

Trail 4: Crafts and Making ✕ **Trail D: Make It, Price It, Sell It** (Self-paced)

MATERIALS

- **Field Notebook (a sketchbook or composition book)** One for the whole track. Tape or glue stitch samples, swatches and pressed flowers into it.
- **A basic sewing box: hand needles, pins, a thimble, fabric scissors, thread, a seam ripper, a tape measure and scrap cotton fabric** For Trails A and B. Keep the fabric scissors for fabric only.
- **Wool or wool-blend yarn (worsted weight), a pair of knitting needles (US 8 / 5 mm), embroidery floss, an embroidery hoop and a piece of Aida cloth** For Trail B.
- **Paper supplies: printer and card stock, a bone folder or butter knife, an awl or push pin, waxed thread or linen thread, a broad-edge calligraphy pen or marker, glue and a metal ruler** For Trail C. A craft knife is optional and only with a parent's permission.
- **A calculator and a simple ledger (a notebook or spreadsheet)** For Trail D.
- **Access to a sewing machine (optional)** Only for A8, and only with a parent present.
- **A Bible (KJV)** For the Scripture at each stop.

GRADING

Explore Tracks are not graded. A stop is done when the student has read the stop, done the hands-on part and made a notebook page. At this level, a parent may also look at the finished work and ask, "Would you buy it?"

Badges are earned every five stops, and trail certificates are earned by finishing a trail's stops and its project.

A NOTE TO PARENTS

You do not need to sew or knit yourself. Read the stop with your student or let them read it alone. Look at the picture together and ask, "What do you notice? How was this made?"

Each stop has a short *For families* note with sources, any facts that are uncertain and any places where historians disagree.

Safety: every practical stop has a safety line. Needles and pins go back in the pincushion, never in the mouth. Scissors and craft knives are used cutting away from the body. A parent should be present for the sewing machine (A8), for an iron and for any hot glue. Beads and small parts should be kept away from little brothers and sisters.

Selling: Trail D works through a real small business. Any actual sale, whether at a craft fair, to neighbors or online, needs a parent's sign-off, which is written into the D7 project. Local rules on selling and sales tax differ, and parents should check them. The student keeps true books, and profit is figured honestly after all costs are counted.

Pictures: picture studies are public-domain works. They include Vermeer's *The Lacemaker*, Velázquez's *The Spinners*, historic American samplers, William Morris's *Strawberry Thief* and the Bayeux Tapestry. The Bayeux Tapestry is in fact embroidery, worked in wool on linen. Its main scenes show the Norman Conquest of 1066 and are discussed plainly, without dwelling on the fighting. A few small figures in its margins are unclothed, so the stop uses details from the main band only.

Scripture is quoted from the King James Version. The stops draw on Exodus 31 and 35 (Bezalel and Aholiab), Proverbs 31 (the woman who works wool and flax with her hands), Acts 9 (Dorcas and the coats and garments she made) and Colossians 3:23: good work done heartily, as to the Lord.

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- 1.4 Sewing On a Button
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- 1.6 A Drawstring Bag
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Trail 2: Crafts and Making ✕ Trail B: Knitting and Needlework

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Trail 3: Crafts and Making ✕ Trail C: Paper and Hand Crafts

- 3.1 Paper: From Papyrus to the Paper Mill
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- 3.4 Cards and Stationery: The Penny Post and the Art of the Letter
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- 4.1 Bezalel and Aholiab, the First Named Craftsmen
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Trails may be done in any order.

CRAFTS AND MAKING ≈ TRAIL A: SEWING

The first trail of the Crafts and Making track teaches plain sewing from the ground up: the tools of the sewing box, threading and knotting, the running stitch and backstitch, sewing on buttons, a first stuffed project (a pincushion), a complete drawstring bag, reading and cutting patterns, and a supervised first meeting with the sewing machine. Along the way it traces the history of needles, pins, buttons, paper patterns and the sewing machine.

This is the ● **Expert** level, for ages 14 and up, at high-school depth. Each stop takes 35 to 50 minutes and stands by itself. Students read primary sources, among them an 1880s needlework manual, Adam Smith's pin factory, the tabernacle curtains of Exodus and Elias Howe's patent claim, and test them at the worktable. They work real numbers (thread use, seam allowances, costs, speeds), write one narration paragraph per stop for the parent to keep, and build a Field Notebook of stitch samples, plans and diagrams.

Five stops earn the **Sewing Expert badge, part 1**; all eight earn part 2 and the **Trail A certificate**. Stop A8 is done only with a parent present.

BEFORE YOU BEGIN

- Measure accurately with a ruler and tape measure to 1/8 inch, and work with fractions and decimals.
- Read a page of older English prose carefully and summarize it in your own words.

MASTERY CHECKLIST

- ☐ I can choose and safely use needles, pins, thimble and shears, and keep an orderly sewing box.
- ☐ I can thread a needle, tie secure knots, and sew even running stitches and backstitches at a set stitch length.
- ☐ I can sew on any button with a proper thread shank and finish a seam so it will not fray.
- ☐ I can plan a project from finished measurements, read pattern markings and cut on grain.
- ☐ I can explain how a lockstitch machine works and sew a straight, backtacked seam with a parent present.

OPTIONAL BOOKS AND RESOURCES

- **Thérèse de Dillmont, *Encyclopedia of Needlework* (Project Gutenberg #20776)** (<https://www.gutenberg.org/ebooks/20776>): Free 1880s manual from the DMC thread company; the primary source for Stops A1-A4 and A6.
- **Grace Rogers Cooper, *The Invention of the Sewing Machine* (Project Gutenberg #32677)** (<https://www.gutenberg.org/ebooks/32677>): A free Smithsonian history with patent details; the source for Stop A8.

- **Adam Smith, *The Wealth of Nations* (Project Gutenberg #3300)**
(<https://www.gutenberg.org/ebooks/3300>): Book I, Chapter 1 holds the pin factory used in Stop A5.
- **Smithsonian National Museum of American History**
(<https://americanhistory.si.edu>): Search the collections for patent-model sewing machines and home sewing.
- ***Reader's Digest New Complete Guide to Sewing*** (<https://www.worldcat.org>): A clear, well-illustrated reference for every stitch and technique on this trail. Look for it at the library.

1.1 THE SEWING BOX: NEEDLES, PINS, THIMBLE AND SCISSORS

OBJECTIVES

- Name the parts and sizes of hand-sewing needles, pins, thimbles and shears, and explain why each is shaped as it is.
- Read a nineteenth-century needlework manual as a primary source and test its advice against a modern kit.
- Assemble, inventory and cost a working sewing box, and keep it safely.

Warm-up. Lay out every sewing tool your household owns. Sort them into four piles: things that pierce, things that hold, things that cut and things that protect. Which pile is biggest? Which tool could you not do without?

Video slot. Video coming. Basic hand-sewing tools explained: needle types and sizes, pins, thimbles, fabric shears versus paper scissors; how needles were made in Redditch. Search approved channels (Smithsonian, Victoria and Albert Museum, a 4-H or university extension sewing channel, Forge Needle Museum Redditch); preview first.

KEY TERMS

sharps

The ordinary hand-sewing needle: medium length, round eye, very sharp point. Sizes run roughly 1 to 12; the higher the number, the finer the needle.

eye

The hole in a needle through which the thread passes. A long, narrow eye takes thicker or several threads; a small round eye suits fine thread.

thimble

A pitted cap worn on the middle finger of the sewing hand to push the needle through cloth without pricking the skin.

shears

Large cutting blades, usually 7 inches or longer, with a bent handle so the lower blade can rest flat on the table while cutting cloth.

selvage

The tightly woven edge that runs along both lengths of a woven fabric and does not fray.

gauge

A numbered scale for the thickness of wire. In the older wire gauges, a higher number meant wire drawn more times and therefore thinner.

CORE IDEAS

Every sewing box, whether a Victorian rosewood chest or a plastic tackle box, holds the same four kinds of tools: something to **pierce** (needles and pins), something to **hold** (pins,

clips, a pincushion), something to **cut** (shears and small scissors), and something to **protect** (a thimble). Each of these is an old answer to a simple problem: how to join two pieces of cloth with a thread so that the join lasts. Archaeologists have found bone and ivory needles with drilled eyes tens of thousands of years old, so the needle is among the oldest tools people have made.

The modern steel needle is a product of industry. In the eighteenth and nineteenth centuries the town of Redditch in Worcestershire, England, became the world's best-known needle center. A needle began as a length of steel wire. The wire was cut, straightened, pointed on a grindstone, stamped and pierced for the eye, hardened by heating and quenching, tempered so it would not be brittle, then scoured and polished. Needle sizes still follow the logic of the old wire **gauges**: wire pulled through more and more dies became thinner, so a higher number means a finer needle. A size 10 **sharps** is thinner than a size 5.

Choosing a needle is a matter of matching three things: the cloth, the thread and the stitch. A fine needle makes a small hole and slips easily through tightly woven cotton, but its small **eye** will not take thick thread. A heavier needle pushes through denim or canvas without bending. Specialty needles exist for good reasons: *betweens* are short for quick, even quilting stitches; *embroidery* or *crewel* needles have long eyes for several strands of floss; *ballpoint* needles slide between the loops of knit fabric instead of piercing them. For a beginner, a mixed pack of sharps, sizes 5 to 10, covers most work.

Pins hold layers in place before they are stitched. Most dressmaker pins are about 1 1/16 to 1 1/4 inches long; quilting pins are longer, and silk pins are thinner. Glass-headed pins will not melt under an iron, while plastic heads can. The **thimble** goes on the middle finger of the sewing hand. Its pits catch the eye end of the needle so the finger can push hard without the needle sliding into the skin. Roman bronze thimbles have been found, and by the 1600s Dutch makers produced them in great numbers. Many beginners find a thimble awkward at first; practice makes it feel natural, and leather or rubber thimbles suit some hands better than metal.

Cutting tools are kept for cloth alone. **Shears** have a bent handle so that the lower blade glides along the table and the fabric is not lifted while cutting; this keeps the cut line accurate. Paper dulls blades quickly because paper contains fine mineral fillers, so households often tie a ribbon on the fabric shears as a warning. Small, sharp-pointed scissors snip threads and clip into seam allowances. Many sewers add a seam ripper, a tape measure 60 inches (152 cm) long, tailor's chalk or a washable marker, and a pincushion or magnetic dish.

Good tools are not a luxury; they save time and cloth. A dull needle drags and leaves holes; bent pins scratch fabric; dull shears chew the **selvage** and the cut edge, wasting material. Yet the box need not be costly. A careful beginner's kit of needles, pins, a thimble, one good pair of shears, small scissors, a tape measure, thread in a few colors and a seam ripper can be gathered for roughly the price of a single ready-made shirt, and it will last for years if kept dry and organized.

Christians have long seen honest craft as part of honoring God. When Moses set out to make the tabernacle, God filled certain men and women with skill: the engraver, the weaver, the embroiderer (Exodus 35). The sewing box is where that kind of patient work begins. Learning to keep it in order, to know what each tool is for, and to use it safely is the first lesson of the trail.

PICTURE STUDY



The Diligent Mother (La Mère laborieuse), Jean-Siméon Chardin, 1740 · Oil on canvas · Musée du Louvre, Paris

Wikimedia Commons · Public domain

Jean-Siméon Chardin painted ordinary households in eighteenth-century Paris with unusual care and respect. He showed this painting at the Paris Salon of 1740 and presented it, with a companion piece showing a family saying grace, to King Louis XV. Here a mother checks her daughter's needlework, the way a teacher checks a pupil's lesson.

Look closely

- Find the piece of work the mother is examining. What might she be pointing out?
- Find the materials and tools around the room. Which ones would belong in a sewing or needlework box?
- Notice the colors. How does Chardin use warm browns and soft light to make the room feel calm and orderly?

Talk about it

1. Why might Chardin, a serious artist, choose a lesson in needlework as a subject worthy of a king?

2. What does the painting suggest about how sewing skills were passed on in a household before schools taught them?

Safety first. Needles, pins and shears are sharp. Keep them in a closed box away from small children and pets; never hold pins or needles in your mouth; pass scissors closed, handles first; count needles out and back in, and if a needle is lost, find it with a magnet before anyone walks barefoot. A swallowed pin or needle is a medical emergency.

HANDS-ON: BUILD, TEST AND COST YOUR SEWING BOX

Assemble a working sewing box for the whole trail. Then test its tools against the advice of a famous nineteenth-century manual (see the Primary source aside) and record what each tool cost.

You will need

- A box with a lid (a shoebox, tin or tackle box with compartments)
- A pack of sharps needles, sizes 5-10, and a few dressmaker pins
- A thimble (try metal and leather if you can)
- Fabric shears and small sharp scissors
- A tape measure, tailor's chalk, a seam ripper, three spools of thread
- Scraps of cotton, felt and denim for testing
- A magnifying glass, a magnet and a notebook

Steps

1. Lay out the tools and sort them into pierce, hold, cut and protect. Label four compartments or small envelopes.
2. With a magnifying glass, compare a size 5 and a size 10 needle. Sketch both eyes and points and write which is finer.
3. Push each needle through cotton, felt and denim scraps. Record which needle works best in each.
4. Try sewing ten stitches in denim with and without a thimble. Note what changes.
5. Cut a straight line in cotton with the shears, keeping the lower blade on the table. Then try lifting the cloth while cutting. Compare the two edges.
6. Read Dillmont's advice on needles, scissors and thimbles. Mark each piece of advice "still true," "partly true" or "out of date," with a reason. (Do not try her needle-breaking test without a parent and eye protection.)
7. Make an inventory card for the lid: each tool, its size, where it lives and its cost. Add up the total cost of the box.

Check your work

- Every tool has a home in the box, and sharp things are closed away.
- I tested needles on three fabrics and recorded the results.
- I judged Dillmont's advice with reasons.

- My inventory card has sizes and a total cost.

FIELD NOTEBOOK

1. **Trail A, page 1: The sewing box.** Draw a labeled diagram of a needle (point, shaft, eye) and of shears (bent handle, pivot screw, upper and lower blades).
2. Copy your tool inventory and total cost.
3. **Narration (parent keeps):** In one paragraph, explain why a well-kept sewing box saves both money and cloth, using at least two tools as examples.

Did you know? Redditch needle makers once worked in a dusty, dangerous trade: dry grinding of needle points filled the air with steel and stone dust, and grinders often died young. Better ventilation and wet grinding later made the work safer. Today the Forge Mill Needle Museum in Redditch preserves a water-powered scouring mill.

Primary source. *Thérèse de Dillmont, Encyclopedia of Needlework (first published in the 1880s by the DMC thread company; Project Gutenberg eBook #20776), chapter "Plain Sewing"*

Needles. These should be of the best quality. To test a needle, try to break it; if it resist, and then break clean in two, the steel is good; if it bend without breaking, or break without any resistance, it is bad.

Scissors. Scissors are a very important accessory of the work-table, and two varieties are indispensable; a pair of large ones for cutting-out, with one point blunt and the other sharp, the latter to be always held downwards; and a pair of smaller ones with two sharp points.

Thimble. Steel thimbles are the best; bone are very liable to break, and silver ones are not deeply enough pitted, to hold the needle.

Go deeper. *Thérèse de Dillmont, Encyclopedia of Needlework* (free at Project Gutenberg); *Reader's Digest New Complete Guide to Sewing* (library); Henry Petroski, *The Evolution of Useful Things* (1992), on how everyday tools take shape; the Forge Mill Needle Museum, Redditch, online pages on needle making.

Goes deeper in. Art, "Chardin and the Painting of Everyday Life," and History, "The Industrial Revolution" (coming soon).

For families. Sources: Dillmont, Gutenberg #20776 (the English edition's exact first date varies by printing, so the stop says "the 1880s"); Louvre collection notes on Chardin's *La Mère laborieuse*. Dates for Roman and Dutch thimbles are given broadly. The explanation that needle numbers follow wire-gauge logic is the usual one, though manufacturers' sizes are not perfectly standard. Dillmont's needle-breaking test can send steel fragments flying; it is described, not required.

PRACTICE

1. **EASY** Which is the finer needle, a size 5 sharps or a size 10 sharps? Why are the numbers “backward”?
2. **EASY** Why do fabric shears have a bent handle?
3. **MEDIUM** Dillmont says the sharp point of the large scissors should be “always held downwards.” Give a practical reason.
4. **MEDIUM** Name a needle you would choose for (a) knit T-shirt fabric and (b) six strands of embroidery floss, and explain each.
5. **CHALLENGE** A pack of 20 assorted needles costs \$3.40 and a sewer breaks or loses about one needle a month. Fabric shears cost \$24 and need sharpening (\$8) every 2 years. What is the yearly cost of needles and shears over the first 4 years (ignore inflation)?
6. **CHALLENGE** Using the primary source, explain which of Dillmont’s three pieces of advice still holds, which has changed, and why her thimble advice made sense in her day.

Make it a game · Blind Sort. A parent puts six safe items in a bag (thimble, spool, tape measure, pincushion with no pins, a closed seam ripper, chalk). Players reach in without looking, name each tool by feel and say what it is for. Sharp tools stay out of the bag.

Scripture. “Them hath he filled with wisdom of heart, to work all manner of work, of the engraver, and of the cunning workman, and of the embroiderer, in blue, and in purple, in scarlet, and in fine linen, and of the weaver, even of them that do any work, and of those that devise cunning work.” (Exodus 35:35, KJV)

Skill with needle and thread is named in Scripture as a gift of God. Learning the tools well is the beginning of using that gift faithfully.

Practice: answers

1. Size 10 is finer. Needle sizes follow old wire gauges, in which a higher number meant wire drawn through more dies and therefore thinner.
2. So the lower blade can rest flat on the table and the cloth is not lifted while cutting, which keeps the cut accurate.
3. The sharp point slides under the cloth along the table and starts cuts cleanly, while the blunt upper point will not snag or pierce the fabric on top (or the sewer’s hand). It also keeps the sharp point aimed away from the body.
4. (a) A ballpoint needle, because its rounded point slips between the knit loops instead of piercing and laddering them. (b) An embroidery (crewel) needle, because its long eye takes several strands.
5. Needles: 12 a year at \$0.17 each = \$2.04 a year. Shears: \$24 + two sharpenings (\$16) = \$40 over 4 years, or \$10 a year. Total about \$12.04 a year, or about \$48 over 4 years.
6. The scissors advice still holds: a large pair for cutting out and a small sharp pair for snipping. The needle test reflects a time when steel quality varied; modern needles are more uniform, and breaking them is a safety risk. Steel thimbles were best then because bone cracked and

silver was soft with shallow pits; today metal, leather and silicone thimbles all work, but deep pits that grip the needle are still the key.

1.2 THREADING A NEEDLE AND TYING A KNOT

OBJECTIVES

- Explain how thread is made and labeled (fiber, twist, weight and tex) and choose a thread for a task.
- Thread a needle cleanly, single and doubled, and tie an overhand knot, a quilter's knot and a secure finishing knot.
- Analyze an 1880s description of hand position and compare it with your own practice.

Warm-up. Untwist the cut end of a piece of sewing thread under a magnifying glass. How many smaller strands do you find? Then roll a 2-foot length between your palms in one direction and watch what it does when you let it hang. Why might thread tangle as you sew?

Video slot. Video coming. How to thread a needle and tie a quilter's knot; how to tie off hand sewing; how thread is spun and plied. Search approved channels (a 4-H or university extension sewing channel, Smithsonian, a museum textile channel); preview first.

KEY TERMS

ply

One of the strands twisted together to make a thread. Most sewing thread is two- or three-ply.

twist

The direction in which fibers or plies are turned, called S or Z after the slant of the letter's middle stroke.

thread weight

A labeling system in which the number is roughly how many kilometers of thread weigh one kilogram; higher numbers are finer.

tex

The weight in grams of 1,000 meters of thread; higher numbers are heavier.

quilter's knot

A neat end knot made by wrapping the thread around the needle two or three times and pulling the needle through the wraps.

tie off

To secure the end of a line of stitching, by small stitches over one another or a knot made close to the cloth.

CORE IDEAS

Thread looks simple, but it is a small piece of engineering. Short fibers of cotton, or long continuous filaments of silk or polyester, are twisted into a yarn; two or three yarns, called **plies**, are then twisted together the other way. The opposing twists lock each other so the thread neither untwists nor kinks. Textile people describe **twist** by letters: an S twist slants like the middle of the letter S, a Z twist like the middle of a Z. Because twist is stored in the thread, every stitch you take adds or removes a little, which is why thread sometimes curls, kinks and knots itself as you sew.

Threads are labeled in more than one system, and the systems run in opposite directions. In the common **thread weight** system, a number such as 50 means roughly that 50 kilometers of the thread weigh one kilogram, so a higher number means finer thread: 50 weight is ordinary all-purpose thread, 30 is heavier, 100 is very fine. In the **tex** system, the number is the weight in grams of 1,000 meters, so a higher number means heavier thread; all-purpose thread is often near tex 25 to 30. Upholstery and button threads are much heavier. Cotton thread suits cotton cloth and takes an iron well; polyester is strong and slightly stretchy, so it suits knits and seams that take strain.

Threading a needle well starts before the thread meets the eye. Cut a working length of about 18 to 24 inches, roughly from your fingertips to your elbow or a little more. Longer thread saves rethreading but wears thin and frays as it is pulled through the cloth hundreds of times, and it tangles more. Cut the end on a slant with sharp scissors so it forms a point; a torn or bitten end fuzzes and will not pass the eye. Many sewers thread the end that came off the spool first and knot the freshly cut end, so the twist runs with the sewing rather than against it. Hold the needle still and bring the thread to it, against a light or dark background as needed. A wire needle threader helps with small eyes.

Next decide between single and doubled thread. With **single thread**, one end is knotted and the other hangs loose a few inches past the eye; this gives fine, neat stitches in seams and hems. With **doubled thread**, both ends are knotted together so the thread folds at the eye; it is twice as strong and cannot slip out, which suits buttons and repairs, but it makes bulkier stitches and is harder to unpick.

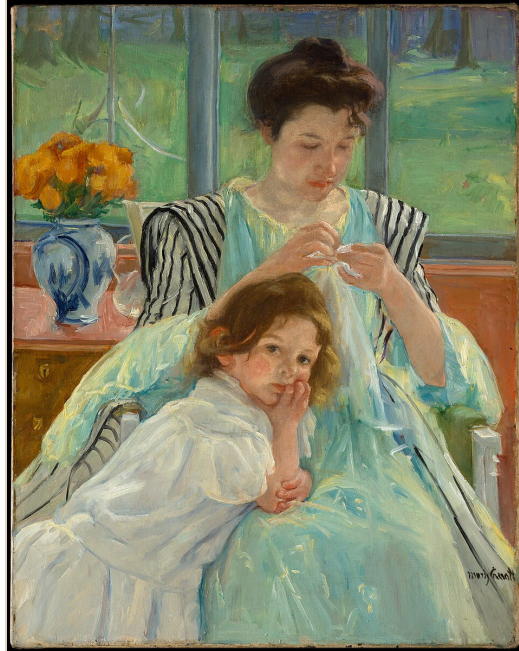
Three knots carry a beginner a long way. The **overhand knot** is a loop with the end passed through it; tying two on top of each other makes a bigger stop. The **quilter's knot** is neater and more consistent: hold the thread end along the needle, wrap the thread around the needle two or three times, pinch the wraps and pull the needle through them, sliding the coil down to the end of the thread. To **tie off** at the end of a seam, take two or three tiny stitches on top of one another on the wrong side, or make a loop with a small stitch, pass the needle through the loop and pull it snug against the cloth; repeat once. Leave a tail of about a quarter inch.

Tangles and knots in the middle of the thread usually come from built-up twist. Every so often, let the needle hang freely and the thread will spin back. If a loop begins to close into a knot, put a pin into the loop and gently pull it open before tightening. Running the thread

across a cake of beeswax, an old practice still used by quilters and tailors, smooths stray fibers and reduces knotting, especially for doubled thread and buttons.

These first motions are worth learning carefully. Thread a needle and tie a knot a hundred times and your hands will do it without thinking, leaving your attention free for the work itself. Old manuals, like the one in this stop's primary source, insisted on correct position of the hands for the same reason: good habits learned at the start make every later stitch easier and neater.

PICTURE STUDY



Young Mother Sewing, Mary Cassatt, 1900 · Oil on canvas · The Metropolitan Museum of Art, New York
Wikimedia Commons · CC0

Mary Cassatt was an American painter who lived most of her working life in France and exhibited with the Impressionists. She often painted mothers and children in ordinary moments. In this picture the mother concentrates on her needle while the child, leaning on her knee, looks straight out at us.

Look closely

- Look at the mother's hands. How is she holding her work and her needle?
- Look at the background. How does Cassatt use light and color to frame the two figures?
- Compare the quick brushstrokes in the background with the more careful painting of the faces.

Talk about it

1. Why might a child learn sewing simply by being near someone who sews every day?

2. How does this 1900 scene compare with Dillmont's instructions about the position of the hands?

Safety first. Keep the threaded needle in a pincushion when you put it down, never in your mouth or clothing. Cut thread with scissors rather than biting it, which can chip teeth. Work at a table with good light so you do not hold the needle close to your eyes.

HANDS-ON: THE THREAD LAB AND KNOT CARD

Test how thread length, twist and knot type change your sewing, then make a reference card of three knots for your Field Notebook. Use Dillmont's description of hand position (Primary source aside) as your standard for one of the trials.

You will need

- Sharps needles, sizes 7-10, and a needle threader
- All-purpose polyester and cotton thread in a contrasting color
- A cake of beeswax (optional)
- Two 6-inch squares of cotton fabric and one 5-by-8-inch index card
- Scissors, a ruler and a timer

Steps

1. Cut three threads: 12, 20 and 36 inches. With each, sew a line of simple stitches across a fabric square until the thread runs out. Record how many times each tangled.
2. Time yourself threading a needle five times with a slanted cut end and five times with a torn end. Record the average time for each.
3. Read Dillmont's paragraph on position of the hands. Sew one line holding your work her way and one line resting your hands on the table. Write which was steadier and why.
4. Tie an overhand knot, a doubled overhand knot and a quilter's knot. Pull each through a fabric square from the back. Which held? Which was neatest?
5. Sew a short line and tie off with a looped finishing knot. Tug the thread firmly from the front to test it.
6. Make your knot card: sew a real example of each knot onto the index card and label it with steps.

Check your work

- I recorded tangles for three lengths and chose a best working length.
- I compared slanted and torn ends with real times.
- I tested Dillmont's hand position and wrote a conclusion.
- My knot card shows three knots that hold.

FIELD NOTEBOOK

1. **Trail A, page 2: Thread and knots.** Draw a magnified thread showing two plies twisted together. Label S and Z twist.
2. Paste or sketch your knot card, with your best working length of thread.
3. **Narration (parent keeps):** In one paragraph, explain why thread tangles and three things a sewer can do about it, using what you learned in your experiment.

Did you know? Sewing thread was once mostly linen or silk. Cotton thread strong enough for sewing became widespread in the early 1800s, and the Scottish town of Paisley became famous for it. The rapid spread of sewing machines in the 1850s created demand for smoother, stronger, more even thread, which encouraged the six-cord cotton thread sold on wooden spools.

Primary source. *Thérèse de Dillmont, Encyclopedia of Needlework (first published in the 1880s; Project Gutenberg eBook #20776), "Plain Sewing," on the position of the hands*

The stuff, fastened to a cushion, must be held with the left hand, which should neither rest on the table, nor on the cushion, the needle must be held between the thumb and forefinger, of the right hand, and the middle finger, armed with the thimble, pushes the needle far enough through the stuff.

Go deeper. Dillmont, *Encyclopedia of Needlework*, "Plain Sewing" (free at Project Gutenberg); *Reader's Digest New Complete Guide to Sewing*, section on hand sewing (library); a second video topic: how cotton is spun into yarn in a modern mill.

Goes deeper in. Arithmetic, "Units and Conversions" (coming soon), and Art, "Mary Cassatt and the Impressionists" (coming soon).

For families. Sources: Dillmont, Gutenberg #20776; The Metropolitan Museum of Art collection page for Cassatt's *Young Mother Sewing*. Thread weight and tex are approximate industry conventions and labels vary by maker; the stop gives typical ranges. Advice about which end to thread is common sewing lore rather than settled science; your student's experiment can test it. Dillmont writes for right-handed sewers; left-handed students simply reverse the hands.

PRACTICE

1. **EASY** Which thread is finer: 30 weight or 60 weight? Which is heavier: tex 25 or tex 40?
2. **EASY** Give one advantage and one disadvantage of sewing with doubled thread.
3. **MEDIUM** Why should a working thread usually be no longer than about 18 to 24 inches?
4. **MEDIUM** In the primary source, what job does Dillmont give each hand and finger? Why should the left hand not rest on the table?

5. **CHALLENGE** A spool holds 500 meters of tex 27 thread. (a) What does the thread on the spool weigh? (b) If you sew with doubled thread, using 50 cm of spool thread per working length plus 5 cm for knots and waste, how many working lengths does the spool give?
6. **CHALLENGE** Explain in terms of twist why letting the needle dangle freely for a moment can cure a tangle, and why a doubled thread waxed with beeswax tangles less.

Make it a game · Threading Relay. Each player has a needle, a pincushion and five precut threads. On “Go,” thread, tie a quilter’s knot, take one stitch in a scrap and park the needle in the cushion. The fastest complete, correct set wins; a knot that pulls through doesn’t count.

Scripture. “A time to rend, and a time to sew; a time to keep silence, and a time to speak;” (Ecclesiastes 3:7, KJV)

Solomon lists sewing among the ordinary, God-ordained seasons of life. Mending what is torn is patient, quiet work, and it begins with something as small as threading a needle.

Practice: answers

1. 60 weight is finer (higher weight numbers are finer). Tex 40 is heavier (higher tex numbers are heavier).
2. Advantage: twice as strong and cannot slip out of the needle (good for buttons).
Disadvantage: bulkier stitches, more tangling, harder to unpick.
3. Every stitch drags the whole length through the cloth, so long thread wears, frays and weakens; it also stores more twist and tangles more. Shorter lengths stay strong and smooth.
4. The left hand holds the cloth; the right thumb and forefinger hold the needle; the right middle finger with the thimble pushes the needle. A hand resting on the table cannot turn and tension the cloth freely, so stitches become uneven and the sewer cramps.
5. (a) Tex 27 means 1,000 m weighs 27 g, so 500 m weighs 13.5 g. (b) Each doubled length uses $2 \times 50 + 5 = 105$ cm = 1.05 m. $500 \div 1.05 \approx 476$ full working lengths.
6. Sewing turns the needle slightly with each stitch, adding or removing twist until the thread is overtwisted and coils on itself. Hanging the needle lets the stored twist spin out. Wax binds stray fibers and makes the two strands cling together as one smooth thread, so they slide past each other less and form fewer loops and knots.

1.3 RUNNING STITCH AND BACKSTITCH

OBJECTIVES

- Sew an even running stitch and backstitch at a set number of stitches per inch, and explain the uses of each.
- Explain with geometry why a backstitch is stronger and uses about three times as much thread as a running stitch.
- Follow an 1880s set of stitch directions exactly and judge whether they are clear.

Warm-up. Look at the inside seams of a shirt and a pair of jeans. Are the stitches continuous lines, or do they have gaps? Pull gently on a seam. What do you think keeps the thread from simply sliding out?

Video slot. Video coming. How to sew a running stitch, backstitch and half backstitch by hand; stitches per inch. Search approved channels (a 4-H or university extension sewing channel, Victoria and Albert Museum, Smithsonian); preview first.

KEY TERMS

running stitch

The simplest stitch: the needle goes in and out along a line, leaving equal stitches and gaps.

backstitch

A strong stitch in which each new stitch goes back to meet the end of the last, making a solid line on top and overlapping stitches beneath.

basting

Long, temporary running stitches that hold layers together before final sewing.

seam allowance

The strip of fabric between the cut edge and the stitching line.

stitches per inch (SPI)

How many stitches fit in one inch of seam; a measure of stitch length.

right side / wrong side

The right side is the face of the fabric meant to show; the wrong side is the back. Seams are usually sewn with right sides together.

CORE IDEAS

Until the middle of the nineteenth century, every seam in every shirt, dress, sail, sheet and flag was sewn by hand, and nearly all of it with a few basic stitches. Two of them, the **running stitch** and the **backstitch**, are the foundation of the rest. A sewer who can make both evenly can build a seam, a gathered ruffle, a quilt and a mended tear.

The running stitch is the needle going in and out along a line: down, up, down, up. A practiced sewer loads several stitches on the needle at once, rocking the cloth onto it, then pulls the thread through. The result is a dashed line, the same on both sides. It is fast and flexible, which makes it ideal for **basting**, for gathering (pull the thread and the cloth bunches), for quilting through layers, and for seams that take little strain. Its weakness is that the thread is not locked: if it breaks or the knot slips, the whole line can pull out.

The backstitch answers that weakness. Bring the needle up one stitch length ahead of where you began, go down at the end of the previous stitch, and come up again one stitch length ahead. On the **right side** the stitches meet in a solid line that looks much like a machine seam; on the **wrong side** they overlap, each one twice as long as a front stitch. Because every stitch wraps back over the last, the thread grips the cloth all along the line. If it breaks, only a short stretch comes loose. Before machines, the strongest hand seams in shirts and coats were backstitched, and tailors still backstitch where strength matters by hand.

Geometry explains the cost of that strength. Let each front stitch be length s . In a running stitch, the thread travels s on top and s underneath for every $2s$ of seam, so it uses about one length of thread per length of seam. In a backstitch, the thread travels s on top and $2s$ underneath for every s of seam, so it uses about three times the length of the seam, plus a little for passing through the cloth. A 10-inch backstitched seam needs at least 30 inches of thread. That is why backstitching a long seam means rethreading more often.

Stitch length matters as much as stitch type. Hand sewers often aim for about 8 to 12 **stitches per inch (SPI)** in a backstitched seam, finer for delicate cloth, while basting stitches may be half an inch long. Short stitches are stronger and neater but slower; long stitches are faster but gape and catch. Two in-between stitches are worth knowing: the *half backstitch*, which goes back only halfway, leaving small gaps on top and saving thread; and the *prick stitch*, which goes back only a thread or two, leaving tiny dots, used to put in zippers by hand.

Most seams are sewn with right sides of the fabric together, along a line set in from the edge by the **seam allowance**. Home sewing patterns in America usually use 5/8 inch; quilters use 1/4 inch. Drawing the line lightly with chalk and pinning across it keeps the layers from creeping. Keep your stitches on the line, check the back every few inches, and keep the thread tension snug but not tight: a seam pulled too hard puckers.

Older manuals measured stitches by counting the threads of the cloth itself, as in this stop's primary source. That method reminds us that woven fabric is a grid. When you count threads, you are using the weaver's own measurement, and the result is perfectly even stitching. Patience with a simple stitch is training in faithfulness: the same care, repeated hundreds of times, makes the difference between a seam that holds for years and one that fails on the first wash.

PICTURE STUDY



Woman Sewing by Lamplight, Jean-François Millet, 1870-1872 · Oil on canvas · The Frick Collection, New York

Wikimedia Commons · Public domain

Jean-François Millet, born to a farming family in Normandy, spent much of his life painting the rural people of France at work. Here a woman sews late into the evening by lamplight, a familiar scene in every household before electric light, when the day's sewing and mending were often done after the outdoor work was finished.

Look closely

- Find the source of light. Which parts of the woman does it touch?
- Look closely at her hands. Can you tell what kind of stitch or motion she is making?
- Notice how much of the picture is in shadow. What does the darkness make you feel about the hour?

Talk about it

1. Why would many families have done their sewing in the evening, and what difficulties would lamplight bring?
2. Millet often painted labor as something dignified. How does he do that here?

Safety first. Keep needles in the pincushion when not in your hand. Sew in good light, sitting upright with the work held at a comfortable distance. Pull the needle away from your body and from anyone sitting beside you.

HANDS-ON: THE SEAM STRENGTH TEST

Sew sample seams with running stitch and backstitch, test which is stronger, and check the thread-use formula. Then follow Dillmont's 1880s directions (Primary source aside) word for word on an evenweave cloth and judge them.

You will need

- Four 4-by-8-inch strips of plain woven cotton (or old sheet)
- A 4-inch square of evenweave fabric such as linen, burlap or Aida cloth
- Contrasting all-purpose thread and sharps needles
- Ruler, chalk, pins, scissors
- A kitchen scale or a bag and some cans for weights (optional)

Steps

1. Pin two cotton strips right sides together and chalk a stitching line $\frac{1}{2}$ inch from one long edge.
2. Measure and record a 30-inch thread. Sew the seam in running stitch at about 8 SPI. Measure the leftover thread; calculate how much you used per inch of seam.
3. Repeat with the other two strips in backstitch at about 8 SPI. Compare thread use with the formula (about 3 times the seam length).
4. Open each sample, hold one end and hang increasing weight (or pull steadily) until the seam begins to gape or fail. Record the result.
5. On the evenweave square, follow Dillmont's directions exactly by counting threads: running stitch over 3 or 4 threads, then backstitch out 6, back 3. Mark any word you found unclear.
6. Write a conclusion: which stitch to use for basting, for gathering, and for a seam that must hold.

Check your work

- I sewed both seams evenly on a chalked line.
- I measured thread use and compared it with the formula.
- I tested strength and recorded results honestly.
- I followed the 1880s directions by counting threads and judged their clarity.

FIELD NOTEBOOK

1. **Trail A, page 3: Two stitches.** Draw front and back views of running stitch and backstitch, with the stitch length s labeled.
2. Tape in your sample seams with a label giving SPI, thread used and strength result.
3. **Narration (parent keeps):** In one paragraph, explain why the backstitch is stronger than the running stitch and what that strength costs, using your own measurements.

Did you know? Medieval and early modern shirts were often sewn with astonishingly small stitches, sometimes 20 or more to the inch, by hand. Museum conservators can sometimes tell a professional seamstress from a beginner just by the evenness of the stitches.

Primary source. *Thérèse de Dillmont, Encyclopedia of Needlework (first published in the 1880s; Project Gutenberg eBook #20776), "Plain Sewing"*

Running stitch. This is the simplest and easiest of all. Pass the needle in and out of the material, at regular intervals, in a horizontal direction, taking up three or four threads at a time.

Back-stitch. Insert the needle, and draw it out six threads further on, carry your thread back, from left to right, and insert the needle three threads back from the point at which it was last drawn out, and bring it out six threads beyond.

Stitching. The production of a row of back-stitches, that exactly meet one another, constitutes what is called stitching.

Go deeper. Dillmont, *Encyclopedia of Needlework*, "Plain Sewing" (free at Project Gutenberg); Victoria and Albert Museum online pages on historic shirts and hand sewing; *Reader's Digest New Complete Guide to Sewing* (library); a second video topic: how a historic shirt was sewn entirely by hand.

Goes deeper in. Arithmetic, "Measurement and Ratios," and Art, "Millet and the Painters of Rural Life" (coming soon).

For families. Sources: Dillmont, Gutenberg #20776; Frick Collection notes on Millet. Dillmont's back-stitch wording can be read two ways (see practice 6); because she names stitches that "exactly meet" separately as "stitching," her back-stitch most likely corresponds to the modern half backstitch, and her "stitching" to the modern full backstitch. The thread-use formula ignores the cloth's thickness, so measured use will run a little higher. SPI ranges are typical, not fixed rules.

PRACTICE

1. **EASY** Name two uses for the running stitch and one for the backstitch.
2. **EASY** A seam has 40 stitches over 4 inches. What is its SPI?
3. **MEDIUM** Why can a running stitch pull out all at once while a backstitch does not?
4. **MEDIUM** According to the primary source, what is the difference between a row of Dillmont's "back-stitch" and what she calls "stitching"?
5. **CHALLENGE** You will backstitch both sides of a bag, 12 inches each, at 10 SPI. You use working threads of 20 inches, of which 4 inches go to knots and waste. Using the 3× rule, how much thread do you need, and how many times must you thread the needle?

6. **CHALLENGE** Dillmont's back-stitch says to come out 6 threads ahead, go back 3, and "bring it out six threads beyond." This can be read two ways: six beyond the point where the needle went in, or six beyond where it last came out. Number the cloth threads from 0, starting with the needle out at 6, and work out for each reading where the top stitches fall and how much thread is used per thread of seam advanced.

Make it a game • Stitch Count Challenge. Each player sews a 2-inch backstitch line on a chalked strip in three minutes. A judge counts stitches per inch and checks the back. Score one point for each inch of even, on-the-line stitching; bonus point for matching a target SPI announced at the start.

Scripture. "And whatsoever ye do, do it heartily, as to the Lord, and not unto men;" (Colossians 3:23, KJV)

Paul wrote this to ordinary workers. A seam no one will see on the inside of a garment is still work done before the Lord, and worth doing well.

Practice: answers

1. Running stitch: basting, gathering, quilting or light seams (any two). Backstitch: strong seams that must hold, such as a bag or clothing seam.
2. 10 stitches per inch.
3. Running stitch thread passes straight in and out without crossing itself, so once the end is free it slides out. In a backstitch each stitch wraps back over the last, so the thread is locked by friction all along the seam and only a short stretch can come loose.
4. "Stitching" is a row of back-stitches that exactly meet one another, a solid line. By defining it separately she implies that her ordinary back-stitch may leave small gaps between stitches on the top, like what modern books call a half backstitch.
5. Seam length 24 inches $\times 3 = 72$ inches of stitching thread. Each working length gives $20 - 4 = 16$ usable inches. $72 \div 16 = 4.5$, so 5 threadings (100 inches of thread from the spool).
6. Reading A (six beyond the insertion point at 3): out at 9, back to 6, out at 12. Top stitches 3-6, 6-9 ... meet in a solid line; advance 3 per cycle; thread 3 on top + 6 beneath = 9 per 3, or $3 \times$ the seam (a full backstitch). Reading B (six beyond the last exit at 6): out at 12, back to 9, out at 18. Top stitches 3-6, 9-12 ... with 3-thread gaps; advance 6 per cycle; thread 3 on top + 9 beneath = 12 per 6, or $2 \times$ the seam (a half backstitch). Because she defines stitches that "exactly meet" separately as "stitching," Reading B is the likelier meaning. Either way the backstitch family costs 2-3 times the seam length, versus about $1 \times$ for running stitch.

1.4 SEWING ON A BUTTON

OBJECTIVES

- Sew on sew-through and shank buttons securely, with a thread shank sized to the fabric.
- Explain the history of the button and buttonhole and the materials buttons have been made from.
- Use button measurement (lignes) and buttonhole arithmetic to plan a closure.

Warm-up. Find a coat, a dress shirt and a pair of trousers. Count the buttons on each and sort them: two holes, four holes, or a loop (shank) underneath. Which buttons are on thick cloth? Do those stand out from the cloth more?

Video slot. Video coming. How to sew on a two-hole, four-hole and shank button by hand with a thread shank; history of pearl buttons in Muscatine, Iowa. Search approved channels (a 4-H or university extension sewing channel, Smithsonian, Iowa PBS); preview first.

KEY TERMS

sew-through button

A flat button with two or four holes through which it is sewn to the cloth.

shank button

A button with a loop or stem on the back, so the button stands away from the cloth.

thread shank

A short stem of thread wrapped between a sew-through button and the cloth, giving room for the buttonhole layer.

buttonhole

A reinforced slit through which a button passes; its length is about the button's diameter plus its thickness.

ligne

The traditional unit of button size: 1/40 of an inch. A 40-ligne button is 1 inch across.

placket

The finished opening of a garment, such as a shirt front, where buttons and buttonholes are placed.

CORE IDEAS

Buttons are older than buttonholes. Small carved or shell ornaments sewn to clothing go back thousands of years, but they were decorations or were fastened with loops. The button working through a slit cut in the cloth appears in Europe in the thirteenth century, and it

changed tailoring: garments could now fit the body closely and still open and close easily. By the 1300s and 1400s fashionable sleeves and doublets might carry dozens of small buttons.

Buttons have been made from almost everything: bone, horn, wood, brass, pewter, glass, porcelain, and shell. In Dorset, England, from the 1600s into the 1800s, families made thread buttons by wrapping thread over a ring; it was an important cottage industry until machine-made buttons undercut it in the mid-1800s. In America, a German immigrant named John Boepple began cutting buttons from Mississippi River mussel shells at Muscatine, Iowa, in the 1890s, and Muscatine became known as the “Pearl Button Capital of the World” until plastic took over in the twentieth century. The trade was so heavy that mussel beds in the river were badly depleted, a reminder that every material comes from somewhere and must be used wisely.

There are two main kinds of buttons. A **sew-through button** is flat with two or four holes; a **shank button** has a loop on the back. Both need space underneath. When a button is buttoned, the layer of cloth with the **buttonhole** sits between the button and the cloth it is sewn to. If a flat button is sewn down tight, there is no room: the buttonhole strains, the cloth puckers, and the thread wears through. The answer is a **thread shank**. Place a toothpick, pin or matchstick across the top of the button and sew over it; then remove the spacer, pull the button up, and wrap the thread several times around the stitches beneath the button before fastening off. A shirt needs a shank of perhaps 1/16 to 1/8 inch; a wool coat needs more.

Button sizes are measured in **lignes** (from the French word for line), a unit of 1/40 inch. A shirt button is often 16 to 18 lignes, about 3/8 to 7/16 inch; coat buttons may be 30 to 40 lignes. Buttonholes follow a simple rule: length equals the button’s diameter plus its thickness, so a 5/8-inch button that is 1/8 inch thick needs a buttonhole about 3/4 inch long. Domed or ball buttons need more. Buttonholes are placed so the button sits at the outer end of the hole when the garment is closed, because that is where strain pulls it.

Sewing a button on well takes only a few minutes. Mark the place by pushing a pin through the buttonhole onto the cloth beneath. Use doubled thread or one strand of heavy button thread, waxed if you have it. Start from the right side under the button so the knot is hidden, or take two small stitches on the spot. Make four to six passes through each pair of holes over the spacer; for four-hole buttons, choose two parallel bars or a cross. Then make the shank, bring the needle to the back, and tie off with several small stitches. On a coat, a tiny flat *stay button* on the inside takes strain off the outer cloth.

A loose button is the most common repair in any household, and it is a small test of faithfulness. Many good garments end up unused because a button fell off and no one sewed it back. A young person who can replace buttons quickly saves the family money and keeps clothing in service. Older manuals, like this stop’s primary source, show that even such a small job was once taught with exact rules, for the same reason.

PICTURE STUDY



Interior with Women beside a Linen Cupboard, Pieter de Hooch, 1663 · Oil on canvas · Rijksmuseum, Amsterdam

Wikimedia Commons · CC BY-SA 4.0

Pieter de Hooch painted the orderly houses of Delft and Amsterdam in the 1600s, when well-kept linen was a treasured part of a family's wealth. Sheets, shirts and napkins were stored folded in large cupboards, counted, and mended carefully; a household that kept its linen in good repair was thought prudent and well run.

Look closely

- Find the stack of linen. How is it being handled?
- Find the open doorway. What do you see beyond it?
- Look at the floor tiles. How do their lines draw your eye into the room?

Talk about it

1. Why would linen have been valuable enough to keep in a locked cupboard?
2. What does a painting like this suggest about the place of care and repair in a well-run home?

Safety first. Pushing a needle through button holes and thick cloth can drive the eye into your finger; wear a thimble. Keep a spare button and the threaded needle in the pincushion when you pause. Keep loose buttons away from small children, who may swallow them.

HANDS-ON: THE BUTTON BOARD AND A REAL REPAIR

Make a sample board of three button methods, including Dillmont's star method from the 1880s (Primary source aside), then repair or replace a real button in your household.

You will need

- A 6-by-8-inch piece of sturdy cotton or denim
- One 2-hole, one 4-hole and one shank button; one flat linen or fabric-covered button if available
- Button thread or doubled all-purpose thread, beeswax (optional)
- Sharps or milliner's needle, thimble, toothpick, pins, ruler, chalk
- A household garment with a loose or missing button (with permission)

Steps

1. Chalk four marks 1 1/2 inches apart on the cloth. Measure each button's diameter and thickness, and record its size in lignes (diameter in inches $\times$ 40).
2. Sew the 2-hole button over a toothpick with four to six passes, then wind a thread shank and tie off on the back.
3. Sew the 4-hole button with a cross pattern and a shank.
4. Sew the shank button with stitches through its loop, keeping them parallel to the edge of the cloth.
5. Follow Dillmont's method on the fourth mark: fasten the thread, come up through the middle of a flat button and make eight stitches diverging like a star. Compare how well it holds.
6. Calculate the buttonhole length each button would need (diameter + thickness).
7. Repair a real garment: match the thread, mark the position through the buttonhole, sew with a shank sized to the cloth, and test by buttoning ten times.

Check your work

- Each button on my board has a shank and is firmly tied off.
- I recorded sizes in lignes and buttonhole lengths.
- I tried the star method and compared it.
- A real garment is back in service.

FIELD NOTEBOOK

1. **Trail A, page 4: Buttons.** Draw a side view of a button sewn on with a thread shank, showing the buttonhole layer in between.
2. Record your buttons in a table: type, diameter, lignes, buttonhole length.
3. **Narration (parent keeps):** In one paragraph, explain why a button needs a shank and what goes wrong without one.

Did you know? Mussel shells at Muscatine were cut into blanks with tube saws, and the holes left in discarded shells can still be found along the river. The Muscatine History and Industry Center tells the story of the town's pearl-button factories.

Primary source. *Thérèse de Dillmont, Encyclopedia of Needlework (first published in the 1880s; Project Gutenberg eBook #20776), "Plain Sewing," on sewing on buttons*

To sew linen, or webbed buttons on to underclothing, fasten in your thread with a stitch or two, at the place where the button is to be; bring the needle out through the middle of the button, and make eight stitches, diverging from the centre like a star.

Dillmont goes on to describe bringing the needle out between the button and the cloth and twisting the thread several times around the stitches to make a shank before fastening off.

Go deeper. Muscatine History and Industry Center (Muscatine, Iowa), pages on the pearl-button industry; Dillmont, *Encyclopedia of Needlework* (free at Project Gutenberg); Victoria and Albert Museum online articles on historic buttons and fastenings; *Reader's Digest New Complete Guide to Sewing*, section on buttons and buttonholes (library).

Goes deeper in. Small Business & Economics, "Industries and Natural Resources," and History, "Daily Life in the Dutch Golden Age" (coming soon).

For families. Sources: Dillmont, Gutenberg #20776; Rijksmuseum notes on De Hooch (SK-C-1191); Muscatine History and Industry Center. The date of the first buttonholes is debated; the thirteenth century in Europe is the usual estimate. The ligne is a traditional trade unit and button sizes vary slightly by maker. Linen and "webbed" (cloth-covered) buttons have no holes, which is why Dillmont stitches through the middle.

PRACTICE

1. **EASY** What is the difference between a sew-through button and a shank button?
2. **EASY** A button is 24 lignes. What is its diameter in inches?
3. **MEDIUM** Why does a coat button need a longer thread shank than a shirt button?
4. **MEDIUM** Dillmont's star method passes the needle through the middle of the button eight times. Why does she not use holes, and what risk does putting all the stitches through one center point bring?
5. **CHALLENGE** A coat button is 32 lignes in diameter and 3/16 inch thick. (a) What buttonhole length is needed? (b) Five buttons are spaced evenly so the top one is 1 inch below the neck edge and the bottom one 2 inches above the hem, on a front opening 30 inches long. How far apart are the buttons, center to center?
6. **CHALLENGE** In the 1890s a Muscatine button cutter might get roughly 15 to 20 blanks from a good mussel shell (assume 16). An order calls for 12 gross of shirt buttons (a gross is 144). If one blank in eight is rejected for flaws, how many shells are needed?

Make it a game · Button Sort Race. Pour a jar of mixed buttons onto a tray. Players race to sort a handful by type (2-hole, 4-hole, shank) and then by estimated size in lignes, checking with a ruler. One point per correct button; two points for any button sized within 2 lignes.

Scripture. “He that is faithful in that which is least is faithful also in much: and he that is unjust in the least is unjust also in much.” (Luke 16:10, KJV)

Jesus taught that faithfulness shows first in small things. Sewing a button back on properly is a little task, but it trains the same faithfulness needed for great ones.

Practice: answers

1. A sew-through button is flat with two or four holes; a shank button has a loop or stem on the back that lifts it off the cloth.
2. $24 \div 40 = 0.6$ inch (a little over $9/16$ inch).
3. The coat's buttonhole layer is much thicker, so the button must stand farther from the cloth to leave room for it without straining or puckering.
4. Linen and cloth-covered buttons have no holes, so she sews through the soft center. Spreading the stitches outward like a star grips the button all around; but if all passes go through one small center point, the fabric there can be weakened or torn, so the stitches must be kept firm and the shank wound to share the strain.
5. (a) Diameter = $32 \div 40 = 0.8$ inch; $0.8 + 0.1875 \approx 0.99$, about 1 inch. (b) Distance from top button to bottom button = $30 - 1 - 2 = 27$ inches, divided into 4 spaces = $6 \frac{3}{4}$ inches apart.
6. $12 \times 144 = 1,728$ buttons. Usable blanks per shell = $16 \times 7/8 = 14$. $1,728 \div 14 \approx 123.4$, so 124 shells. (The numbers are for practice; real yields varied with shell size.)

1.5 A PINCUSHION

OBJECTIVES

- Sew, turn, stuff and close a pincushion with a backstitched seam and an invisible ladder stitch.
- Explain how pins were made by hand and by machine, using Adam Smith's pin factory (1776) as a primary source.
- Calculate productivity and cost with division-of-labor numbers.

Warm-up. Hold an ordinary straight pin. Count how many separate steps you think it takes to make one: from wire to point to head to packet. Write your guess down; you will check it against a famous eighteenth-century description.

Video slot. Video coming. How to sew a simple pincushion with a ladder stitch; how pins are made; Adam Smith's pin factory explained. Search approved channels (a 4-H or university extension sewing channel, Smithsonian, Victoria and Albert Museum, a university economics channel); preview first.

KEY TERMS

division of labor

Splitting a job into many small tasks, each done by a different worker who becomes skilled and quick at it.

productivity

How much is produced per worker (or per hour) of work.

ladder stitch

A hand stitch that closes an opening invisibly by taking small stitches alternately in each folded edge, then pulling them tight.

emery

A hard, gritty mineral powder; a small cushion filled with it cleans and sharpens needles pushed through it.

turning gap

An opening left in a seam so a sewn shape can be turned right side out and stuffed.

CORE IDEAS

A pincushion is the first complete object most young sewers make, and it teaches four skills at once: sewing a seam, leaving a **turning gap**, turning and stuffing a shape, and closing it invisibly. It is also useful every day after; a sewer who keeps pins in a cushion rather than a heap loses fewer and pricks fewer fingers.

Pins were once costly. Before machines, each pin passed through many hands. Wire was drawn, straightened and cut; each piece was pointed on a grindstone; a separate tiny coil of wire was spun, cut and fixed on as the head; and the pins were whitened with a tin coating and stuck in paper for sale. Pins were valuable enough that the phrase “pin money” came to mean a sum set aside for small personal expenses. Households kept them carefully in pin-pillows, pin-poppets and pincushions, which were often given as gifts and decorated with pins pushed in to spell names or dates.

In 1776 the Scottish moral philosopher Adam Smith opened his book *An Inquiry into the Nature and Causes of the Wealth of Nations* with a description of a pin factory. A single untrained worker, he wrote, could hardly make one pin a day, and certainly not twenty. But in a small shop where the work was split into about eighteen operations, ten people could make upwards of 48,000 pins a day, or 4,800 each. Smith called this the **division of labor**, and he gave three reasons it raised **productivity**: each worker grew more skillful at one task, no time was lost moving from task to task, and the attention given to one task led people to invent machines for it.

Smith’s figures are worth testing, not just quoting. Some of his description came from French encyclopedia articles on pin-making rather than only from his own visits, and output varied from shop to shop. Still, the main point has held up: dividing tasks multiplies output. It also brings costs Smith himself admitted later in the same book, where he warned that a person doing one simple operation all his life may lose the chance to use and grow his wider understanding. The honest picture has both the gain and the cost. In the 1830s and 1840s, inventors in England and America built machines that made a whole pin with a solid head in one machine, and pins became cheap enough to buy by the hundred.

Today you can choose your pins and your cushion. Dressmaker pins are about 1 1/16 inches long; quilting pins are longer; glass-headed pins resist an iron. A cushion can be filled with polyester fiberfill (light and cheap), wool roving (the natural lanolin is said to keep pins from rusting), crushed walnut shells (heavy, so it stays put) or sawdust. The familiar red “tomato” cushion with a small strawberry attached is usually traced to the nineteenth century; the strawberry is filled with **emery**, which polishes rust from needles.

Making one is simple geometry. Two 5-inch squares sewn with a 1/2-inch **seam allowance** make a 4-inch cushion. Leave a 2-inch gap on one side, clip the corners so they turn sharply, turn right side out, push the corners out with a blunt chopstick, and stuff firmly, because a soft cushion lets pins fall over. Close the gap with a **ladder stitch**: fold the edges in, then take small stitches straight across, alternately in each fold, like the rungs of a ladder. When you pull the thread, the stitches disappear and the seam closes as if it had been sewn from the inside.

A pincushion is small, but it connects the sewing box to the history of how ordinary goods became affordable. When you hold a cheap packet of pins, you hold the result of centuries of invention, trade and work by many hands.

PICTURE STUDY



The Lacemaker, Johannes Vermeer, c. 1669–1670 · Oil on canvas, mounted on panel · Musée du Louvre, Paris

Wikimedia Commons · CC BY-SA 3.0

The Lacemaker is one of Vermeer's smallest paintings, about 9 1/2 by 8 1/4 inches. A young woman makes bobbin lace on a pillow, placing pins to hold each crossing of thread. In the foreground is a *naaikussen*, a sewing cushion with a box inside, from which loose red and white threads spill like paint.

Look closely

- Find the pins on the lace pillow. What job are they doing?
- Find the sewing cushion in the foreground. Why are the threads painted so softly while her fingers are sharp?
- Notice how close you are to her. How does the small size of the painting make you lean in, as she does?

Talk about it

1. What does the painting suggest about the concentration that fine handwork demands?
2. Pins were costly in Vermeer's day. Why would a lacemaker need hundreds of them?

Safety first. Count your pins before and after a project and keep them in the cushion, never in your mouth. Use a blunt tool, not scissor points, to push out corners. Keep finished pincushions with pins away from young children and pets. Emery is gritty: do not open an emery strawberry.

HANDS-ON: A SQUARE PINCUSHION AND THE PIN SHOP TEST

Sew a pincushion with a backstitched seam and a ladder-stitch closing. Then run a small “pin shop” at the table to test Adam Smith’s claim (Primary source aside) on a simple task of your own.

You will need

- Two 5-inch squares of tightly woven cotton or wool felt
- Thread to match, sharps needle, thimble, pins
- Fiberfill, wool roving or crushed walnut shells (pet-store bird or reptile litter)
- Chalk, ruler, scissors, a chopstick
- For the test: 40 index cards, a hole punch, string, scissors, a timer, and two to four helpers

Steps

1. Place the squares right sides together and pin. Chalk a stitching line 1/2 inch in from every edge.
2. Backstitch around all four sides, leaving a 2-inch gap on one side. Tie off securely at both ends of the gap.
3. Clip the corners diagonally, close to (not through) the stitching. Turn right side out and push the corners out gently.
4. Stuff firmly, a little at a time, working into the corners first.
5. Fold in the gap edges and close with a ladder stitch. Pull snug and hide the thread end inside the cushion.
6. Pin shop test: making a simple tag means cut a card, punch a hole, cut 6 inches of string, and tie it on. First, each person makes complete tags alone for 3 minutes. Then divide the four tasks, one per person, and work as a line for 3 minutes. Count tags per person each time.
7. Compare your result with Smith’s ratio and list what the line gained and what each worker lost.

Check your work

- My cushion has square corners, a firm stuffing and an invisible closing.
- My backstitched seam has no gaps.
- I recorded tags per person both ways and calculated the change.
- I wrote one gain and one cost of dividing the work.

FIELD NOTEBOOK

1. **Trail A, page 5: Pins and pincushions.** Draw a ladder stitch before and after pulling tight.
2. Make a bar graph of your pin-shop test: tags per person alone versus on the line.

3. **Narration (parent keeps):** In one paragraph, explain Adam Smith's pin factory, what your own test showed, and one cost of the division of labor that Smith himself noticed.

Did you know? The safety pin was patented by Walter Hunt of New York in 1849. He is said to have twisted it from a piece of wire in a few hours to pay a debt, and he sold the rights for a few hundred dollars. Hunt also built an early lockstitch sewing machine, but never patented it.

Primary source. Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations* (1776), Book I, Chapter 1, "Of the Division of Labour" (Project Gutenberg eBook #3300)

To take an example, therefore, from a very trifling manufacture, but one in which the division of labour has been very often taken notice of, the trade of a pin-maker: a workman not educated to this business (which the division of labour has rendered a distinct trade), nor acquainted with the use of the machinery employed in it (to the invention of which the same division of labour has probably given occasion), could scarce, perhaps, with his utmost industry, make one pin in a day, and certainly could not make twenty. But in the way in which this business is now carried on, not only the whole work is a peculiar trade, but it is divided into a number of branches, of which the greater part are likewise peculiar trades. One man draws out the wire; another straightens it; a third cuts it; a fourth points it; a fifth grinds it at the top for receiving the head; to make the head requires two or three distinct operations; to put it on is a peculiar business; to whiten the pins is another; it is even a trade by itself to put them into the paper; and the important business of making a pin is, in this manner, divided into about eighteen distinct operations ...

... Those ten persons, therefore, could make among them upwards of forty-eight thousand pins in a day. Each person, therefore, making a tenth part of forty-eight thousand pins, might be considered as making four thousand eight hundred pins in a day.

Go deeper. Adam Smith, *The Wealth of Nations*, Book I, Chapters 1-3 (free at Project Gutenberg); Henry Petroski, *The Evolution of Useful Things* (1992), chapter on pins and paper clips; Victoria and Albert Museum online collection of historic pincushions and pin-poppets; a second video topic: how a modern pin factory works.

Goes deeper in. Small Business & Economics, "Division of Labor and Productivity" (coming soon), and Art, "Vermeer and the Dutch Golden Age" (coming soon).

For families. Sources: Smith, Gutenberg #3300 (the excerpt omits the middle of the passage, marked by ellipses); Louvre notes on *The Lacemaker*. Historians have shown that Smith drew on French encyclopedia accounts of pin-making as well as observation, so his numbers are illustrative. His warning about the narrowing effects of repetitive

work is in Book V, Chapter 1. The claim that lanolin in wool protects pins is common lore and is presented as such. Walter Hunt's story is widely told; details of the debt vary between accounts.

PRACTICE

1. **EASY** According to Smith, how many pins could ten workers make in a day, and how many is that per worker?
2. **EASY** Why do you clip the corners of a pincushion before turning it right side out?
3. **MEDIUM** Give Smith's three reasons the division of labor raises productivity.
4. **MEDIUM** Two 5-inch squares are sewn with a 1/2-inch seam allowance. What size is the finished cushion, and what size squares would you cut for a 6-inch cushion with a 3/8-inch seam allowance?
5. **CHALLENGE** Using Smith's numbers, compare a lone untrained worker making at most 20 pins a day with a worker in the divided shop. By what factor did output per worker increase? If the shop paid each worker a day's wage of 10 pence and other costs were 2 pence per hundred pins, what was the cost per hundred pins in the shop, and what would a lone worker's labor cost per hundred pins be at 20 a day?
6. **CHALLENGE** Smith says the machinery used in pin-making was "probably" invented because of the division of labor. Explain his reasoning, and then name one thing his pin-factory picture leaves out that a careful reader should keep in mind.

Make it a game · Pin Drop Inventory. A parent hides ten pins in a pincushion and a few more on a felt mat (never on the floor). Players have one minute to find and count all of them using a magnet. Anyone who gets the exact count earns the title of Master Pin-Keeper for the day.

Scripture. "Seest thou a man diligent in his business? he shall stand before kings; he shall not stand before mean men." (Proverbs 22:29, KJV)

Diligence and skill in ordinary work are honored in Scripture. Whether pin-making or pin-cushion sewing, careful work done well is a calling, not a trifle.

Practice: answers

1. Upwards of 48,000 pins a day; 4,800 per worker.
2. Removing the extra fabric in the seam allowance at the corners lets them turn out sharp and flat instead of bulky and rounded.
3. Greater skill (dexterity) from repeating one task; saving the time lost in moving from one task to another; and the invention of machines by workers focused on one task.
4. Finished size $5 - 2 \times 1/2 = 4$ inches square. For 6 inches with 3/8-inch allowance: $6 + 2 \times 3/8 = 6 \text{ } 3/4$ -inch squares.
5. $4,800 \div 20 = 240$ times as much. Shop labor: 10 pence per 4,800 pins ≈ 0.21 pence per hundred, plus 2 pence other costs ≈ 2.2 pence per hundred. Lone worker: 10 pence per 20 pins = 50 pence per hundred in labor alone, more than 20 times as costly. (Wages here are hypothetical for the exercise.)

6. A worker who does one small task all day thinks about it constantly and is likely to notice a quicker way, including a tool or machine to do it. Left out: the cost to the worker of narrow, repetitive work (which Smith himself discusses later, in Book V), and the fact that his numbers partly came from published accounts and varied in practice. Also left out: the larger market needed to sell 48,000 pins a day, which Smith treats in Chapter 3.

1.6 A DRAWSTRING BAG

OBJECTIVES

- Plan a drawstring bag from finished measurements, calculating cutting size, seam allowances, casing and cord length.
- Sew a complete bag by hand with backstitched seams, a double-fold casing and finished seam edges.
- Explain why raw edges fray and compare ways of finishing them, including an 1880s hemming method.

Warm-up. Pull a single thread from the cut edge of a scrap of woven cotton. Keep pulling threads for a minute. What happens to the edge? Now imagine that happening inside a bag carried every day. What would you do to stop it?

Video slot. Video coming. How to sew a lined or unlined drawstring bag by hand; how to make a drawstring casing; French seams by hand. Search approved channels (a 4-H or university extension sewing channel, Smithsonian, Victoria and Albert Museum); preview first.

KEY TERMS

casing

A tunnel of folded fabric, stitched down, through which a drawstring or elastic is threaded.

double-fold hem

A hem folded twice so the raw edge is hidden inside the fold.

fraying

The unraveling of loose threads from a cut edge of woven fabric.

French seam

A seam sewn twice, first wrong sides together and then right sides together, enclosing the raw edges inside.

bodkin

A blunt, large-eyed tool, or a safety pin, used to pull cord or elastic through a casing.

finished size

The size of an item after all seams and hems are sewn, as opposed to the cutting size.

CORE IDEAS

A bag gathered by a cord is one of the oldest containers people have sewn. Shepherds and travelers carried srips and purses; in Scripture, Judas carried the disciples' "bag" and the prophet Haggai warned of wages put into "a bag with holes." In Europe, before garments had built-in pockets, many women wore a separate tied-on pocket under their skirts, and around 1800, when slim dresses left no room for one, a small drawstring bag called a

reticule became fashionable. Drawstring bags still carry shoes, laundry, marbles, Bibles and lunches. The design lasts because it is simple, strong and uses cloth efficiently.

Planning starts at the end, with the **finished size**. Suppose you want a bag 9 inches wide and about 11 3/4 inches tall. Cut one rectangle and fold it at the bottom, so there is no bottom seam. Add a 1/2-inch seam allowance on each side: $9 + 1/2 + 1/2 = 10$ inches wide. For each half, add the casing: a first fold of 1/4 inch and a second of 1 inch, so $11\ 3/4 + 1\ 1/4 = 13$ inches per side, or 26 inches for the whole length. A 10-by-26-inch rectangle cut on the grain yields the bag. The opening is $2 \times 9 = 18$ inches around, so a single cord needs about 18 inches plus 12 inches for tying, or 30 inches.

Woven fabric is made of threads crossing at right angles, and at a cut edge those threads are free to slide out. That is **fraying**. A bag that is used, washed and stuffed will fray inside unless its edges are finished. There are several honest choices. Pinking shears cut a zigzag that slows fraying. Overcasting by hand wraps the thread around the edge. A **French seam** sews the seam twice, first with wrong sides together close to the edge, then turned and sewn again with right sides together, so the raw edge is locked inside a neat tube. For a bag sewn entirely by hand, French seams are strong, tidy and worth the extra time.

The **casing** at the top is a **double-fold hem**. Before it can be folded, the side seams must stop short of the top, leaving a gap the cord can pass through. Stitch the side seams from the bottom fold to about 1 1/2 inches below the top edge, press the seam allowances apart, and sew down the unsewn allowances so they lie flat. Then fold the top edge down 1/4 inch, press, fold again 1 inch, press, and stitch close to the lower fold with a small backstitch or a slip stitch. Old manuals, such as this stop's primary source, describe the same principle: enclose the raw edge between two layers of cloth.

Cord passes through the casing with a **bodkin** or a safety pin fastened to its end. Choose a cord that slides freely; a casing 1 inch wide comfortably takes a cord up to about 1/2 inch thick. Knot or stitch the ends so they do not unravel. A second cord, threaded from the opposite side and knotted on that side, makes the bag close from both ends and pull up evenly, a common improvement on shoe bags and laundry bags.

Fabric choice matters. Medium-weight cotton such as quilting cotton, canvas or an old pillowcase is easy to sew and holds a crease. Cotton often shrinks a few percent the first time it is washed, so pre-wash it if the bag will be washed later. Thin silks slip and fray; thick denim is hard to sew by hand. Keep the cloth on grain: the long side of your rectangle should run parallel to the **selvage**, so the bag hangs straight instead of twisting.

A drawstring bag is a good first gift. In Acts 9, the believers at Joppa showed Peter the coats and garments that Dorcas had made for widows; her needlework was remembered as love put into useful form. A well-made bag, sewn with even stitches and finished edges, carries the same spirit.

PICTURE STUDY



The Young Virgin, Francisco de Zurbarán, c. 1632-1633 · Oil on canvas · The Metropolitan Museum of Art, New York
Wikimedia Commons · CC0

Francisco de Zurbarán was a Spanish painter of the 1600s known for quiet religious pictures with strong light and deep shadow. A medieval legend, not found in Scripture, said that Mary as a girl lived at the Temple in Jerusalem, praying and sewing vestments. Spanish artists of his time painted that scene as a picture of a diligent and devout life, using objects from their own city of Seville. Here she has paused her sewing to pray.

Look closely

- Find the sewing in her lap. What is she working on?
- Find the basket and the scissors. How carefully has Zurbarán painted each simple object?
- Notice the strong light against the dark background. Where does your eye go first?

Talk about it

1. Why do you think Spanish painters linked needlework with prayer in pictures of the young Mary?
2. How might sewing be a time for thinking and prayer as well as work?

Safety first. Pins and needles go back in the cushion. Press folds with an iron only with a parent nearby, set to the right heat for the fabric, and keep fingers clear of steam. Use a blunt bodkin or a closed safety pin for threading cord, and keep cords away from small children's necks.

HANDS-ON: PLAN AND SEW A DRAWSTRING BAG

Make a bag from your own calculations, with finished seams and a casing hemmed by the double-fold method Dillmont describes (Primary source aside). Plan it as a gift if you like, perhaps for someone who needs it, as Dorcas did.

You will need

- A rectangle of medium-weight cotton, 10 by 26 inches (or your own calculated size), pre-washed
- Matching thread, sharps needle, thimble, pins
- 30 inches of cord or ribbon (or two cords of 30 inches for a double draw)
- Ruler, chalk, scissors, a safety pin or bodkin
- An iron and ironing board (with a parent)

Steps

1. Decide your finished size and fill in a plan: width + 2 seam allowances; height + casing ($\frac{1}{4}$ + 1 inch) for each side; cord length = opening + 12 inches. Have a parent check your arithmetic.
2. Cut the rectangle on grain. Fold it in half crosswise, right sides out, for a French seam.
3. French seam, first pass: running stitch or backstitch each side $\frac{1}{4}$ inch from the edge, from the fold up to 1 $\frac{1}{2}$ inches below the top. Trim to $\frac{1}{8}$ inch, turn wrong side out, press, and backstitch again $\frac{1}{4}$ inch from the folded edge, enclosing the raw edges. (Together the two passes use the $\frac{1}{2}$ -inch allowance.)
4. At the top of each side, press the unsewn allowance to the inside and hem it down with tiny stitches so the cord gap is neat.
5. Following Dillmont, turn the top edge down $\frac{1}{4}$ inch along its whole length, then turn again 1 inch. Pin and stitch close to the lower fold all around the bag, keeping the side gaps open.
6. Thread the cord through with a safety pin, knot the ends, and test the bag with a load.
7. Inspect: Are the seams straight? Are any raw edges showing? Does the bag hang straight?

Check your work

- My plan shows correct cutting size and cord length.
- My side seams are French seams with no raw edges showing.
- My casing is even and the cord slides freely.
- The bag holds a load without seams opening.

FIELD NOTEBOOK

1. **Trail A, page 6: The drawstring bag.** Draw your cutting plan with every measurement, and a cross-section of the casing and of a French seam.
2. Record the time you spent on each step, and the cost of materials.

3. **Narration (parent keeps):** In one paragraph, explain how you worked backward from the finished size to the cutting size and why the order of steps (side seams, then casing) matters.

Did you know? Many museum collections hold tie-on pockets from the 1700s and 1800s, often sewn from scraps and embroidered. They hung from a tape around the waist, reached through a slit in the skirt. The nursery rhyme “Lucy Locket lost her pocket” comes from the days when a pocket was a separate thing you could lose.

Primary source. *Thérèse de Dillmont, Encyclopedia of Needlework (first published in the 1880s; Project Gutenberg eBook #20776), “Plain Sewing,” on the hemming-stitch*

Your first turning should not be more than 2 m/m. wide; turn down the whole length of your hem, and then make the second turning of the same width, so that the raw edge is enclosed between two layers of stuff.

Go deeper. Victoria and Albert Museum and Colonial Williamsburg online pages on tie-on pockets and reticules; Barbara Burman and Ariane Fennetaux, *The Pocket: A Hidden History of Women’s Lives, 1660–1900* (2019; library); Dillmont, *Encyclopedia of Needlework* (free at Project Gutenberg); a second video topic: sewing French seams by hand.

Goes deeper in. Arithmetic, “Measurement and Fractions,” and Small Business & Economics, “Costing a Product” (coming soon).

For families. Sources: Dillmont, Gutenberg #20776 (her “2 m/m.” means 2 millimeters; her hem is narrow, with two equal turnings, while a casing uses a narrow first turning and a wider second, so students adapt rather than copy); Metropolitan Museum notes on Zurbarán’s *The Young Virgin*; John 12:6 and Haggai 1:6 for the Scripture “bag” references. Reticules are dated to around 1800 in museum collections; exact dates vary. If the bag will hold anything heavy, use a backstitch for the second pass of the French seam.

PRACTICE

1. **EASY** What is a casing, and why must the side seams stop short of the top edge?
2. **EASY** How does a French seam stop fraying?
3. **MEDIUM** Dillmont’s first and second turnings are both 2 mm. For a drawstring casing you use 1/4 inch and then 1 inch. Why change her method this way?
4. **MEDIUM** You want a finished bag 7 inches wide and 9 inches tall from the bottom fold to the top of the casing, with 1/2-inch side seams and a casing of 1/4 + 3/4 inch. What size rectangle do you cut?
5. **CHALLENGE** Cotton fabric is 44 inches wide and sold by the yard (36 inches). How many 10-by-26-inch bag rectangles can you cut from 1 1/2 yards, with the 26-inch side along the length of the fabric? If the fabric costs \$8.00 a yard and cord costs \$0.20 a foot, what are the material costs per bag?

6. **CHALLENGE** The cotton shrinks 4% in length and 2% in width at the first wash. If you cut a 10-by-26-inch rectangle without pre-washing and sew it with 1/2-inch side seams, about what will the finished width and the total length be after washing? Is that a problem?

Make it a game • Pack It Right. Set out a dozen objects of different sizes. Each player estimates which will fit in a 9-by-11-inch bag with the cord pulled closed, then tests. One point for each correct guess; the player who packs the most items so the bag still closes wins.

Scripture. “Then Peter arose and went with them. When he was come, they brought him into the upper chamber: and all the widows stood by him weeping, and shewing the coats and garments which Dorcas made, while she was with them.” (Acts 9:39, KJV)

Dorcas was remembered for the clothing she sewed for widows. Her needle served her neighbors; a well-made gift can do the same.

Practice: answers

1. A folded, stitched tunnel for a cord. The side seams stop short so there is a gap where the cord can enter and leave the casing.
2. It is sewn twice, so the raw edges are trapped inside a narrow folded tube where they cannot unravel or show.
3. A hem only needs to hide the raw edge, so two equal narrow turns are neat. A casing must also make a tunnel wide enough for a cord, so the second turn is wide; the first stays narrow just to hide the raw edge.
4. Width $7 + \frac{1}{2} + \frac{1}{2} = 8$ inches. Each half: $9 + \frac{1}{4} + \frac{3}{4} = 10$ inches, so 20 inches long. Cut 8 by 20 inches.
5. $1 \frac{1}{2}$ yards = 54 inches long, so only one 26-inch length fits twice (52 inches), giving 2 rows. Across the width, $44 \div 10 = 4$ rectangles. $2 \times 4 = 8$ bags. Fabric: $\$12.00 \div 8 = \1.50 per bag. Cord: 30 inches = 2.5 feet $\times \$0.20 = \0.50 . Total about \$2.00 per bag, before thread.
6. Width before: 9 inches finished; after 2% shrinkage ≈ 8.8 inches. The 26-inch length shrinks 4% to about 25 inches, so each side loses about 1/2 inch of height ($11 \frac{3}{4}$ to about $11 \frac{1}{4}$). The bag still works but becomes slightly smaller and may pucker where thread and cloth shrink differently; pre-washing avoids this.

1.7 PATTERNS AND PINNING

OBJECTIVES

- Read pattern markings (grainline, place-on-fold, notches, dots, cutting and stitching lines) and lay out, pin and cut a pattern on grain.
- Explain the history of patterns, from tailors' drafting books to Butterick's graded paper patterns of the 1860s.
- Draft a simple pattern from measurements, adding seam allowance and ease, and calculate fabric needed.

Warm-up. Take a woven cotton scrap and tug it three ways: along the selvage, across from selvage to selvage, and diagonally. Which way stretches most? Write it down; that single fact explains why every pattern piece carries an arrow.

Video slot. Video coming. How to read a sewing pattern: grainline, place on fold, notches; how to lay out, pin and cut fabric; history of the Butterick paper pattern. Search approved channels (a 4-H or university extension sewing channel, Smithsonian, Victoria and Albert Museum, The Metropolitan Museum Costume Institute); preview first.

KEY TERMS

grain

The direction of the threads in woven fabric: lengthwise grain runs parallel to the selvage; crosswise grain runs across it.

bias

The diagonal of woven fabric, at 45 degrees to the grain, where it stretches most.

grainline arrow

The long arrow printed on a pattern piece; it must lie parallel to the selvage.

notch

A small triangle or mark on a cutting line used to match pieces exactly when they are sewn together.

ease

Extra room added to body measurements so a garment can be moved in (wearing ease) or to create a style (design ease).

grading

Making the same pattern in a range of sizes by systematically enlarging or reducing it.

CORE IDEAS

A pattern is a plan in two dimensions for something that will be three-dimensional. Before printed patterns, a tailor or dressmaker *drafted* each garment from the customer's measurements, marking lines in chalk directly on the cloth or on paper. Skill was passed

from master to apprentice, but a few tailors published their methods. In 1580 Juan de Alcega of Madrid printed a book of tailoring geometry with diagrams showing how to lay out the pieces of cloaks, gowns and cassocks on a length of cloth so as to waste as little as possible; it is among the earliest known printed pattern books.

In 1863 Ebenezer Butterick, a tailor in Sterling, Massachusetts, began selling **graded** paper patterns: the same design printed in a set of sizes, cut from tissue paper and folded into an envelope. His family business and other firms such as Demorest and McCall made patterns cheap, standard and easy to mail. For the first time a home sewer could buy the newest style in the right size for a few cents. The paper pattern became one of the great household technologies of the following century.

Every pattern piece speaks a standard language. The **grainline arrow** must lie parallel to the selvage. A bracketed arrow marked “place on fold” means the piece is cut with one edge on the fold, giving a symmetrical whole. **Notches** on the cutting line are matched like puzzle tabs. Dots mark the ends of darts, pocket positions and where stitching stops. Two lines run around many pieces: the outer *cutting line* and the inner *stitching line*; the space between is the seam allowance, usually 5/8 inch on American home patterns. Some European patterns are printed without allowance, and the sewer must add it; always read the instruction sheet before cutting.

Why the fuss about **grain**? Woven cloth is a grid of threads. Along the lengthwise grain it hardly stretches; along the crosswise grain it stretches a little; on the **bias** it stretches and drapes a great deal. A piece cut off-grain hangs crooked, twists after washing and makes seams pull. Bias is used on purpose for flowing skirts and for binding curved edges. Fabrics with a nap (velvet, corduroy) or a one-way print must also be cut with every piece facing the same direction, which uses more fabric.

Pinning holds the pattern and fabric still while cutting, and holds layers together while sewing. Pins go inside the cutting line and roughly every 3 to 4 inches, closer on curves. Pins placed at right angles to a seam line hold best and can be removed easily as you sew; pins along the seam allowance avoid marking delicate cloth. Many sewers use pattern weights instead, and cut with long smooth strokes of the shears, keeping the lower blade on the table. Mark notches and dots before removing the pattern. The old rule “measure twice, cut once” holds; cloth can be unpicked, but a wrong cut cannot be undone.

Sizing deserves honest attention. Pattern sizes are based on body measurements printed on the envelope and often do not match ready-to-wear sizes, so sewers measure first and choose by measurement, not by the number on a store label. The difference between body measurements and the finished garment is **ease**: a fitted bodice may add 2 to 3 inches at the bust, a loose shirt far more. Experienced sewers make a test garment, or muslin, from cheap cloth before cutting good fabric.

Scripture records a pattern of great precision. God showed Moses a pattern for the tabernacle and told him to make everything “after their pattern” (Exodus 25:40). The curtains were to be of one measure, each exactly the same, and joined edge to edge.

Whether we cut a tabernacle curtain or a pillowcase, faithful work follows a careful plan, measures exactly and treats materials as something entrusted to us.

PICTURE STUDY



The Tailor (Il Tagliapanni), Giovanni Battista Moroni, c. 1565–1570 · Oil on canvas · The National Gallery, London
Wikimedia Commons · Public domain

Giovanni Battista Moroni painted portraits in and around Bergamo in northern Italy. It was unusual in his time for a working craftsman to be painted at his trade, and with such dignity. The tailor pauses with his shears on cloth already marked with chalk, ready to cut, and looks up as if a customer has just come in.

Look closely

- Find the chalk lines on the black cloth. What do they tell you about how the tailor works?
- Look at the shears. How is he holding them, and how big are they compared with modern scissors?
- Look at his own clothing. How might a tailor's clothes serve as an advertisement?

Talk about it

1. Why might a tailor want his portrait painted at work rather than in his best clothes at leisure?
2. What does marking before cutting tell you about the value of cloth in the 1500s?

Safety first. Cut with the shears flat on the table and your other hand well away from the blades. Keep pins inside the cutting line so the shears do not hit them, and count pins in

and out. Use an iron for pressing patterns only with a parent nearby, on a low dry setting for tissue paper.

HANDS-ON: DRAFT, LAY OUT, PIN AND CUT: A TOTE OR CUSHION COVER

Draft your own paper pattern for a simple item from measurements (an envelope cushion cover or a flat tote), mark it in standard pattern language, lay it out on grain, pin and cut it. Then use the tabernacle curtain measurements (Primary source aside) to practice planning to a single measure.

You will need

- Large paper (wrapping paper, grocery bags or pattern tissue), a ruler or yardstick, a square
- Pencil, eraser, tape
- Fabric (about 1 yard of medium-weight cotton), pre-washed and pressed
- Pins or pattern weights, fabric shears, chalk
- A cushion form or a tote you want to copy, and a tape measure

Steps

1. Measure the object (cushion form, or the size of tote you want). Write the finished measurements.
2. On paper, draw the finished shape with a square so the corners are true. Add 5/8-inch seam allowance around every sewn edge; add ease if needed (a cushion cover is usually cut the same size as the form for a plump fit; a tote needs none).
3. Mark the pattern: name of piece, "cut 2" or "cut 1 on fold," grainline arrow, notches at the centers of edges, and the seam line dashed inside the cutting line.
4. Calculate how much fabric you need for all pieces on 44-inch fabric, and sketch a layout that wastes the least.
5. Lay the pattern on the fabric. Measure from each end of the grainline arrow to the selvage; adjust until both measurements match. Pin every 3 to 4 inches inside the cutting line.
6. Cut with long, smooth strokes. Snip the notches outward 1/8 inch or chalk them. Keep the pieces for sewing later.
7. Practice with the source: draw the ten tabernacle curtains to scale (1 cubit = 1/2 inch) and calculate their size in feet.

Check your work

- My pattern has a grainline, cutting line, seam line, notches and cutting instructions.
- My grainline was measured parallel to the selvage at both ends.
- My pieces are cut cleanly with notches marked.
- I calculated fabric needed and the curtain sizes correctly.

FIELD NOTEBOOK

1. **Trail A, page 7: Pattern language.** Draw a sample pattern piece with every symbol labeled: grainline, place on fold, notches, dots, cutting line, seam line.
2. Draw a woven-fabric grid showing lengthwise grain, crosswise grain and bias.
3. **Narration (parent keeps):** In one paragraph, explain why cutting on grain matters and what happens to a piece cut off-grain.

Did you know? Early Butterick patterns were not printed; the pieces were cut from tissue and marked with punched holes and notches. Printed tissue patterns, with lines and words on the paper, were introduced by McCall in the early twentieth century and soon became the standard.

Primary source. *Exodus 26:1-2, King James Version (1611)*

Moreover thou shalt make the tabernacle with ten curtains of fine twined linen, and blue, and purple, and scarlet: with cherubims of cunning work shalt thou make them.

The length of one curtain shall be eight and twenty cubits, and the breadth of one curtain four cubits: and every one of the curtains shall have one measure.

Go deeper. The Metropolitan Museum of Art Costume Institute online collection, for historic garments and their construction; Janet Arnold, *Patterns of Fashion* series (library), which draws real historic garments piece by piece; Smithsonian National Museum of American History online pages on home sewing and paper patterns; a second video topic: how a tailor drafts a pattern from measurements.

Goes deeper in. Arithmetic, “Measurement and Scale Drawing,” and History, “The Tabernacle and the Exodus” (coming soon).

For families. Sources: National Gallery notes on Moroni’s *The Tailor* (dated c. 1565–1570); histories of the Butterick company (patterns sold from 1863). Alcega’s book is dated 1580, with a second edition in 1589. The length of the biblical cubit is uncertain; about 18 inches (45 cm) is a common estimate, and the stop treats it as approximate. McCall’s printed patterns are usually dated to the 1920s. The cushion-cover sizing is a common rule of thumb; preferences vary.

PRACTICE

1. **EASY** Which direction of woven fabric stretches most? Which stretches least?
2. **EASY** What does a bracketed arrow marked “place on fold” mean?
3. **MEDIUM** How do you check that a pattern piece is on grain?
4. **MEDIUM** A tote bag front is to be 14 by 16 inches finished, sewn on all four sides with 5/8-inch seam allowance. What size is the pattern piece?

5. **CHALLENGE** Using the primary source and $1 \text{ cubit} \approx 18 \text{ inches}$, give the size of one tabernacle curtain in feet, the area of all ten in square feet, and the width of five curtains joined edge to edge (Exodus 26:3 says five were coupled together, and the other five likewise).
6. **CHALLENGE** Why does “every one of the curtains shall have one measure” matter in practice, both for the tabernacle and for any pattern cut many times? Then calculate: if each of ten curtains were cut $1/2$ inch too wide and joined into two sets of five, how far off would each set be?

Make it a game • Pattern Symbol Snap. Make cards with pattern symbols on some and their meanings on others. Deal them face down. Players turn up two at a time; a matched symbol and meaning is kept. The player with the most pairs explains each one aloud to win.

Scripture. “And look that thou make them after their pattern, which was shewed thee in the mount.” (Exodus 25:40, KJV)

God gave Moses an exact pattern and expected it to be followed with care. A sewing pattern is a small picture of the same truth: good work follows a good plan.

Practice: answers

1. The bias (diagonal) stretches most; the lengthwise grain, parallel to the selvage, stretches least.
2. Lay that edge of the pattern exactly on the folded edge of the fabric and cut both layers, so the piece opens into one symmetrical whole.
3. Measure from each end of the grainline arrow to the selvage and adjust until the two distances are equal; then the arrow is parallel to the selvage.
4. $14 + 5/8 + 5/8 = 15 \frac{1}{4}$ inches by $16 + 5/8 + 5/8 = 17 \frac{1}{4}$ inches.
5. One curtain: $28 \times 18 = 504$ inches = 42 feet long; $4 \times 18 = 72$ inches = 6 feet wide. Area of one = $42 \times 6 = 252$ sq ft; ten = 2,520 sq ft. Five joined = $5 \times 6 = 30$ feet wide (each set of five is 42 by 30 feet). (Approximate, since the cubit is uncertain.)
6. Pieces made to one measure fit together interchangeably; joined edges and loops line up, and the whole hangs true. Small errors add up when pieces are joined. Five curtains each $1/2$ inch too wide make each set $2 \frac{1}{2}$ inches too wide, enough to misalign the loops and clasps that couple the two sets.

1.8 MEET THE SEWING MACHINE (WITH A PARENT)

OBJECTIVES

- Name the main parts of a sewing machine and explain how a lockstitch is formed by needle, hook or shuttle and bobbin.
- Trace the invention of the sewing machine from Thimonnier and Hunt to Howe's 1846 patent and Singer's 1851 machine, using Howe's patent claim as a primary source.
- Under a parent's supervision, thread a machine, wind a bobbin and sew straight, backtacked seams, and compare machine and hand speed with numbers.

Warm-up. Look at a machine-sewn seam on a shirt with a magnifying glass, front and back. Then look at your hand backstitch from Stop A3. How are they alike? How are they different? Where do the two threads of the machine seam meet?

Video slot. Video coming. How a lockstitch sewing machine works (slow-motion animation of needle, hook and bobbin); history of Elias Howe and Isaac Singer; how to thread a home sewing machine. Search approved channels (Smithsonian National Museum of American History, a university extension sewing channel, the machine maker's official channel); preview first.

KEY TERMS

lockstitch

A machine stitch in which an upper (needle) thread and a lower (bobbin) thread interlock in the middle of the fabric.

bobbin

A small spool under the needle plate that holds the lower thread.

feed dogs

Toothed metal bars under the presser foot that move the fabric forward one stitch at a time.

presser foot

The part that holds the fabric down against the feed dogs while stitching.

tension

The adjustable resistance on the upper thread that balances it against the bobbin thread so the stitches lock in the middle of the cloth.

backtack

A few stitches sewn in reverse at the start and end of a seam to lock it.

CORE IDEAS

For most of history, all clothing was sewn by hand, and much of it was sewn by women at home or by poorly paid needleworkers in cities. Hand sewing is slow: a skilled sewer might

make perhaps 30 to 40 stitches a minute. One often-quoted comparison from the 1860s put a man's shirt at about 14 hours of hand sewing and a little over an hour by machine. Many inventors tried to mechanize the needle. The French tailor Barthélemy Thimonnier patented a chain-stitch machine in 1830 and set up a workshop sewing army uniforms, but in 1831 a crowd of tailors, fearing for their livelihoods, broke into the shop and destroyed his machines. In New York, Walter Hunt built a machine that formed a lockstitch in the early 1830s but did not patent it; accounts say he worried it would put seamstresses out of work.

Elias Howe, a young machinist from Massachusetts, built a working lockstitch machine and by April 1845 had sewn all the seams of two wool suits with it. He received U.S. Patent No. 4,750 on September 10, 1846. His machine used a curved, eye-pointed needle on a swinging arm and a shuttle carrying a second thread. Howe found few buyers at first and went to England, returning poor. Meanwhile, others built improved machines. In 1851 Isaac Merritt Singer patented a machine with a straight needle moving up and down, a presser foot holding the cloth, and a table and treadle, a practical design for workshops and, soon, homes.

Howe sued manufacturers who used his patented combination, and the courts upheld his claim. The "sewing machine war" of lawsuits ended in 1856 when Howe, Singer and two other firms formed the Sewing Machine Combination, pooling their patents and charging a fee on each machine made. Howe, who had once pawned his patent papers, earned large royalties. Singer's company sold machines on installment plans and built a worldwide business; by the 1870s sewing machines were common in American homes and factories.

The machine changed work in two directions at once. It saved enormous labor in the home: a mother could sew a family's clothes in a fraction of the time. It also made ready-made clothing cheap and helped create large garment workshops in cities, where long hours and crowded rooms were common until reforms in the early twentieth century. The honest story includes both the relief and the hardship.

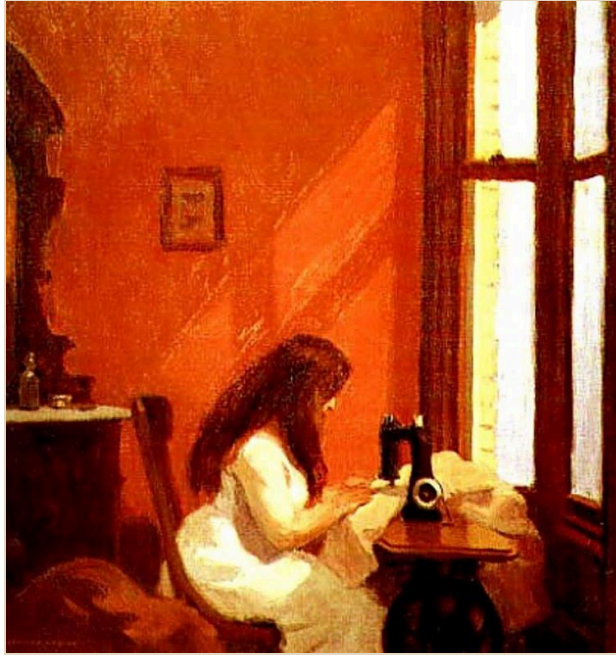
How does it work? The needle carries the upper thread down through the cloth. As it starts to rise, the thread forms a small loop beneath. A rotating **hook** (or, in older machines, a shuttle) catches that loop and carries it around the **bobbin**, so the bobbin thread passes through the loop. The **take-up lever** then pulls the upper thread up tight, locking the two threads together in the middle of the cloth: a **lockstitch**. Meanwhile the **feed dogs** rise, grip the cloth under the **presser foot**, move it one stitch length, and drop again. Upper **tension** must balance the bobbin; if it is too tight the bobbin thread shows on top, too loose and loops form underneath.

Modern home machines set stitch length in millimeters; 2.5 mm, about 10 stitches per inch, is a common straight stitch. They can run at several hundred to more than a thousand stitches a minute, which is why a beginner must control speed with the foot pedal and keep fingers well away from the needle. Every seam is started and ended with a **backtack** of three or four reverse stitches to lock it, the machine's version of tying off.

A sewing machine is a serious tool, like a power saw or a stove, and learning it beside a parent is the right way. The first rule is patience: sew slowly, go straight, stop with the

needle down to turn a corner, and never sew over pins. Machines did not end hand sewing. Buttons, hems, closings and fine finishing are still often done by hand, and the hand skills from this trail make a better machine sewer.

PICTURE STUDY



Girl at a Sewing Machine, Edward Hopper, 1921 · Oil on canvas · Museo Nacional Thyssen-Bornemisza, Madrid

Wikimedia Commons · Public domain

Edward Hopper was an American painter of quiet, lonely scenes in city rooms, diners and streets. In 1921, the sewing machine was an everyday household tool. Hopper shows a girl absorbed in her work beside a sunny window. The painting is small, about 19 by 18 inches.

Look closely

- Find the sewing machine. What parts can you identify?
- Find the strongest light. How does Hopper divide the room into light and shadow?
- Look at the girl's posture. How does Hopper show her concentration without showing us much of her face?

Talk about it

1. How had the sewing machine changed home life by 1921 compared with 1821?
2. Hopper painted many people alone. Does this scene feel lonely, peaceful or busy to you? Why?

Safety first. Use the sewing machine only with a parent present. Unplug or switch off the machine before threading, changing the needle or presser foot, or clearing a jam. Keep fingers at least an inch from the needle; guide the fabric, do not push or pull it. Remove

pins before they reach the presser foot. Tie back long hair, roll up loose sleeves, keep the cord out of walkways, and sew slowly. Wear eye protection if your parent prefers; a breaking needle can fly.

HANDS-ON: FIRST SEAMS ON THE MACHINE, AND THE SPEED TEST

With a parent beside you, learn the machine's parts, thread it, wind a bobbin and sew straight seams. Then make a second drawstring bag (Stop A6) by machine and compare time and quality with your hand-sewn bag. Use Howe's patent claim (Primary source aside) to label the parts that do the jobs he described.

You will need

- A home sewing machine and its manual (a parent supervises throughout)
- A new universal needle, size 80/12, and all-purpose thread
- Lined notebook paper and scrap cotton strips
- Fabric and cord for a second drawstring bag (10 by 26 inches, 30 inches of cord)
- A timer, ruler and seam ripper

Steps

1. With the machine unplugged, find and name with your parent: spool pin, thread guides, tension dial, take-up lever, needle, presser foot, feed dogs, bobbin case, hand wheel, stitch length and reverse controls.
2. Practice control without thread: sew on lined paper along the lines, then curves and corners (needle down, lift foot, turn), keeping speed slow and steady.
3. Wind a bobbin and thread the machine following the manual. Bring up the bobbin thread. Sew a test line on scrap cotton and check that the stitches lock in the middle of the cloth; adjust tension with your parent if needed.
4. Sew three 8-inch seams on scrap at 5/8 inch, with backtacks at both ends. Measure how straight each is.
5. Read Howe's claim. On a sketch of your machine, label the parts that do what he described: carrying a thread through the cloth, and passing a second thread between the needle and its thread. Note what is different in your machine (straight needle, rotary hook).
6. Make the second drawstring bag by machine. Time each step and compare with your hand-sewn bag.

Check your work

- I named the machine's main parts and threaded it correctly with a parent present.
- My test stitches lock in the middle of the cloth.
- My seams are straight and backtacked.
- I recorded hand and machine times and compared them.

FIELD NOTEBOOK

1. **Trail A, page 8: The lockstitch.** Draw the four stages of a lockstitch: needle down, loop formed, hook carries loop around bobbin, thread pulled tight.
2. Make a timeline from 1830 to 1856: Thimonnier, Hunt, Howe, Singer, the Combination.
3. **Narration (parent keeps):** In one paragraph, tell how the sewing machine was invented and explain both the help and the hardship it brought.

Did you know? Howe did not invent the eye-pointed needle; others had used needles with an eye near the point before him. His patent covered the combination of the curved eye-pointed needle and a shuttle forming a lockstitch. A popular story says the idea came to him in a dream of spears with holes in their tips; it is a family legend, not a documented fact.

Primary source. *Elias Howe, U.S. Patent No. 4,750 (September 10, 1846), first claim, as quoted in Grace Rogers Cooper, The Invention of the Sewing Machine (Smithsonian Institution, United States National Museum Bulletin 254, 1968; Project Gutenberg eBook #32677)*

1. The forming of the seam by carrying a thread through the cloth by means of a curved needle on the end of a vibrating arm, and the passing of a shuttle furnished with its bobbin, in the manner set forth, between the needle and the thread which it carried, under combination and arrangement of parts substantially the same with that described.

Go deeper. Grace Rogers Cooper, *The Invention of the Sewing Machine* (free at Project Gutenberg); Smithsonian National Museum of American History online collection of patent-model sewing machines; Adam Smith, *The Wealth of Nations*, Book I, Chapter 1, on machinery and the division of labor; a second video topic: a slow-motion view of a rotary hook forming a lockstitch.

Goes deeper in. History, “Inventors of the Industrial Age,” and Small Business & Economics, “Patents, Inventions and Markets” (coming soon).

For families. Sources: Cooper, Gutenberg #32677 (patent number, date, the April 1845 suits, and the point that Howe did not claim the eye-pointed needle); Singer’s first patent, August 12, 1851, as given by Cooper. The hand-versus-machine shirt figures and the reasons given for Hunt’s not patenting come from nineteenth-century accounts and are presented as such. Hopper’s painting was made in the United States in 1921 and is used here under the site’s rule for American works before 1931; families may also view it on the Thyssen-Bornemisza museum website. Always follow the manual for your own machine.

PRACTICE

1. **EASY** In a lockstitch, where should the upper and bobbin threads meet? What does it mean if the bobbin thread shows on top?
2. **EASY** Give the patent number and date of Howe's sewing machine patent, and the year of Singer's first patent.
3. **MEDIUM** What two parts of a machine work together to move the cloth forward, and what should the sewer's hands do?
4. **MEDIUM** Read Howe's claim. Which phrase describes the upper thread, and which describes the lower thread? What part of a modern machine does each job?
5. **CHALLENGE** A machine sews at 600 stitches per minute with a 2.5 mm stitch. A hand sewer backstitches at 30 stitches per minute with a 3 mm stitch. (a) How many centimeters of seam does each produce per minute? (b) How many times faster is the machine? (c) How long would each take to sew the 24 inches (61 cm) of side seams on a drawstring bag?
6. **CHALLENGE** Thimonnier's machines were destroyed by tailors in 1831, and Hunt is said to have held back his invention out of concern for seamstresses. Yet within fifty years the sewing machine was in millions of homes. Weigh the arguments: who gained from the sewing machine, who lost, and how did the patent pool of 1856 affect the price and spread of machines?

Make it a game • Human Lockstitch. Three players act out a lockstitch with a long piece of yarn (upper thread) and a ball of string (bobbin thread): the "needle" pushes a loop of yarn down through a hula hoop (the cloth), the "hook" carries the loop around the "bobbin" player, and the "take-up lever" pulls the yarn up. Can the team lock the threads in the middle of the hoop five times in a row?

Scripture. "My son, hear the instruction of thy father, and forsake not the law of thy mother:" (Proverbs 1:8, KJV)

Solomon urges a child to learn from both parents. Learning a powerful machine at a parent's side, and listening carefully, is wisdom as well as safety.

Practice: answers

1. In the middle of the layers of cloth. If the bobbin thread shows on top, the upper tension is too tight (or the bobbin tension too loose).
2. U.S. Patent No. 4,750, September 10, 1846. Singer: 1851.
3. The feed dogs (below) and the presser foot (above). The sewer only guides the fabric lightly and keeps it straight; pushing or pulling bends needles and makes uneven stitches.
4. Upper: "carrying a thread through the cloth by means of a curved needle on the end of a vibrating arm" (today a straight needle on a needle bar). Lower: "the passing of a shuttle furnished with its bobbin ... between the needle and the thread which it carried" (today usually a rotary hook carrying the loop around the bobbin).
5. (a) Machine: $600 \times 2.5 \text{ mm} = 1,500 \text{ mm} = 150 \text{ cm}$ per minute. Hand: $30 \times 3 \text{ mm} = 90 \text{ mm} = 9 \text{ cm}$ per minute. (b) $150 \div 9 \approx 17$ times faster. (c) Machine: $61 \div 150 \approx 0.4$ minute (about 25

seconds of stitching, plus handling). Hand: $61 \div 9 \approx 6.8$ minutes of steady stitching, plus rethreading and handling.

6. Gains: households saved great labor; clothing became cheaper and more plentiful; new jobs arose in making, selling and repairing machines and in ready-made clothing. Losses: some hand sewers lost work or saw wages fall, and many new jobs were in crowded garment workshops with long hours. The 1856 Combination ended costly lawsuits, letting the major makers build machines freely while paying a fee on each; that fee kept prices higher until the key patents expired in the 1870s, after which competition lowered prices and spread machines further. A good answer names both sides and uses the dates.

TRAIL 1 BADGE QUIZ

The badge quiz is optional and may be written or oral. Show your work on number problems. Four right out of five earns the first badge; five right out of six earns the second. Badges and the certificate are earned by completing the stops, not by scores.

Badge quiz 1 (Stops 1-5)

1. Why is a size 10 sharps finer than a size 5, and why do fabric shears have a bent handle?
2. Which is finer, 40 weight or 60 weight thread? Which is heavier, tex 25 or tex 40? Why is a working length kept to about 18-24 inches?
3. About how much thread does a 12-inch backstitched seam use, and why is a backstitch stronger than a running stitch?
4. A 30-ligne button is 1/8 inch thick. What is its diameter, and how long should the buttonhole be? Why does it need a thread shank?
5. Using Adam Smith's figures, how many times more pins did a worker in the divided shop make than a lone untrained worker making 20 a day? Give one cost of the division of labor.

Badge quiz 2 (Stops 6-8)

6. Plan a drawstring bag 8 inches wide and 10 inches tall finished, cut from one folded rectangle with 1/2-inch side seams and a 1/4 + 1-inch casing. What size rectangle, and how long a single cord?
7. Explain how a French seam is made and why it is used.
8. How do you place a pattern piece on grain, and what happens to a piece cut off-grain?
9. Using 1 cubit $\approx$ 18 inches, how long and wide in feet was one tabernacle curtain (28 by 4 cubits)?
10. Describe how a lockstitch is formed, and name Howe's patent number and year.
11. What is a 2.5 mm stitch length in stitches per inch, and name three safety rules for the sewing machine.

TRAIL CERTIFICATE: MY SEWING SAMPLER BOOK AND TRAIL A CERTIFICATE

Assemble a sampler book: your knot card, seam samples with SPI and strength results, button board, pattern piece, and machine test seams, each labeled with stop number and date.

Include your finished pincushion and both drawstring bags (hand and machine), with your cost sheet and time comparison.

Add your eight narration paragraphs and a one-page reflection: which primary source taught you the most, and what you would sew next.

When the book is complete, a parent reviews it and signs the Trail A certificate.

- **Workmanship:** Stitches are even and on the line, seams are finished, and buttons and closings are secure.
- **Planning and numbers:** Cutting sizes, seam allowances, thread use, costs and speeds are calculated correctly and shown.
- **Sources and history:** Primary sources are read accurately, quoted correctly and tested at the worktable; history is told with fair, specific facts.
- **Safety and care:** Tools are kept in order, safety rules are followed, and machine work is done with a parent present.

Answer key

1. Needle numbers follow old wire gauges, where higher numbers meant wire drawn thinner. The bent handle lets the lower blade lie flat on the table so the cloth is not lifted while cutting.
2. 60 weight is finer; tex 40 is heavier. Longer thread frays from being pulled through the cloth so many times and tangles more.
3. About 36 inches (3 times the seam length). Each stitch wraps back over the last, locking the thread, so a break loosens only a short stretch.
4. $30 \div 40 = 3/4$ inch; buttonhole $3/4 + 1/8 = 7/8$ inch. The shank leaves room for the buttonhole layer so the cloth does not strain or pucker.
5. $4,800 \div 20 = 240$ times. Cost: narrow, repetitive work can dull a worker's wider understanding (Smith's own warning).
6. Width $8 + 1 = 9$ inches; length $2 \times (10 + 1 \frac{1}{4}) = 22 \frac{1}{2}$ inches. Cord: opening 16 inches + 12 = 28 inches.
7. Sew first with wrong sides together close to the edge, trim, turn so right sides are together, and sew again, enclosing the raw edges. It prevents fraying and looks neat inside.
8. Measure from both ends of the grainline arrow to the selvage and make the distances equal. An off-grain piece hangs crooked, twists after washing and makes seams pull.
9. 42 feet long and 6 feet wide.
10. The needle carries the upper thread down; a loop forms; the hook or shuttle carries the loop around the bobbin; the take-up lever pulls it tight so the threads lock in the middle of the cloth. U.S. Patent No. 4,750, 1846.
11. $25.4 \div 2.5 \approx 10$ stitches per inch. Any three: parent present; unplug before threading or changing the needle; fingers away from the needle; remove pins before the foot; tie back hair; sew slowly.

CRAFTS AND MAKING ≈ TRAIL B: KNITTING AND NEEDLEWORK

The second trail of the Crafts track follows thread from the sheep to the finished heirloom. It begins with wool and the science and history of spinning (Proverbs 31:13, 19), moves through finger knitting and needle knitting to a full garter-stitch scarf, then turns to the needle: the four essential embroidery stitches, the history of the sampler, a cross-stitched verse, and the quilt and the quilting bee. Along the way it reads real primary sources, from Exodus and an inventory of King Edward VI to an 1843 knitting book, a 1917 Red Cross muffler pattern, a child's sampler verse of 1686 and Marie Webster's history of quilts.

This is the ● **Expert** level, for ages 14 and up, at a high-school standard. Each stop takes 35 to 50 minutes of reading and discussion, plus project time that continues between sessions (the scarf and the sampler take several weeks). Students work largely on their own: they read the core ideas, study the picture and the primary source, do the hands-on project, complete the practice problems (including at least two challenge problems), and write a one-paragraph narration that a parent keeps. Every stop stands alone, but Stops B3 and B4 (swatch, then scarf) and B6 and B7 (sampler, then verse) are designed as pairs.

Five stops earn the **Needlework Expert badge, part 1**; all eight stops earn part 2 and the **Trail B certificate**. The optional badge quizzes below check understanding; the badges themselves are earned by doing the stops and finishing the portfolio pieces, not by test scores.

BEFORE YOU BEGIN

- Thread a needle and tie a knot, and work a running stitch and backstitch (Trail A, Stops A2 and A3), or learn them with a parent before Stop B5.
- Work with fractions, decimals, ratios and area, and read a passage of older English (such as the King James Version) with care.

MASTERY CHECKLIST

- ☐ I can explain how wool becomes yarn and why spinning was the bottleneck of cloth-making until the 1760s.
- ☐ I can cast on, knit garter stitch, bind off, measure gauge, and use gauge to plan a project.
- ☐ I can work stem, chain, satin, French knot and cross stitch neatly and say what each is for.
- ☐ I can chart and center a verse on graph paper and read a sampler or quilt as a historical source.
- ☐ I have finished a knitted scarf, a sampler with a cross-stitched verse, and a small hand-quilted piece.

OPTIONAL BOOKS AND RESOURCES

- **Project Gutenberg: needlework classics** (<https://www.gutenberg.org>): Free texts used on this trail: Lambert, *My Knitting Book* (#33502); McCormack, *Spool Knitting* (#22029); *Khaki Knitting Book* (#76611); Huish, *Samplers and Tapestry Embroideries* (#41717); Webster, *Quilts* (#24682); de Dillmont, *Encyclopedia of Needlework* (#20776).
- **Smithsonian National Museum of American History: textiles and Harriet Powers's Bible Quilt** (<https://americanhistory.si.edu>): High-quality images and background for Stops B6 to B8; search the collections for "sampler" and "Bible Quilt."
- **Bayeux Museum: the Bayeux Tapestry online** (<https://www.bayeuxmuseum.com>): The whole embroidery scene by scene, for Stop B5.
- **Victoria and Albert Museum: knitting, samplers and embroidery** (<https://www.vam.ac.uk>): Articles and collection images, including the Jane Bostocke sampler of 1598 and Berlin woolwork.
- **Richard Rutt, *A History of Hand Knitting* (1987) and Anne L. Macdonald, *No Idle Hands* (1988)** (<https://www.worldcat.org>): Two standard histories for older students; look for them at the library or through interlibrary loan.

2.1 WOOL: FROM SHEEP TO YARN

OBJECTIVES

- Trace wool from the sheep's back to plied yarn and explain the fiber science (crimp, scales, micron count) that makes each step work.
- Explain why spinning was the great bottleneck of cloth-making for thousands of years and how the spinning jenny and the mill changed it.
- Read Exodus 35:25-26 and Proverbs 31 as primary sources and explain what they show about spinning in Israel.

Warm-up. Before you read, estimate: how many hours would it take one person, with only a hand spindle, to spin enough yarn for one wool sweater? Write your guess and keep it. At the end of the stop, check it against the numbers in the practice problems.

Video slot. Video coming. Hand spinning wool on a drop spindle and a treadle spinning wheel; sheep shearing and wool processing from fleece to yarn. Search approved channels (Smithsonian, Colonial Williamsburg, a state extension or 4-H channel, the American Sheep Industry Association); preview first.

KEY TERMS

staple

The natural length of a lock of wool fiber. Long-staple wool spins into smooth, strong worsted yarn; short-staple wool spins into soft, fluffy woolen yarn.

micron

One millionth of a meter, the unit used to grade wool fineness. Fine Merino measures roughly 17 to 24 microns across; a human hair is several times thicker.

crimp

The natural waves along a wool fiber. Crimp traps air for warmth and helps fibers grip one another when they are spun.

worsted and woolen

Two ways of preparing wool. Worsted fibers are combed parallel for a smooth, dense yarn; woolen fibers are carded into a light, airy tangle for a lofty, warm yarn.

ply

One spun strand in a yarn; also the act of twisting strands together in the direction opposite to their spin so the yarn is balanced.

spinning jenny

A hand-powered spinning machine invented by James Hargreaves in England in the 1760s; the first jenny worked eight spindles at once.

CORE IDEAS

Wool is one of the oldest fibers people have used for clothing, and Scripture assumes its importance from the first pages: Abel was “a keeper of sheep,” and the law of Moses speaks of shearing, wool and linen again and again. A sheep grows a new fleece each year. Most modern breeds do not shed, so they must be shorn; an American fleece averages roughly 7 to 8 pounds raw, and fine-wool breeds such as the Merino and Rambouillet give more. That raw weight is misleading, though. A greasy fleece carries lanolin, sweat salts (called suint), dirt and plant matter, and washing (scouring) commonly removes a third to half of it. The percentage that remains is called the **yield**, and wool buyers pay by clean weight, not raw.

Why can loose fluff become a strong thread? The answer lies in the fiber itself. Under a microscope a wool fiber is covered with tiny overlapping scales, and it bends in a natural wave called **crimp**. Fine wool has more crimp per inch than coarse wool. When fibers are twisted together, scales and crimp catch on their neighbors, so twist turns friction into strength. Fineness is graded in **microns**: fine Merino may measure 17 to 24 microns, while carpet wools can be 35 or more. The finer the fiber, the softer it feels against the skin, which is why fine wool has long brought the highest prices.

The **staple**, or lock length, decides how wool is prepared. Short, crimpy wool is carded with toothed cards into a loose, airy roll and spun **woolen**, giving a soft, warm, fuzzy yarn. Long wool is combed so every fiber lies parallel and the short bits are removed, then spun **worsted**, giving a smooth, hard-wearing yarn for suits and fine fabric. (The name comes from Worstead, a village in Norfolk, England, once famous for this cloth.) A single spun strand has twist in one direction and wants to kink, so spinners **ply** two or more singles together the opposite way, and the twists balance.

For most of history spinning was the slowest step in all of cloth-making. Weaving a yard of cloth goes fairly quickly once a loom is threaded, but every inch of that cloth must first be spun by hand, thread by thread. Historians commonly estimate that several spinners were needed to keep one weaver busy. This is why spindles and distaffs appear in nearly every ancient household, and why the woman of Proverbs 31 is pictured with her hands on them. When Moses asked for materials for the tabernacle, Exodus records that the skilled women of Israel spun blue, purple, scarlet and fine linen, and some spun goats’ hair, which went into the eleven curtains of goats’ hair that covered the tabernacle (Exodus 26:7).

The spinning wheel, probably first developed in Asia, was in use in Europe by the 1200s. It sped up spinning considerably, and by the 1500s wheels with a flyer and a foot treadle could twist and wind at the same time, leaving both hands free to draft the fiber. Wool also built fortunes. Medieval England grew rich exporting raw wool to the weavers of Flanders, and to this day the Lord Speaker of the House of Lords sits on a cushion called the Woolsack, a reminder of where the kingdom’s wealth once came from.

Then came the great change. In the 1760s James Hargreaves built the **spinning jenny**, which let one worker turn eight spindles at once, and later models ran many more. Richard Arkwright’s water frame (patented 1769) put spinning in water-powered mills, and Samuel

Crompton's mule (1779) combined the two ideas. Within a lifetime, the bottleneck that had limited clothing for thousands of years was broken. Cloth became cheaper and far more plentiful, and work moved from cottages into factories, with real gains in comfort and real hardships for families whose hand spinning was no longer needed. Both sides of that story are true and worth weighing.

Today Australia, China and New Zealand are among the largest wool producers, and machines do in seconds what took our ancestors hours. Yet the steps are the same ones Bezalel's helpers knew: shear, skirt, scour, card or comb, spin, ply. When you knit or stitch with wool on this trail, you are using a fiber God designed with built-in warmth, spring and grip, prepared by skill that took human beings thousands of years to perfect.

PICTURE STUDY



The Spinners, or The Fable of Arachne (Las Hilanderas), Diego Velázquez, c. 1655–1660 · Oil on canvas ·
Museo del Prado, Madrid
Wikimedia Commons · Public domain

Velázquez, court painter to Philip IV of Spain, painted a working tapestry shop, probably the royal workshop of Santa Isabel in Madrid. For an Expert, the painting is also a lesson in the economics of cloth: in the dark front room, workers do the slow, necessary labor of spinning and winding; in the bright room behind, the finished luxury product is displayed. The back scene also tells the old Greek fable of Arachne, the weaver who boasted of her skill. Art historians still debate how the two halves fit together, and strips were added to the canvas by a later hand, which changes how the picture is framed.

Look closely

- Trace the steps of wool processing you can see: loose wool, spinning, winding into balls. Which step from the stop is missing from the room?

- Study the spinning wheel. Why might a painter in the 1650s have chosen to blur the spokes rather than paint each one?
- Compare the light in the front room and the back room. Where does Velázquez put the brightest light, and on whom?

Talk about it

1. Using what you learned about spinning as a bottleneck, explain why a tapestry workshop needed so many spinners in the foreground for one tapestry on the wall.
2. Velázquez placed laborers in front and wealthy visitors in the back. Write two or three sentences on what the arrangement might be saying about skill and work, without claiming more than the picture shows.

Safety first. Wire carders and dog slicker brushes have sharp teeth: brush away from your hands and keep fingers off the teeth. Use hot tap water, not a boiling pot, to wash raw wool, and never agitate it in hot water (it will felt). Raw fleece can carry dirt and bacteria: wash your hands after handling it, and keep it away from your face.

HANDS-ON: FIBER LAB: TEST, SPIN AND MEASURE

You will work like a wool grader and a spinner. You will test fibers, spin a short length of yarn on a handmade spindle, ply it, and measure your own spinning speed so you can check the claim that spinning was the bottleneck of cloth-making. Then you will compare your results with Exodus 35:25-26 (in the Primary source box).

You will need

- About 1 ounce of washed wool roving (craft store, yarn shop or a 4-H sheep family), plus a cotton ball and a scrap of acrylic yarn for comparison
- A pencil or ¼-inch dowel and an old CD or a 3- to 4-inch wooden toy wheel for a spindle whorl
- A magnifying glass or a phone camera on zoom
- A kitchen scale (grams), a tape measure and a timer
- A notebook

Steps

1. **Fiber test.** Pull a single fiber from the wool, the cotton and the acrylic. Under magnification, sketch each. Gently stretch each and let go: which springs back? Record your observations in a three-column table.
2. **Make the spindle.** Push the pencil through the whorl so it sits about a quarter of the way from the top. Tie an 18-inch leader of yarn just above the whorl, wrap it around the shaft twice, and take a half hitch at the top.
3. **Spin.** Overlap the leader's end with a few wool fibers. Twirl the spindle clockwise and let it hang. Pinch above the twist with one hand and draft (draw out) fibers with the other, letting the twist climb into them. Wind each finished arm's length onto the shaft.

4. **Time yourself.** Spin for exactly 15 minutes. Unwind and measure your yarn in yards. Calculate your rate in yards per hour.
5. **Ply.** Fold your single in half and let it twist back on itself (or wind it into two balls and spin them together counterclockwise). Note how the kinks disappear.
6. **Calculate.** A plain adult sweater takes roughly 1,200 yards of worsted-weight yarn. Using your rate, how many hours would you need to spin it (doubled for plying)? Compare with your warm-up guess.
7. **Read the source.** Read Exodus 35:25-26. Write two sentences on what it shows about skill and willing work, using your own spinning experience as evidence.

Check your work

- My fiber table compares wool, cotton and acrylic in at least three ways.
- I spun and plied at least one yard of yarn on a spindle I made.
- I calculated my spinning rate and the hours for a sweater, showing my work.
- I connected my results to the Exodus passage in two careful sentences.

FIELD NOTEBOOK

1. **Diagram: one fiber, magnified.** Draw a wool fiber 6 inches long across the page. Label the scales, the crimp, and a micron scale bar. Beside it draw a cotton fiber (a flat, twisted ribbon) for comparison.
2. **Flow chart with numbers.** Shear → skirt → scour → card or comb → spin → ply. Under each step write one number from the stop (for example, the yield of a fleece, or the eight spindles of the first jenny).
3. **Narration.** In one well-built paragraph, explain why spinning, not weaving, was the slowest step in making cloth before the 1760s, and what changed afterward. Use at least two numbers or dates. A parent keeps this page.

Did you know? The word *spinster* once meant simply “a woman who spins,” and it was used in English legal records as a job title. The Merino sheep was so valuable to Spain that for centuries the crown restricted the export of live Merinos; by the late 1700s and early 1800s flocks finally reached other countries, and the breed later became the backbone of Australia’s wool industry. A single pound of fine wool can be spun into many miles of very fine yarn.

Primary source. *Exodus 35:25-26, King James Version (1611). The people of Israel bring gifts and skill for the tabernacle.*

And all the women that were wise hearted did spin with their hands, and brought that which they had spun, both of blue, and of purple, and of scarlet, and of fine linen. And all the women whose heart stirred them up in wisdom spun goats’ hair.

Notice two phrases: “wise hearted” and “whose heart stirred them up.” Scripture treats spinning skill as wisdom given by God and offered willingly. Use this passage in Step 7 of the

project.

Go deeper. Elizabeth Wayland Barber, *Women's Work: The First 20,000 Years* (1994), a readable history of spinning and weaving in the ancient world (parents may preview). Deborah Robson and Carol Ekarius, *The Fleece and Fiber Sourcebook* (2011), a reference to more than 200 sheep breeds and their wool. Online: the Museo del Prado's page on *The Fable of Arachne*. Second video topic: "Arkwright's water frame and Cromford Mill."

Goes deeper in. Gardening & Animals, "Sheep and Goats"; History, "The Industrial Revolution"; Small Business & Economics, "Bottlenecks and Productivity" (coming soon).

For families. Sources: American Sheep Industry Association (fleece weights); Encyclopaedia Britannica on wool, the spinning wheel and the spinning jenny; Museo del Prado catalog. Fleece weight and yield vary widely by breed and flock, so the stop gives ranges. The date of the jenny is given as "the 1760s" because sources differ (about 1764 to 1765 for its invention; patented 1770). The number of spinners per weaver is a historians' estimate that varied by fiber and period; the stop says "several." The spinning-wheel origin is uncertain (India and China are both proposed). The Exodus text is quoted from the KJV. Spinning one sweater's worth of yarn takes a beginner many hours; let the numbers make the point rather than pushing a child to finish.

PRACTICE

1. **EASY** Name the two features of a wool fiber that help it hold together when spun, and say what each does.
2. **EASY** What is the difference between woolen and worsted yarn?
3. **MEDIUM** A raw fleece weighs 9 pounds. Its yield is 55 percent. How many pounds of clean wool are left, and how much weight was washed away?
4. **MEDIUM** A fine Merino fiber is 18 microns across and a human hair is about 72 microns. How many times thicker is the hair? Why does fineness matter to a buyer?
5. **CHALLENGE** Suppose a skilled hand spinner with a spindle produces 120 yards of single yarn per hour. A sweater needs 1,200 yards of two-ply yarn. Ignoring plying time, how many hours of spinning does the sweater take? If she spins 5 hours a day around her other work, how many days is that?
6. **CHALLENGE** The first spinning jenny turned 8 spindles at once. If one jenny worker spins at the same rate per spindle as the spinner in problem 5, how long would the 2,400 yards take? Then name one benefit and one hardship that came with machines like this.

Make it a game • Bottleneck Relay. Set up four stations in a line: Card (fluff a cotton ball), Spin (twist it into a 6-inch strand), Ply (twist two strands together) and Weave (lace the plied strand through a slotted paper "loom"). Run it once with one player per station and time it. Where does the line back up? Then add a second and third spinner and run it again. Discuss how many spinners one weaver needs, and what a spinning jenny would do to the line.

Scripture. “She seeketh wool, and flax, and worketh willingly with her hands. ... She layeth her hands to the spindle, and her hands hold the distaff.” (Proverbs 31:13, 19, KJV)

In a world where every thread was spun by hand, the virtuous woman of Proverbs 31 is praised for diligence in this slow, essential work. She “seeketh” her materials and works “willingly.” Skill joined to a willing heart is the same pairing Exodus 35 honors in the tabernacle spinners, and it is the pattern for every craft on this trail.

Practice: answers

1. Scales, which catch on neighboring fibers like shingles, and crimp, the natural wave that makes fibers grip and traps air for warmth.
2. Woolen yarn is spun from carded, short-staple wool with fibers going every direction, so it is soft, airy and warm. Worsted yarn is spun from combed, long-staple wool with fibers parallel, so it is smooth, dense and hard-wearing.
3. $0.55 \times 9 = 4.95$ pounds of clean wool; $9 - 4.95 = 4.05$ pounds of grease, dirt and plant matter washed away.
4. $72 \div 18 = 4$, so the hair is about 4 times thicker. Finer fibers feel softer against the skin and can be spun into finer, lighter cloth, so they bring higher prices.
5. Two-ply means $2 \times 1,200 = 2,400$ yards of singles. $2,400 \div 120 = 20$ hours of spinning. At 5 hours a day, $20 \div 5 = 4$ days, before any plying, knitting or weaving. This shows why spinning was the bottleneck.
6. $8 \times 120 = 960$ yards per hour; $2,400 \div 960 = 2.5$ hours, eight times faster. Benefit: cloth became much cheaper and more plentiful, so ordinary families could own more clothing and bedding. Hardship: many cottage spinners lost income, and work moved into mills with long hours, including for children. (Any reasonable pair, explained.)

2.2 FINGER KNITTING: THE LOOP THAT MAKES A FABRIC

OBJECTIVES

- Explain how a knitted fabric is built from one continuous strand of interlocking loops, and how that differs from weaving and from nålebinding.
- Finger-knit a two-loop cord and measure its yarn-to-length ratio, comparing it with a 1909 spool-knitting manual.
- Test whether three cords braided together are stronger than one, and connect the result to Ecclesiastes 4:12.

Warm-up. Find a knitted T-shirt or sock and a woven dish towel or a pair of jeans. Stretch each sideways and on the diagonal. Which stretches more? Pull a loose thread at a cut edge of each. What happens? Write down two differences before you read.

Video slot. Video coming. Finger knitting a cord with two or four fingers; spool knitting (French knitting) on a peg knitter; lucet cord. Search approved channels (a library or museum craft channel, a 4-H channel, Homeschool Pop (Alternate)); preview first.

KEY TERMS

loop (stitch)

The basic unit of knitting: a bend of yarn pulled through another bend of yarn. Every knitted fabric is rows or rounds of loops caught in one another.

weft knitting

Knitting in which one continuous strand runs across the work, making each row or round of loops in turn; hand knitting, finger knitting and spool knitting are all weft knitting.

spool knitting

Knitting a narrow tube on a short wooden cylinder with pegs or nails around its hole; also called French knitting or peg knitting.

nålebinding

An old looped craft, older than true knitting, in which short lengths of yarn are passed through earlier loops with a single eyed needle (say “NOLL-eh-bin-ding”).

gauge

How many stitches and rows fit in a set measure, such as an inch; in cords, how much yarn is used per inch of finished work.

CORE IDEAS

There are two great ways to turn yarn into fabric. **Weaving** crosses two sets of threads at right angles: the warp held tight on a loom, and the weft passed over and under it. **Knitting** uses a single strand and builds the fabric from loops pulled through loops. That one difference explains almost everything about how the fabrics behave. Woven cloth is firm and

stretches mainly on the diagonal. Knitted fabric stretches in every direction, because each loop can change shape, and it clings and recovers, which is why socks, sweaters and T-shirts are knitted. It also explains knitting's weakness: because the fabric is one continuous strand, a dropped loop can run, and pulling the free end can unravel the whole piece.

Finger knitting is the simplest way to see the structure. You wrap yarn around one, two or four fingers, lay a second strand above the first loops, and lift each lower loop up and over the top strand and off the finger. Each lifted loop becomes a stitch held by the new one. With two fingers you make a narrow cord; with four you make a flat-backed strip. No tools are needed, so the craft can be taught to a five-year-old, yet it uses exactly the same "loop over loop" motion that hand-knitting needles and modern knitting machines perform.

The same motion on pegs is **spool knitting**. A knitter drives two to four pins or nails into the end of a spool or wooden cylinder, winds the yarn around them, and lifts each lower loop over the upper one, letting the finished tube drop through the hole. Spool knitting was a familiar children's handicraft in Europe and America in the 1800s and early 1900s. In 1909 the New York publisher A. S. Barnes issued *Spool Knitting* by Mary A. McCormack, a manual for children and their teachers, with directions for reins, mats, bags, caps and doll clothes. Teachers of that era valued such work for training the hands, patience and orderly thinking, not merely for amusement.

Looped fabrics are older than knitting with needles. Archaeologists have found socks and other pieces from Roman-era and early medieval Egypt made by **nålebinding**, in which the worker sews short lengths of yarn through earlier loops with one eyed needle. Nålebinding looks a little like knitting, but it cannot unravel from a pulled end, because each length is sewn through. True knitting, with a continuous strand and two or more needles, appears later; some of the oldest known pieces are finely patterned cotton socks from Egypt, generally dated to roughly A.D. 1000 to 1300.

Knitting is also hungry for yarn. Because every stitch is a loop doubled back on itself, a knitted cord or fabric uses far more yarn than its finished length. McCormack gives a precise figure: on a two-post knitter, seven yards of yarn make one yard of web, a ratio of 7 to 1. That ratio is a **gauge**, and knitters and manufacturers must know it to buy enough material and to price their work. You will measure your own ratio in the project, and you will find that tension (how tightly you work) changes it.

Finally, a single cord is useful, but cords combined are stronger and more useful still. Sailors, weavers and harness makers have long braided or plied three strands together to spread a load, so that one weak spot does not break the whole. The writer of Ecclesiastes noticed the same thing three thousand years ago and turned it into a picture of friendship: "a threefold cord is not quickly broken." In this stop you will test that claim with your own hands and a kitchen scale.

PICTURE STUDY



Girl Knitting (Strickendes Mädchen), Albert Anker, 1888 · Oil painting · Private collection (sold at Koller Auctions, Zürich, 2009)

Wikimedia Commons · Public domain

Albert Anker (1831–1910) was a Swiss painter who spent most of his life in the village of Ins, near Bern. He painted village children again and again: reading, writing on slates, peeling potatoes, and knitting. Anker had first studied theology before turning to art, and his paintings show ordinary work with quiet respect. He painted knitting girls many times, which tells us how common the skill was for children of his day.

Look closely

- Look at the girl's hands. Which hand seems to be doing the work, and which holds the work steady?
- Find the strand of yarn. Where does it come from, and where does it go?
- What has Anker left plain or dark so that your eye goes to the hands and face?

Talk about it

1. Anker painted children working, not playing. What does that choice suggest about how he and his neighbors thought about children and useful work?
2. Compare the girl's focus with how you felt while finger knitting. What does a craft like this train in a person besides skill of hand?

Safety first. Keep the yarn loose on your fingers; if a fingertip turns red or tingles, slip the loops off and start again more loosely. Never put a cord around your neck or a younger child's neck, and keep long cords away from babies and toddlers. Use small, round-tipped scissors.

HANDS-ON: MEASURE IT, BRAID IT, TEST IT

You will finger-knit three cords, measure how much yarn each one uses per inch, compare your results with Mary McCormack's 1909 figure (in the Primary source box), braid the cords together, and run a simple strength test.

You will need

- A ball of worsted-weight or bulky yarn (wool or acrylic), in one or three colors
- A tape measure and scissors
- A kitchen scale and a sturdy plastic grocery bag
- Cans or water bottles to use as weights
- A notebook with a data table

Steps

1. **Measure first.** Measure out exactly 5 yards (180 inches) of yarn and mark the end with a small knot of scrap yarn.
2. **Cast on.** Hold the yarn tail between your thumb and palm. Weave the yarn around your index and middle fingers in a figure eight, then lay one more strand across the front of both fingers above the loops.
3. **Knit.** On each finger, lift the lower loop up and over the top strand and off the back of the finger. Lay a new strand across the front and repeat. Gently tug the tail every few rows so the cord comes down the back of your hand.
4. **Measure your gauge.** Knit until you reach the scrap-yarn marker. Lay the cord flat without stretching and measure it. Compute your ratio: $180 \text{ inches} \div \text{cord length}$. Compare it with McCormack's 7 to 1.
5. **Bind off.** Lift the loop from one finger onto the other, lift the lower loop over it, then cut the yarn and pull the end through the last loop.
6. **Make two more cords** the same length (try one tighter and one looser and record the ratios).
7. **Test strength.** Tie one cord to the bag handle and lift weights in the bag one can at a time until the cord stretches badly or a stitch fails; record the weight. Then braid the three cords, tie the braid to the bag, and test again. (Stop before anything breaks if you want to keep your braid.)

Check your work

- My table shows the yarn used, cord length and ratio for all three cords.
- I compared my ratios with McCormack's 7-to-1 figure and explained the difference using tension.
- I tested one cord against a braid of three and recorded both results.
- My finished braid is even and the ends are secured.

FIELD NOTEBOOK

1. **Structure diagram.** Draw three panels side by side: woven cloth (warp and weft crossing), knitted fabric (loops pulled through loops), and a single finger-knit cord in close-up. Label the warp, weft, loop and running strand.
2. **Data page.** Copy your three-cord table and draw a bar graph of the ratios. Write one sentence explaining why the tightest cord has the ratio it does.
3. **Narration.** Write one paragraph explaining to someone who has never knitted why a knitted sock stretches and can unravel while a woven towel does not. Use the words *loop*, *strand* and *warp*. A parent keeps this page.

Did you know? In parts of Britain a spool knitter has been nicknamed a “knitting Nancy,” and in other places the craft is called “corking” or “French knitting.” A *lucet*, a small two-pronged fork, makes a square, firm cord with a similar lift-the-loop motion; lucets were used in Europe for centuries to make laces for clothing. Today’s circular knitting machines that make T-shirt fabric still work on the same principle as a spool knitter: hooked needles arranged in a ring, each pulling a new loop through an old one.

Primary source. Mary A. McCormack, *Spool Knitting* (New York: A. S. Barnes, 1909), *directions for the round web on a two-post knitter*. Project Gutenberg eBook #22029.

Drop worsted through the hole in the center of the knitter and draw it out at the other end, three inches. This end is used to draw the work through the knitter. Carry the worsted leading from the ball, around the post to the right, across the center of the hole in the knitter and around the post to the left; then back across the center to the post at the right, thus making two stitches on this post. Lift the lower or first stitch with a large pin or knitting needle, carry it over the second stitch and drop it over the post; then across the center to the post at the left and repeat. So continue until the desired length is obtained. It will require seven yards of yarn to make one yard of web on the two-post knitter.

Compare McCormack’s two posts with your two fingers. Use her last sentence in Step 4 of the project and in practice problems 4 and 6.

Go deeper. Mary A. McCormack, *Spool Knitting* (1909), free at Project Gutenberg, with dozens of projects. Richard Rutt, *A History of Hand Knitting* (1987), the standard history, including early Egyptian knitting and nålebinding (a library book for older readers). Online: the Victoria and Albert Museum’s pages on the history of knitting. Second video topic: “How a circular knitting machine makes T-shirt fabric.”

Goes deeper in. Arithmetic, “Ratios and Rates”; Art, “Line, Pattern and Texture” (coming soon).

For families. Sources: McCormack, *Spool Knitting* (1909), quoted from Project Gutenberg; Rutt, *A History of Hand Knitting*; Victoria and Albert Museum. Dates for the

earliest true knitting are debated; the stop gives the Egyptian socks a range of about A.D. 1000 to 1300, as most museum sources do. The braid test is informal: results depend on the knots and the yarn, and a knot is often the weakest point in either test. Let the student notice and explain this rather than expecting an exact factor of three. Picture: Albert Anker, *Strickendes Mädchen*, 1888 (auction record, Koller, Zürich); details of the support are not confirmed, so the medium is given simply as an oil painting.

PRACTICE

1. **EASY** In one sentence each, describe how woven fabric and knitted fabric are built.
2. **EASY** Why can a knitted piece unravel when you pull its end, while nålebinding cannot?
3. **MEDIUM** Why are socks and T-shirts usually knitted rather than woven?
4. **MEDIUM** Using McCormack's figure (7 yards of yarn per yard of web), how much yarn is needed for a 3-foot jump-rope handle cord and for a 54-inch belt?
5. **CHALLENGE** Your finger-knit cord used 180 inches of yarn and came out 30 inches long. What is your ratio? Is your cord looser or tighter than McCormack's, and why might that be?
6. **CHALLENGE** A crafter wants to sell 20 spool-knit bag handles, each 18 inches long, using McCormack's 7-to-1 ratio. A skein holds 200 yards and costs \$6. How many skeins must the crafter buy, and what is the yarn cost per handle? (Any real selling needs a parent's sign-off.)

Make it a game • Human Spool. Four players stand in a small circle as the "posts," each holding up one hand. A fifth player, the knitter, walks a long strip of crepe paper or a jump rope around the posts, laying a loop on each hand, then a second round above it. On the call "Lift!" each post passes its lower loop over the upper one and lets it drop toward the center. After six rounds, look at the "tube" forming in the middle. Then pull the free end gently and watch it unravel: proof that knitting is one continuous strand.

Scripture. "And if one prevail against him, two shall withstand him; and a threefold cord is not quickly broken." (Ecclesiastes 4:12, KJV)

The Preacher has just said that "two are better than one" (4:9). A single strand can snap at its weakest point, but three strands share the load. Your braid test is a small, measurable picture of a spiritual truth: God made us to stand together, in families, friendships and the church, not alone.

Practice: answers

1. Woven fabric is made of two sets of threads, warp and weft, crossing over and under at right angles. Knitted fabric is made from one continuous strand formed into loops pulled through other loops.
2. Knitting is one continuous strand of loops, so freeing the last loop lets each loop pull out of the one before. In nålebinding each short length is sewn through earlier loops, so the loops are locked and cannot pull free.

3. Knitted loops can change shape, so the fabric stretches in every direction and springs back. It fits around feet and bodies comfortably and moves with them; woven cloth stretches mainly on the diagonal.
4. 3 feet is 1 yard, so 7 yards. 54 inches is 1.5 yards, so $1.5 \times 7 = 10.5$ yards.
5. $180 \div 30 = 6$, a ratio of 6 to 1. It uses less yarn per inch than McCormack's 7 to 1, so the loops are larger and looser (or the fingers are thicker than her posts), which stretches more length out of each loop.
6. Each handle: 18 inches = 0.5 yard $\times 7 = 3.5$ yards. Twenty handles: $20 \times 3.5 = 70$ yards, so 1 skein is enough. Cost per handle: $\$6 \div 20 = \0.30 if the whole skein is counted, or about $\$0.11$ if only the yarn actually used is counted ($3.5 \div 200 \times \$6 = \0.105). Either answer with clear reasoning is correct; Trail D discusses which method to use.

2.3 CASTING ON AND THE KNIT STITCH

OBJECTIVES

- Cast on with the long-tail method, work the knit stitch in garter stitch, and bind off a finished swatch.
- Measure gauge (stitches and ridges per inch) and use it to plan the width of a project.
- Trace knitting from medieval Spain and the Knitting Madonna to Elizabethan England's caps and stocking frame, reading an 1843 knitting book as a primary source.

Warm-up. Hold two pencils as if they were knitting needles. Now look at a hand-knitted or machine-knitted scarf, hat or sweater. Can you find the little V shapes (on the smooth side) or the bumpy ridges (on the other)? Each V or bump is one stitch. Count how many stitches make one inch.

Video slot. Video coming. Long-tail cast-on, the knit stitch (English and Continental styles), garter stitch, and binding off for beginners. Search approved channels (a public-library craft channel, a 4-H or state extension channel, the Victoria and Albert Museum); preview first.

KEY TERMS

cast on

To make the first row of loops on a needle, the foundation every other row is built on. Common methods include the long-tail, knitted, cable and backward-loop cast-ons.

knit stitch

The basic stitch: the right needle enters a loop from front to back, catches the yarn, pulls a new loop through, and slips the old loop off.

garter stitch

Fabric made by knitting every row. It forms horizontal ridges (two rows make one ridge), lies flat and does not curl.

gauge

The number of stitches and rows in a set measure, usually 4 inches or 10 centimeters. Gauge decides how big a finished piece will be.

bind off (cast off)

To finish the work by knitting two stitches and lifting the first over the second, again and again, so the loops cannot unravel.

stocking frame

A knitting machine invented by William Lee in England in 1589, which used a row of hooked needles to knit a whole row of stitches at once.

CORE IDEAS

Knitting with needles is younger than spinning or weaving, but it has a long and well-documented history. Some of the earliest securely dated European pieces are silk cushion covers knitted with fine patterns and found in the royal tombs of the monastery of Las Huelgas in Burgos, Spain, buried with a prince who died in 1275. By the late 1300s and early 1400s, painters in Italy and Germany showed the Virgin Mary knitting. The clearest is a panel of the Buxtehude Altar by Master Bertram of Hamburg, painted around 1400, in which Mary knits a small garment in the round on four double-pointed needles, exactly as sock and sweater knitters still do.

In the 1500s knitting became an industry. In England, knitted woolen caps were made in such numbers that Parliament in 1571 passed a law requiring most people over six years old to wear a woolen cap of English make on Sundays and holy days, to protect the cappers' trade (nobles and some others were exempt). Hand-knitted stockings were prized, and in 1589 William Lee, a clergyman of Calverton in Nottinghamshire, invented the **stocking frame**, a machine that knitted a whole row of loops at once. Queen Elizabeth I reportedly refused him a patent, worried that it would put hand knitters out of work. Lee's frame nevertheless became the ancestor of every knitting machine in the world.

Every piece of knitting begins with a **cast-on**, a first row of loops on the needle. The **long-tail cast-on** is the most popular general-purpose method because it is firm yet stretchy and makes the first row at the same time. It uses two strands at once: the yarn tail, measured out before you begin, and the yarn from the ball. A common rule of thumb is to leave about one inch of tail for each stitch in worsted-weight yarn, or a tail about three to four times the width of the finished piece. A **backward-loop** (thumb) cast-on is easier to learn but loose and uneven, which is why the stop teaches the long-tail.

The **knit stitch** has four motions, which knitters teach with a rhyme: in through the front door, around the back, out through the window, and off jumps Jack. Insert the right needle into the first loop from front to back; wrap the yarn around the right needle counterclockwise; pull the new loop through; slip the old loop off the left needle. Knit every stitch of every row and you get **garter stitch**, a ridged fabric that lies flat. Two rows make one ridge, so counting ridges is the quickest way to count rows. Knitters who carry the yarn in the right hand and "throw" it are said to knit English style; those who carry it in the left hand and "pick" it knit Continental style. Both make identical stitches.

Needles and yarn together set the **gauge**. Worsted-weight yarn on US size 8 (5 millimeter) needles in garter stitch commonly gives about 4 to 5 stitches per inch. Older British needle sizes ran the opposite way from American sizes, with larger numbers for thinner needles (an old British No. 8 is about 4 millimeters, which is a US 6), so careful knitters today check the millimeter size. To plan a piece, multiply the width you want by your stitches per inch. A 7-inch-wide scarf at 4.5 stitches per inch needs 31.5 stitches, so you would cast on 31 or 32. Small differences add up: half a stitch per inch over 40 stitches changes the width by more than an inch.

The final step is the **bind-off**. Knit two stitches, then lift the first over the second and off the needle; knit one more and lift again, until one loop remains. Cut the yarn and pull the end through. Miss Lambert's *My Knitting Book* of 1843 defined it in a single sentence that is still accurate (see the Primary source box). Lambert wrote for readers who already knew the basic motions, which reminds us that for centuries knitting was learned at a parent's or teacher's side, not from books.

Paul prayed for the Colossians that their hearts might be "knit together in love." The picture is apt. A single loop of yarn holds nothing; it becomes strong only when it is caught by the loop above and catches the loop below. A swatch of garter stitch is a small, honest lesson in that kind of connection.

PICTURE STUDY



The Visit of the Angels (the "Knitting Madonna"), from the Buxtehude Altar, Master Bertram (Bertram von Minden), c. 1400 · Tempera on oak panel · Hamburger Kunsthalle, Hamburg, Germany
Wikimedia Commons · Public domain

Master Bertram ran a busy workshop in Hamburg in the late 1300s and early 1400s. The Buxtehude Altar, painted for a convent at Buxtehude near Hamburg, has many small scenes from the life of Mary. In this one she is knitting in the round on four double-pointed needles. Many viewers have connected the seamless garment with the seamless coat of Christ described in John 19:23, for which the soldiers cast lots. Angels approach bearing the instruments of the Passion, and the young Jesus turns to look at them. The painter places an ordinary household task beside a foreshadowing of the Cross.

Look closely

- Count the needles. How do you know Mary is knitting in the round and not flat?
- Follow the yarn to the needles. Where does it come from, and which needle is working?

- Find the angels. What are they carrying, and why is that surprising in a peaceful domestic scene?

Talk about it

1. Why is this painting valuable to historians of knitting as well as to historians of art? What does it prove about knitting around 1400?
2. Explain the connection many viewers draw between the garment Mary knits and John 19:23. Then read that verse in your own Bible and say whether you think the connection is likely.

Safety first. Knitting needles have points: carry them point-down, store them in a case or with point protectors, and never leave them on a chair or the floor. Bamboo or wooden needles are less slippery for beginners.

HANDS-ON: A GAUGE SWATCH WITH A LESSON FROM 1843

Every serious knitter knits a swatch before starting a project. You will cast on, knit a garter-stitch square, bind off, measure your gauge, and use it to plan the scarf for Stop B4. Along the way you will test Miss Lambert's 1843 definitions against your own hands.

You will need

- One skein of smooth, light-colored worsted-weight wool or acrylic yarn (light colors show stitches clearly)
- A pair of US size 8 (5 mm) straight needles, wooden or bamboo
- Scissors, a tape measure and a tapestry needle
- A ruler and a few straight pins

Steps

1. **Measure the tail.** For 20 stitches, pull out about 20 inches of yarn and make a slipknot there. Put it on one needle.
2. **Long-tail cast-on.** Hold the needle in your right hand. Drape the tail over your left thumb and the ball yarn over your left index finger, holding both strands in your palm (a "slingshot"). Go up through the thumb loop, over and around the index-finger strand, back down through the thumb loop, drop the thumb loop and snug the stitch. Repeat until you have 20 stitches.
3. **Knit.** Move the full needle to your left hand. Knit every stitch using the four motions: in, around, through, off. At the end of each row, count: you should still have 20 stitches.
4. **Knit 30 rows** (15 ridges), or until the piece is roughly square. Practice fixing a dropped stitch with a crochet hook or the needle tip if you need to.
5. **Bind off** by following Miss Lambert's 1843 definition word for word (Primary source box). Weave the ends in with the tapestry needle.
6. **Measure gauge.** Lay the swatch flat without stretching. Pin across 4 inches and count the stitches inside the pins; divide by 4. Count the ridges in 4 inches; double for rows

and divide by 4.

7. **Plan the scarf.** Choose a width for your Stop B4 scarf (6 to 8 inches) and compute how many stitches to cast on. Write the plan in your notebook.

Check your work

- My cast-on edge is even and stretchy, and I kept the same stitch count every row.
- I bound off by following Lambert's definition and wove in both ends.
- I recorded my gauge in stitches per inch and rows per inch.
- I calculated the cast-on number for my scarf and showed the math.

FIELD NOTEBOOK

1. **Four-panel diagram: the knit stitch.** Draw two needles and a loop in each of the four positions (in, around, through, off). Use arrows and label which needle is which.
2. **Timeline.** Draw a line from 1200 to 1600 and place: the Las Huelgas cushions (buried 1275), the Knitting Madonna (c. 1400), England's cap law (1571) and William Lee's stocking frame (1589).
3. **Narration.** In one paragraph, explain why a knitter swatches and measures gauge before beginning a project, using your own swatch's numbers. A parent keeps this page.

Did you know? William Lee's first frame is said to have made coarse wool stockings, and he later improved it for fine silk. When he could not win support in England, he took his frames to France around 1610 and died there; his brother eventually brought the trade back to England, and the Nottingham area became the center of frame knitting. The Worshipful Company of Framework Knitters received its charter in 1657. Hand knitting never disappeared: in the Shetland Islands, Wales and the Yorkshire Dales, whole families knitted stockings and sold them for cash income into the 1800s.

Primary source. *Miss Lambert, My Knitting Book (London: John Murray, 1843), from the Preface and the explanation of terms. Project Gutenberg eBook #33502. ("Cotton" here means the working thread; Lambert's patterns were often worked in cotton.)*

The examples of knitting, contained in the following pages, have been selected with the greatest care,—many are original,—and the whole are so arranged as to render them comprehensible even to a novice in the art.

To cast on.—The first interlacement of the cotton on the needle.

To cast off.—To knit two stitches, and to pass the first over the second, and so on to the last stitch, which is to be secured by drawing the thread through.

A plain row.—That composed of simple knitting.

Use the “To cast off” definition in Step 5 of the project, and compare Lambert’s wording with the modern definition in practice problem 6.

Go deeper. Richard Rutt, *A History of Hand Knitting* (1987). Elizabeth Zimmermann, *Knitting Without Tears* (1971), a witty, practical classic that teaches knitters to think for themselves. Miss Lambert, *My Knitting Book* (1843), free at Project Gutenberg. Online: the Hamburger Kunsthalle’s collection page for the Buxtehude Altar. Second video topic: “William Lee’s stocking frame” (museum demonstrations exist).

Goes deeper in. History, “Tudor England and Elizabeth I”; Art, “Medieval Altarpieces”; Arithmetic, “Measurement and Rates” (coming soon).

For families. Sources: Rutt, *A History of Hand Knitting*; Victoria and Albert Museum; Hamburger Kunsthalle (Buxtehude Altar dated about 1400 to 1410); Lambert quoted exactly from Project Gutenberg. The Las Huelgas pieces are associated with Prince Fernando de la Cerda (died 1275); dating knitted textiles is difficult, and specialists debate some attributions. The 1571 cap law (13 Elizabeth c. 19) is real; its exemptions were broad. The story that Elizabeth I refused Lee a patent for fear of unemployment is traditional and widely repeated, so the stop says “reportedly.” Gauge figures are typical, not exact; every knitter’s tension differs, which is the point of the swatch.

PRACTICE

1. **EASY** List the four motions of the knit stitch in order.
2. **EASY** Your garter-stitch swatch has 18 ridges. How many rows did you knit?
3. **MEDIUM** Your gauge is 18 stitches in 4 inches. How many stitches per inch is that, and how many should you cast on for a 7-inch-wide scarf?
4. **MEDIUM** Why did England pass the cap law of 1571, and what does it show about knitting in Elizabethan England?
5. **CHALLENGE** Two knitters cast on 40 stitches for the same pattern. One knits 4.5 stitches per inch; the other knits 5 stitches per inch. How wide is each piece, and what is the difference? What should the tighter knitter do?
6. **CHALLENGE** Rewrite Miss Lambert’s 1843 definition of “to cast off” in modern knitting language, then explain why the last stitch must be “secured by drawing the thread through.”

Make it a game · In, Around, Through, Off. One player is the caller; everyone else holds a pair of pencils or needles. The caller says the four motions in order, faster and faster; players must act each one out. Then the caller mixes them up (“Through!” “In!”). Anyone who acts out the wrong motion, or a motion that is out of order for a real stitch when the caller says “Stitch!”, sits out a round. The last player standing teaches the next beginner.

Scripture. “That their hearts might be comforted, being knit together in love, and unto all riches of the full assurance of understanding, to the acknowledgement of the mystery

of God, and of the Father, and of Christ;" (Colossians 2:2, KJV)

Paul prays that the believers at Colossae would be "knit together in love." In knitting, no stitch stands alone; each holds and is held. Paul's goal is not only warm fellowship but "full assurance of understanding" of Christ. A church, like good fabric, is strong when its members are joined in both love and truth.

Practice: answers

1. Insert the right needle into the loop from front to back; wrap the yarn around the right needle; pull the new loop through; slip the old loop off the left needle.
2. 36 rows, because two rows make one ridge.
3. $18 \div 4 = 4.5$ stitches per inch. $4.5 \times 7 = 31.5$, so cast on 31 or 32 stitches.
4. To protect the cappers' trade by requiring most people to wear English-made woolen caps on Sundays and holy days. It shows knitting was a large industry that employed many people and that the government cared about its jobs.
5. $40 \div 4.5 \approx 8.9$ inches; $40 \div 5 = 8$ inches. The difference is about 0.9 inch. The tighter knitter should go up a needle size (or loosen tension) and swatch again until the gauge matches.
6. Modern: "Knit two stitches. Lift the first stitch over the second and off the needle. Knit one more and repeat until one stitch remains; cut the yarn and pull the end through that loop." The last loop must be secured because knitting is one continuous strand: if the final loop is left open, a tug on the yarn will pull it free and the whole bound-off edge, and then the fabric, can unravel.

2.4 A FIRST SCARF

OBJECTIVES

- Plan a garter-stitch scarf from a gauge swatch: width, length, stitch count, yarn amount and knitting time.
- Begin the scarf and learn to join a new ball, count rows and fix common mistakes.
- Read a 1917 Red Cross muffler pattern as a primary source and explain the home-front knitting campaigns of the First World War.

Warm-up. Wrap a long scarf (or a towel) around your neck and measure how long it needs to be to wrap once and hang down to your chest. Then guess: how many stitches would a 6-foot scarf contain? Write your guess; you will calculate it in the practice problems.

Video slot. Video coming. Knitting a garter-stitch scarf for beginners: joining a new ball of yarn, counting garter ridges, fixing a dropped stitch, adding fringe; also “Knit Your Bit” Red Cross knitting in World War I. Search approved channels (Library of Congress, The National WWI Museum and Memorial, a public-library craft channel); preview first.

KEY TERMS

yardage

The length of yarn in a skein or ball, printed on the label, and the amount a project requires.

selvage

The side edge of a piece of knitting or cloth. Neat selvages make a scarf look finished.

stockinette stitch

Fabric made by knitting one row and purling the next; smooth on one side, but it curls at the edges, which is why beginner scarves use garter stitch instead.

hank

A loose loop of yarn twisted for sale, which must be wound into a ball before knitting; patterns of the early 1900s often measure yarn in hanks.

muffler

An older word for a long, warm scarf wrapped around the neck and face.

home front

The civilians of a nation at war and the work they do at home to support the armed forces.

CORE IDEAS

A scarf is the classic first project because it is a long rectangle: no shaping, no seams, and nothing to fit. That does not mean it needs no planning. A good knitter decides the width and length first, then uses the gauge from a swatch to work out how many stitches to cast on,

how much yarn to buy and how long the work will take. For a beginner's scarf, **garter stitch** is the best choice. It looks the same on both sides, lies flat, and does not curl. **Stockinette stitch**, the smooth fabric of most sweaters, rolls inward at the edges, and a stockinette scarf soon becomes a tube.

Yarn is the largest cost of most knitting, so estimating **yardage** matters. The most reliable method uses the swatch itself. Weigh the swatch in grams, measure its area in square inches, and find the grams per square inch. Multiply by the area of the planned scarf to find the total weight of yarn, then convert to balls using the label. A swatch of 16 square inches that weighs 6 grams uses 0.375 grams per square inch; a scarf 7 inches by 60 inches (420 square inches) will need about 158 grams. Because dye lots vary in color, buy all the yarn at once, plus one extra ball for safety.

Knitting a scarf also teaches the habits of all good work. Count the stitches every few rows so that mistakes are caught early. Slip the first stitch of each row, if you like, for a neat, chain-like **selvage**. Join a new ball at the side edge, never in the middle, by leaving 6-inch tails to weave in later. Expect mistakes and learn to fix them: a dropped stitch can be caught with a crochet hook and laddered back up, and when all else fails, knitters "tink" ("knit" spelled backward), undoing a row one stitch at a time. Patience is not a side lesson in knitting; it is the main one.

Scarves have also been a way to serve. When the United States entered the First World War in April 1917, the American Red Cross asked civilians to knit for soldiers and sailors. Posters urged Americans to "Knit Your Bit." Within months, women, girls, men and boys, from schoolchildren to the elderly and the wounded in hospitals, were knitting socks, sweaters, helmets (close-fitting hoods), wristlets and mufflers in khaki, gray and navy. The Red Cross issued standard patterns so that every article would fit and wear well, and volunteer knitters across the country produced millions of pieces during the war.

Patterns spread through little booklets. One, the *Khaki Knitting Book*, was published in New York in 1917 by a relief group called Allies Special Aid, and its proceeds went to the war effort. Its muffler pattern, courtesy of the American Red Cross, is just a few lines long: 50 stitches on No. 6 needles, about 11 inches wide, knitted plain until it measures 68 inches. That is a garter-stitch scarf, nearly six feet long, exactly like the one you are beginning. The pattern did not need to say more, because its readers already knew how to knit; the booklet's own foreword says it is "in no sense an instruction book."

Why so long and so wide? A soldier in a cold trench or on a ship's deck in the North Atlantic needed a scarf that could wrap twice around the neck and tuck into a coat. The colors were practical too: gray, navy and khaki matched uniforms and did not show dirt. Wool was chosen because it stays warm when damp. The numbers in the pattern, in other words, were not arbitrary; they came from the needs of the person who would wear it. That is the right way to plan any piece of work for someone else.

Proverbs praises the household that is ready before winter comes: "She is not afraid of the snow for her household: for all her household are clothed with scarlet." Your first scarf may

be for yourself, but a knitter soon learns the joy of making something warm for someone else.

PICTURE STUDY



The Knitting Lesson, Jean-François Millet, 1869 · Oil on canvas · Saint Louis Art Museum, Missouri
Wikimedia Commons · Public domain

Jean-François Millet (1814–1875) was a French painter who grew up on a farm in Normandy and later lived in the village of Barbizon, near the forest of Fontainebleau. He painted peasants at their work, sowing, gleaning and knitting, with great dignity. He returned to the subject of a mother teaching her daughter to knit several times; this large version was shown at the Paris Salon of 1869. The girl is knitting a stocking on four needles, the way the Knitting Madonna knitted nearly five hundred years earlier.

Look closely

- Look at the mother's hands and the daughter's hands. Who is in control of the needles? How can you tell?
- Find the ball of yarn and follow the strand. How does Millet use the white yarn to lead your eye?
- Find two details that tell you this is a poor but orderly home.

Talk about it

1. Millet shows a skill being handed from one generation to the next. Who taught (or is teaching) you to knit, and what did you learn besides the stitches?
2. Compare this painting with the Anker girl in Stop B2. What is the difference between a child learning a skill and a child practicing one?

Safety first. Carry and store needles point-down or capped. When you stop knitting, slide the stitches to the middle of the needle and push a point protector or cork on each tip so stitches do not slip off. Knit sitting upright with good light to avoid eye and neck strain during long sessions.

HANDS-ON: PLAN AND BEGIN A GARTER-STITCH SCARF

Using your Stop B3 swatch, you will write a pattern for your own scarf in the style of the 1917 Red Cross muffler, estimate the yarn and time, and knit the first 10 inches. Finish it over the next weeks; it becomes part of your trail portfolio.

You will need

- Your gauge swatch from Stop B3 and its measurements
- Worsted-weight wool or wool-blend yarn (about 150 to 250 grams; see Step 2), all from one dye lot
- US size 8 (5 mm) needles, or the size that gave you good gauge
- A kitchen scale (grams), a tape measure, a crochet hook (size H or 5 mm) and a tapestry needle
- A row counter or a pencil and tally sheet

Steps

1. **Decide the size.** Choose a width (6 to 8 inches) and a length (50 to 68 inches). Compare with the 1917 muffler (Primary source box).
2. **Estimate the yarn.** Weigh your swatch in grams and measure its area. Compute grams per square inch, multiply by the scarf's area, and add 10 percent. Read the yarn label to convert grams to balls.
3. **Write your pattern** on an index card in the Red Cross style: yarn, needles, cast-on number, stitch, finished length. Keep it to four lines.
4. **Cast on** with the long-tail method. Knit every row. If you like, slip the first stitch of every row purlwise for a neat edge.
5. **Keep records.** Count your stitches every 10 rows. Time yourself for one full row and record it.
6. **Join new yarn** at the start of a row when a ball runs out, leaving 6-inch tails on both strands.
7. **Knit the first 10 inches.** Measure on a flat table, not dangling. Then use your row time to estimate the hours left to finish.

Check your work

- My written pattern has yarn, needles, cast-on number, stitch and length.
- My yarn and time estimates show the math.
- My stitch count is the same as when I cast on, and my edges are straight.
- I have knitted at least 10 inches and have a plan to finish.

FIELD NOTEBOOK

1. **Pattern card.** Paste or copy your four-line scarf pattern beside a copy of the 1917 muffler pattern. Note every way they differ and why.
2. **Progress chart.** Draw a long, narrow bar the shape of your scarf, marked every 10 inches. Shade it in as you finish each section and date each mark.
3. **Narration.** Write one paragraph explaining how ordinary Americans served during the First World War through knitting, and why a simple scarf pattern of a few lines was enough. A parent keeps this page.

Did you know? During the First World War, Americans knitted in schoolrooms, on streetcars and trains, and at public meetings. The Junior Red Cross, founded in 1917, enlisted schoolchildren, and many classes knitted squares, wash cloths and mufflers. In the Second World War, Americans knitted again for “Bundles for Britain” and the Red Cross. Garter stitch uses more yarn than stockinette for the same area because its ridges pack the rows closer together.

Primary source. “Knitted Muffler (Courtesy of American Red Cross),” in Olive Whiting, ed., *Khaki Knitting Book* (New York: Allies Special Aid, 1917). Project Gutenberg eBook #76611.

2½ Hanks of Gray, Blue or Khaki Yarn

1 Pair Amber or Bone Needles No. 6

Cast on 50 stitches, these should measure at least 11 inches, and knit forward and back in plain knitting until muffler measures 68 inches.

“Plain knitting” is garter stitch: knit every row. Use this pattern in Steps 1 and 3 of the project and in practice problems 3, 5 and 6.

Go deeper. Anne L. Macdonald, *No Idle Hands: The Social History of American Knitting* (1988), with chapters on both World Wars. Olive Whiting, ed., *Khaki Knitting Book* (1917), free at Project Gutenberg. Online: The National WWI Museum and Memorial (Kansas City) on home-front knitting, and the Library of Congress’s WWI posters (search “Knit your bit”). Second video topic: “How a wool scarf is machine-knitted in a mill.”

Goes deeper in. History, “The United States in the First World War”; Arithmetic, “Area and Estimation”; Small Business & Economics, “Estimating Materials” (coming soon).

For families. Sources: *Khaki Knitting Book* (1917), quoted exactly from Project Gutenberg; American Red Cross history pages; The National WWI Museum and Memorial; Macdonald, *No Idle Hands*. The total number of articles knitted by Americans in WWI is reported differently by different sources, so the stop says “millions.” Needle “No. 6” in 1917 may not equal a modern US 6; needle sizing was not standardized then, which is why the pattern also gives the width. Millet’s painting date and Salon showing

are from the Saint Louis Art Museum. Finishing a full scarf takes many hours; plan to work on it over two to four weeks.

PRACTICE

1. **EASY** Why is garter stitch better than stockinette for a first scarf?
2. **EASY** Why should you buy all the yarn for a project from the same dye lot?
3. **MEDIUM** The 1917 muffler is 11 inches wide and 68 inches long. What is its area? How many stitches per inch does the pattern expect?
4. **MEDIUM** A 4-by-4-inch swatch weighs 6 grams. How many grams will a 7-by-60-inch scarf need? With 10 percent extra, how many 100-gram balls should you buy?
5. **CHALLENGE** In garter stitch, suppose the muffler knits 9 rows per inch. How many rows and how many stitches are in the whole 68-inch muffler? At 20 stitches a minute, how many hours of knitting is that?
6. **CHALLENGE** Using the pattern, give three reasons from the soldier's situation for its choices of size, color and fiber. Then explain why a pattern only three lines long was enough for knitters in 1917.

Make it a game • Knit Your Bit Relay. Two teams, one scarf in progress (or a practice swatch) per team. Each knitter knits one row, counts the stitches aloud, and passes it to the next. A row with the wrong stitch count must be tinked (undone) by the knitter who made it before the team can continue. After ten minutes, the team with the most correct ridges wins. Talk afterward: how did knitters in 1917 keep standard patterns when millions of people worked separately?

Scripture. “And whatsoever ye do, do it heartily, as to the Lord, and not unto men;” (Colossians 3:23, KJV)

A scarf has thousands of stitches and no one will inspect most of them. Paul tells Christians to work “heartily, as to the Lord,” even at ordinary tasks no one praises. The home-front knitters of 1917 never met most of the men who wore their mufflers; they worked for people they could not see. Work done for the Lord is done well even when no one is watching.

Practice: answers

1. Garter stitch lies flat, does not curl, and looks the same on both sides. Stockinette curls at the edges and has a wrong side.
2. Different dye lots can differ slightly in color, and the difference may show as a stripe where you join a new ball.
3. $11 \times 68 = 748$ square inches. $50 \text{ stitches} \div 11 \text{ inches} \approx 4.5 \text{ stitches per inch}$.
4. $6 \div 16 = 0.375 \text{ g per square inch}$. $7 \times 60 = 420 \text{ square inches}$; $420 \times 0.375 = 157.5 \text{ g}$. Plus 10 percent $\approx 173 \text{ g}$, so buy 2 balls.
5. $68 \times 9 = 612 \text{ rows}$. $612 \times 50 = 30,600 \text{ stitches}$. $30,600 \div 20 = 1,530 \text{ minutes} = 25.5 \text{ hours}$.
6. Size: 68 inches long and 11 wide lets it wrap twice and tuck into a coat in a cold trench or on deck. Color: gray, blue or khaki matched uniforms and hid dirt. Fiber: wool yarn stays warm

even when damp. The pattern could be short because nearly every reader already knew how to cast on, knit plain and bind off; the booklet itself says it is “in no sense an instruction book.”

2.5 EMBROIDERY STITCHES: STEM, CHAIN, SATIN AND FRENCH KNOT

OBJECTIVES

- Work the stem, chain, satin and French knot stitches neatly and explain what each is best used for.
- Explain how the Bayeux Tapestry was made and why it is properly called an embroidery.
- Read the tabernacle passages on needlework in Exodus as primary sources and define their craft vocabulary.

Warm-up. Look closely at any embroidered item in your house: a logo on a shirt, a pillowcase, a dish towel, a patch. Turn it over. Is the back neat or messy? Can you tell how the stitches were made? Sketch one small section front and back.

Video slot. Video coming. Hand embroidery for beginners: stem stitch, chain stitch, satin stitch and French knot; the Bayeux Tapestry and how it was stitched. Search approved channels (Royal School of Needlework, the Victoria and Albert Museum, Bayeux Museum, Smithsonian); preview first.

KEY TERMS

embroidery

Decorating finished cloth with stitches of thread or yarn worked with a needle, as opposed to weaving a pattern into the cloth as it is made.

stranded floss

Embroidery thread of six fine strands loosely twisted together, which can be separated so the stitcher can work with one, two, three or more.

stem stitch

An outline stitch in which each stitch overlaps the one before it by half, making a smooth, rope-like line; also called outline stitch.

satin stitch

Straight stitches laid closely side by side to fill a shape with smooth, solid color.

laid and couched work

A filling method in which long threads are laid across a shape and then tied down (couched) with small stitches; used for the large color areas of the Bayeux Tapestry.

crewelwork

Embroidery in fine twisted wool, especially popular in England and colonial America in the 1600s and 1700s for bed hangings and curtains.

CORE IDEAS

Weaving builds pictures into cloth as it is made; **embroidery** adds them afterward, stitch by stitch, to cloth that is already finished. That freedom is what makes embroidery so old and so widespread. A stitcher needs only a needle, thread and fabric, and can draw with the needle in any direction. Scripture names the craft plainly. When God gave Moses the plans for the tabernacle, the hanging for the door of the tent was to be “wrought with needlework,” and Aholiab of the tribe of Dan, Bezalel’s partner, is called “an embroiderer in blue, and in purple, and in scarlet, and fine linen” (Exodus 38:23). Embroidery, in other words, was one of the skills God filled His people with to build a place for His worship.

The most famous embroidery in Europe is misnamed. The **Bayeux Tapestry** is not a tapestry at all, because its pictures are not woven but stitched in wool onto plain linen. It is about 68.4 meters (roughly 224 feet) long and about 50 centimeters (20 inches) tall, made of nine linen panels joined together. It tells the events leading to the Norman Conquest of England in 1066 in more than seventy scenes, with Latin captions. It was most likely made in England in the 1070s, perhaps commissioned by Bishop Odo of Bayeux, William the Conqueror’s half-brother. Its stitchers used only a few stitches: **stem** (or outline) stitch for lettering and outlines, and **laid and couched work** to fill large areas, in about ten colors of naturally dyed wool.

Each stitch on this stop has a job. **Stem stitch** makes lines. The needle comes up, goes down a short distance ahead, and comes up again halfway back along the previous stitch, always with the thread kept on the same side. The overlaps form a smooth, slightly twisted line that bends well around curves, perfect for stems, vines and lettering. **Chain stitch** also makes lines, but each stitch is a loop held down by the next, like links in a chain. It is one of the oldest decorative stitches, found on ancient textiles from many parts of the world, and it makes bold, textured outlines.

Satin stitch fills. Straight stitches are laid side by side across a shape, close enough to hide the fabric beneath. It gives the smoothest, shiniest surface of any stitch, but it has limits: stitches longer than about half an inch tend to snag and sag, so large shapes are better filled with long-and-short stitch or couching, as the Bayeux stitchers did. Satin stitch looks best when the edge of the shape is first outlined, and stitchers often slant the stitches slightly to catch the light. The **French knot** makes dots: bring the needle up, wrap the thread once or twice around it, and go down just beside (not into) the hole where the thread came up, holding the wraps snug as you pull through. Knots make eyes, flower centers, berries and texture.

Fine work depends on a few habits more than on talent. Stretch the fabric tight in a **hoop** so stitches lie flat without puckering. Cut thread no longer than about 18 inches (roughly from fingertip to elbow), because longer pieces fray and tangle as they are pulled through the cloth again and again. Separate **stranded floss** into the number of strands the work needs: two for fine lines, three or four for bold ones, six for a heavy fill. Start and end with small stitches hidden on the back rather than big knots that make lumps. Old needlework teachers judged a piece by its back as well as its front; a tidy back means a tidy mind.

Over the centuries, embroidery reached great heights. From about 1200 to 1350, English church embroidery in silk and gold thread, called *opus anglicanum* (“English work”), was so prized that popes and kings across Europe ordered vestments from London workshops. In the 1600s and 1700s, households in England and colonial America worked **crewelwork** bed hangings in wool, with twining vines, flowers and birds, using the very stitches on this stop. In the 1800s, William Morris revived hand embroidery in England against cheap machine work. Each age has used the same few stitches in new combinations.

Embroidery teaches a quiet theological lesson too. Exodus says that God “filled” the craftsmen “with wisdom of heart” to work as engravers, embroiderers and weavers (35:35). Skill with a needle is not a lesser gift than skill with a pen or a hammer. It is part of how God’s people have beautified the places and things devoted to Him.

PICTURE STUDY



*The Bayeux Tapestry, Scene 23: Harold Swears an Oath to Duke William, Unknown English embroiderers, 1070s · Wool embroidery (stem stitch and laid and couched work) on linen · Bayeux Museum (Musée de la Tapisserie de Bayeux), Normandy, France
Wikimedia Commons · Public domain*

This scene shows the moment on which the whole story turns. The Latin caption reads, “Here Harold made an oath to Duke William.” Harold, an English earl, swears with his hands on two reliquaries, and the Norman version of events says he promised to support William’s claim to the English throne. When Harold was crowned king in 1066 instead, William invaded. The embroiderers worked the letters and outlines in stem stitch and filled the figures with laid and couched wool. The borders above and below hold animals and patterns that run the whole length of the work.

Look closely

- Find the lettering. Is it worked in thick lines or thin? Which stitch do you think made it?
- Find one figure filled with solid color. Can you see the direction of the laid threads?
- Count the colors you can see in this scene. Which colors are used for people and which for furniture?

Talk about it

1. The Bayeux Tapestry tells the Norman side of the story. Why should a historian be careful when using any single source, even a beautiful one, to learn what happened?
2. The embroiderers used only a few stitches across 224 feet. What are the advantages of a small set of stitches for a large team working together?

Safety first. Embroidery needles are sharp: keep them in a needle book or pincushion, never in your mouth or clothing, and count them at the end of each session. Keep needles and loose floss away from small children and pets. Use embroidery scissors carefully and cut away from your fingers.

HANDS-ON: A FOUR-STITCH SPECIMEN BAND

Before Stop B6's sampler, you will make a specimen band: a strip of fabric with each of the four stitches worked in rows, tested on straight lines, curves and a filled shape. Then you will stitch one design element from the Bayeux Tapestry in the original technique.

You will need

- A 6-by-12-inch piece of medium-weight cotton or linen in a light color
- A 6-inch embroidery hoop
- Six-strand embroidery floss in four colors (or crewel wool, if you can find it)
- Embroidery (crewel) needles, size 5 to 7
- A water-soluble fabric marker or a sharp pencil, and small scissors

Steps

1. **Draw the guide.** Divide the fabric into four bands with light pencil lines. In each band draw one straight line, one S-curve, and one small shape (a leaf or circle about $\frac{3}{4}$ inch across).
2. **Stem stitch.** Using three strands, work the first band's straight line and curve in stem stitch. Keep stitches about $\frac{1}{4}$ inch long and the thread always below the needle.
3. **Chain stitch.** Work the second band's line and curve in chain stitch. Keep loops even and not pulled tight.
4. **Satin stitch.** Outline the third band's leaf in stem stitch, then fill it with satin stitch, slanting the stitches slightly. Keep each stitch shorter than $\frac{1}{2}$ inch.
5. **French knots.** Fill the fourth band's circle with French knots, wrapping once for small knots and twice for larger ones.
6. **Bayeux test.** Using the picture study, copy the outline of one small figure or animal (2 to 3 inches). Outline it in stem stitch and fill it the Bayeux way: lay long parallel

stitches across, then tie them down every ¼ inch with small crossing stitches.

7. **Inspect the back.** Turn the work over. Are the starts and ends hidden? Are there long jumps across the back? Write one improvement for next time.

Check your work

- All four stitches are worked on both a straight line and a curve or shape.
- My stem stitch overlaps evenly and my chain loops are the same size.
- My satin stitch covers the fabric with no gaps, and my French knots are firm.
- I tried laid and couched work and can explain why it suits large areas.

FIELD NOTEBOOK

1. **Stitch diagrams.** Draw each of the four stitches with numbered needle positions (1 = up, 2 = down, 3 = up) and arrows, like a page from a needlework manual.
2. **Timeline of embroidery.** Place on a line: the tabernacle needlework (Exodus), the Bayeux Tapestry (1070s), opus anglicanum (about 1200 to 1350), colonial crewelwork (1600s to 1700s), and William Morris (later 1800s).
3. **Narration.** Write one paragraph explaining why the Bayeux Tapestry is called an embroidery, how it was made, and why historians treat it as an important but one-sided source. A parent keeps this page.

Did you know? In 1066 Halley's Comet appeared in the sky, and the Bayeux Tapestry shows it, with a group of men pointing up in alarm and the caption ISTI MIRANT STELLA ("These men wonder at the star"). The tapestry was hidden and moved several times in war, and it has hung in Bayeux for most of the last nine centuries. A full-size Victorian copy, stitched by members of the Leek Embroidery Society in England in 1885-1886, hangs in Reading Museum.

Primary source. *Exodus 26:36 and 38:23, King James Version (1611). The first is God's instruction for the tabernacle door; the second names the craftsman who helped Bezalel carry it out.*

And thou shalt make an hanging for the door of the tent, of blue, and purple, and scarlet, and fine twined linen, wrought with needlework.

And with him was Aholiab, son of Ahisamach, of the tribe of Dan, an engraver, and a cunning workman, and an embroiderer in blue, and in purple, and in scarlet, and fine linen.

In 1611, "cunning" meant skillful or knowing, not sly, and "wrought" means worked or made. Use these verses in practice problem 6.

Go deeper. David M. Wilson, *The Bayeux Tapestry* (1985), with full-color photographs of the whole work. Mary Thomas, *Mary Thomas's Dictionary of Embroidery Stitches* (1934; later editions), a classic reference with clear diagrams. Online: the Bayeux Museum's

website, which shows the whole tapestry scene by scene; the Victoria and Albert Museum's pages on opus anglicanum. Second video topic: "Crewelwork bed hangings in colonial America" (Colonial Williamsburg).

Goes deeper in. History, "The Norman Conquest"; Art, "Line and Texture in Textile Art"; Literature, "Reading Old Sources" (coming soon).

For families. Sources: Bayeux Museum; Encyclopaedia Britannica; Wilson, *The Bayeux Tapestry*; Victoria and Albert Museum. The tapestry's patron and place of making are not documented; Bishop Odo and an English (probably Canterbury) workshop are the leading scholarly view, so the stop says "most likely" and "perhaps." Measurements (about 68.4 m by 50 cm) are from the Bayeux Museum. The number of scenes depends on how they are divided; the stop says "more than seventy." The picture study shows an oath scene rather than battle scenes; the later battle scenes include fighting shown in a stylized way, which parents may preview. Scripture quoted from the KJV.

PRACTICE

1. **EASY** Match each stitch to its main use: stem, chain, satin, French knot. Uses: dots, smooth lines and curves, bold looped lines, filling small shapes.
2. **EASY** Why is the Bayeux Tapestry not really a tapestry?
3. **MEDIUM** The Bayeux Tapestry is about 68.4 meters long. One meter is about 3.28 feet. How long is it in feet, and how many 9-foot classroom walls would it cover end to end?
4. **MEDIUM** Why should satin stitches be kept shorter than about half an inch, and what did the Bayeux stitchers do instead for large areas?
5. **CHALLENGE** A stem-stitch line uses stitches $\frac{1}{4}$ inch long, each overlapping the last by half. How many stitches are needed for a 6-inch line? If each stitch uses about $\frac{1}{2}$ inch of thread on the front and back together, how many 18-inch lengths of floss will the line need, allowing 3 inches per length for starting and ending?
6. **CHALLENGE** Using Exodus 26:36 and 38:23 (Primary source box), define "wrought" and "cunning" as the 1611 translators used them. Then explain what these verses, with Exodus 35:35, teach about how God regards skilled handwork.

Make it a game • Name That Stitch. One player secretly chooses a stitch and "draws" it in the air or on a whiteboard using only the needle path (up, down, wrap, loop), saying "up" and "down" aloud. The others guess the stitch and its best use. Score one point for the stitch and one for a correct use. For a harder round, the drawer shows only the back of a stitched sample, and players must name the stitch from the back.

Scripture. "Them hath he filled with wisdom of heart, to work all manner of work, of the engraver, and of the cunning workman, and of the embroiderer, in blue, and in purple, in scarlet, and in fine linen, and of the weaver, even of them that do any work, and of those that devise cunning work." (Exodus 35:35, KJV)

Moses tells Israel that God Himself filled Bezalel and Aholiab with skill and with the ability to teach others (35:34). The embroiderer is named beside the engraver and the weaver. Every careful stitch is a small use of a gift God gives, and the best way to honor a gift is to practice it well and to pass it on.

Practice: answers

1. Stem: smooth lines and curves. Chain: bold looped lines. Satin: filling small shapes. French knot: dots.
2. A tapestry has its picture woven into the cloth on a loom. The Bayeux pictures are stitched in wool onto finished linen, so it is an embroidery.
3. $68.4 \times 3.28 \approx 224$ feet. $224 \div 9 \approx 24.9$, so it would need about 25 walls.
4. Long satin stitches snag, loosen and sag. For large areas the Bayeux stitchers laid long threads across the shape and tied them down with small couching stitches, which holds them flat and uses less thread on the back.
5. Each stitch advances the line by $\frac{1}{8}$ inch (half its length), so $6 \div \frac{1}{8} = 48$ stitches. Thread: $48 \times \frac{1}{2} = 24$ inches. Each 18-inch length gives $18 - 3 = 15$ usable inches, so $24 \div 15 = 1.6$, meaning 2 lengths of floss.
6. “Wrought” means worked or made; “cunning” means skillful or knowledgeable. The verses show that needlework was commanded by God for the tabernacle and that an embroiderer, Aholiab, is named with honor. Exodus 35:35 says God filled such workers with wisdom of heart. Together they teach that skilled handwork is a gift from God that can be offered back to Him in worship and service.

2.6 A SAMPLER, AS CHILDREN STITCHED FOR CENTURIES

OBJECTIVES

- Explain how the sampler changed from an adult's record of patterns in the 1500s to a child's school exercise in the 1700s and 1800s.
- Read early documentary references to samplers in Marcus Huish's 1900 study and judge what they prove.
- Plan a sampler on graph paper with border, alphabet, numerals, name and date, and stitch its first band.

Warm-up. Imagine you had no printer, no copier, no internet and no pattern books, but you wanted to remember twenty stitch patterns you had seen. How would you keep them? Write your idea in two sentences. You have just invented the reason samplers exist.

Video slot. Video coming. Historic needlework samplers: band samplers, schoolgirl samplers, alphabets and verses; museum conservators examining a sampler. Search approved channels (Smithsonian, Cooper Hewitt, the Victoria and Albert Museum, Colonial Williamsburg, Winterthur Museum); preview first.

KEY TERMS

sampler

A piece of needlework made to record or practice stitches and patterns; from the Old French *essamplaire*, "an example."

band sampler

A long, narrow sampler of the 1600s with horizontal rows (bands) of repeating patterns, often kept rolled up in a workbasket for reference.

marking

Stitching initials and numbers onto household linen so that sheets, shirts and towels could be identified, counted and rotated; samplers taught children to mark.

even-weave

Fabric with the same number of threads per inch in both directions, so counted stitches come out square.

thread count

The number of threads per inch in an even-weave fabric; 28-count linen has 28 threads per inch.

CORE IDEAS

Before printed pattern books were common, a needleworker who saw a beautiful border or flower had only one way to keep it: stitch a copy. That is what a **sampler** first was, a "sample" or example, from the Old French *essamplaire*. Early samplers belonged to grown

women and professional embroiderers. They were working records, often stitched with random motifs and bits of lace patterns placed wherever there was room, and they were valuable enough to be listed in inventories and left in wills. The earliest English references are from around 1500. Marcus Huish, writing in 1900, cited the poet John Skelton and an inventory of the young King Edward VI taken in 1552 (see the Primary source box).

Printed pattern books appeared in Germany and Italy in the 1520s, and they slowly changed the sampler's purpose. In the 1600s English stitchers made long, narrow **band samplers**, often 6 to 9 inches wide and two or three feet long, with rows of geometric and floral borders and areas of cutwork and needle lace. They were rolled, not framed, and pulled out when a pattern was needed. The oldest surviving English sampler with a date, now in the Victoria and Albert Museum, was stitched by Jane Bostocke in 1598 and includes the name of a little girl, Alice Lee, born in 1596, perhaps a relative for whom it was made.

Across the 1600s and 1700s, the sampler moved from the workbasket to the schoolroom. Girls, usually between about seven and fifteen, stitched samplers to learn the stitches and the alphabet together. A major practical goal was **marking**. In households where sheets, towels and shirts were costly and were sent out to wash or counted at the end of each season, each item was stitched with initials and a number. A girl who could work a clear alphabet and numerals in tiny cross stitches had a real household skill. Samplers became square, framed and signed, with a border, one or more alphabets, the numerals, a verse, the maker's name, often her age, and the date.

America has its own long tradition. The oldest known American sampler was stitched by Loara Standish, daughter of the Plymouth Colony's Myles Standish, probably in the 1640s. It includes a short verse prayer asking the Lord to guide her heart and hands, and it is the earliest known sampler anywhere with a verse. By the late 1700s and early 1800s, girls' schools and academies in towns such as Providence, Philadelphia and Boston developed recognizable regional styles, and teachers' names can sometimes be traced from the designs. Some samplers show houses, family records, maps or memorials. Others record the alphabet and nothing more.

Samplers are also historical documents. Because they are signed and dated, they tell us who learned to read and stitch, at what age, and in what places. Their verses show what families wanted children to remember: Scripture, prayers, warnings about the shortness of life, and praise of learning and virtue. Historians read them carefully, though. A sampler shows what a school or a family taught, but not always what a child herself believed, and a verse may simply have been copied from a teacher's pattern.

Making a sampler today means working the same way those children did. Choose an **even-weave** fabric so each stitch covers a fixed square of threads. Plan everything on graph paper first, with one square for each stitch. Count carefully: on 28-count linen stitched over two threads, there are 14 stitches to the inch, so a 5-stitch-wide letter with a 1-stitch space takes 6 stitches, or about 0.43 inch. A 26-letter alphabet in that style needs 156 stitches, about 11 inches, more than most beginners expect. Planning is not optional; it is the craft.

Proverbs teaches, “Train up a child in the way he should go.” For two centuries, many Christian families trained children partly through samplers, joining skill of hand to the memorization of Scripture and godly sayings. The finished pieces still hang in museums and homes, signed in childish letters, witnesses that small, patient lessons last.

PICTURE STUDY

Sampler by Loara Standish, Loara Standish, c. 1640s · Silk thread on linen · Pilgrim Hall Museum, Plymouth, Massachusetts

Loara Standish was one of the children of Myles and Barbara Standish of Plymouth Colony; she was born after 1627 and died young, before 1656. Her sampler, probably stitched in the 1640s, is a band sampler in the English style her mother and the other Pilgrim women would have known. It stayed in the family of her brother Josiah until it was given to Pilgrim Hall in 1844. It is the oldest known sampler made in America, and its stitched verse, a prayer for the Lord to guide her heart and to give her hands skill, is the earliest known sampler verse anywhere.

Look closely

- Count the bands. Which patterns repeat, and which appear only once?
- Find the lettering at the bottom. How is it different in style and size from the patterned bands above?
- The colors have faded over almost four hundred years. Which colors can you still see, and what might they once have been?

Talk about it

1. Is this sampler more like the pattern records of the 1500s or the schoolroom samplers of the 1700s? Give evidence from its shape and contents.
2. Loara asked for skill of hand and a guided heart together. Why might a child in Plymouth Colony have connected those two things?

Safety first. Keep needles in a needle book and count them before putting work away. Work in good light, and rest your eyes every 20 minutes by looking at something far away; counted work is close and tiring.

HANDS-ON: PLAN AND BEGIN YOUR SAMPLER

You will design a full sampler on graph paper in the historic pattern, then stitch its first band. Stop B7 adds the cross-stitched verse; together they become the trail’s showpiece. Use stitches from Stop B5, plus running stitch and backstitch from the Sewing trail if you know them.

You will need

- A 12-by-14-inch piece of even-weave fabric: 14-count Aida cloth for beginners, or 28-count linen if you are confident

- Graph paper (10 squares to the inch) and a pencil
- Embroidery floss in 3 to 5 colors (the historic palette: dark green, faded red, blue, gold and brown)
- A tapestry needle (blunt, size 24 or 26) and an embroidery hoop or small frame
- A ruler and a water-soluble marker

Steps

1. **Study the models.** Look at the Loara Standish sampler and at least two others online (Smithsonian, Cooper Hewitt or the V&A). List the elements they share.
2. **Measure.** Leave a 2-inch margin on every side for framing. Calculate how many stitches fit across and down the stitching area (14-count Aida: 14 per inch).
3. **Lay out on graph paper,** one square per stitch: a border all around; a band for an alphabet; a band for numerals 1 to 10; a space for your verse (Stop B7); and a final line with your name, age and the year. Count every letter and center each line.
4. **Mark the center.** Fold the fabric in half each way and mark the center with a pin or a basted line. Every sampler is stitched outward from a counted center.
5. **Stitch the first band:** a repeating border of your own design using at least three stitches from Stop B5 (for example, stem-stitch vines, satin-stitch leaves and French-knot berries).
6. **Record your plan.** Keep the graph-paper layout with your sampler; historians wish more early stitchers had.

Check your work

- My graph-paper plan has a border, an alphabet, numerals, a place for a verse, and my name, age and date.
- Every line of lettering is counted and centered.
- My first band uses at least three stitches neatly and repeats evenly.
- My margins are at least 2 inches on every side.

FIELD NOTEBOOK

1. **Then and now chart.** Make two columns: “Sampler, 1500s to 1600s” and “Sampler, 1700s to 1800s.” Compare who made it, its shape, its contents and its purpose.
2. **Your layout.** Paste or redraw your graph-paper plan and label each part with its historic purpose (border, alphabet for marking, numerals for counting linens, verse, signature).
3. **Narration.** Write one paragraph explaining how and why the sampler changed from a pattern record to a schoolroom exercise. Use at least two dates and one named sampler. A parent keeps this page.

Did you know? Shakespeare mentions a sampler in *A Midsummer Night’s Dream*, where Helena remembers how she and her friend Hermia, as girls, once stitched a flower together on a single sampler, sitting side by side on one cushion. Some American

schoolgirl samplers now sell for tens or even hundreds of thousands of dollars at auction. Museums study the backs of samplers as closely as the fronts, because the back shows how the stitcher moved from one area to the next.

Primary source. *Marcus B. Huish, Samplers and Tapestry Embroideries (London, first published 1900; the Gutenberg text is the second edition), introductory chapter on English needlework. Project Gutenberg eBook #41717. Huish quotes the earliest written references to samplers he could find.*

The earliest record which we have met with is one by the poet Skelton (1469-1529), who speaks of ‘the sampler to sowe on, the laces to embroide.’ The next is an inventory of Edward VI. (1552), which notes a parchment book containing —‘*Item: Sampler or set of patterns worked on Normandy canvas, with green and black silks.*’

Notice that the 1552 entry calls the sampler a “set of patterns” and lists it among a king’s possessions. Use this source in practice problem 5.

Go deeper. Marcus B. Huish, *Samplers and Tapestry Embroideries* (1900), free at Project Gutenberg, with many photographs. Ethel Stanwood Bolton and Eva Johnston Coe, *American Samplers* (1921), a large catalog of early American samplers and their verses, available free online through the Internet Archive. Online: Pilgrim Hall Museum’s page on the Loara Standish sampler; the Victoria and Albert Museum’s page on the Jane Bostocke sampler; the Smithsonian’s Cooper Hewitt sampler collection. Second video topic: “How museums conserve antique samplers.”

Goes deeper in. History, “Plymouth Colony” and “Colonial Family Life”; Art, “Pattern and Border Design”; Arithmetic, “Measurement and Grids” (coming soon).

For families. Sources: Huish, quoted exactly from Project Gutenberg; Pilgrim Hall Museum and the Textile Research Centre, Leiden (Loara Standish sampler); Victoria and Albert Museum (Jane Bostocke sampler, 1598). Loara Standish’s dates are uncertain (born after 1627; died before about 1656), and her sampler is dated by style to the 1640s. The sampler verse is not quoted here because an exact public-domain transcription could not be confirmed; parents can read it on Pilgrim Hall’s website. Samplers were made mostly by girls in this period; the stop reports that as history. The Shakespeare reference is to *A Midsummer Night’s Dream*, Act 3, Scene 2 (paraphrased, not quoted). Commons file name for the picture was not confirmed; search the name given.

PRACTICE

1. **EASY** What does the word “sampler” come from, and what was a sampler first used for?
2. **EASY** Why did schoolgirls stitch alphabets and numerals on their samplers?
3. **MEDIUM** Jane Bostocke dated her sampler 1598, and Alice Lee was born in 1596. How old was Alice when the sampler was made? How many years before the Mayflower sailed

(1620) was it stitched?

4. **MEDIUM** On 14-count Aida, how wide is a border of 168 stitches? How many stitches fit across a stitching area 9 inches wide?
5. **CHALLENGE** Using the Primary source box, explain what the 1552 inventory entry proves about samplers and what it does not prove. Then say why Huish wrote “the earliest record which we have met with” rather than simply “the earliest record.”
6. **CHALLENGE** You want an alphabet of 26 capital letters, each 5 stitches wide with 1 stitch of space after each, on 14-count Aida. Your stitching area is 9 inches wide. Will it fit on one line? If not, how would you divide it, and how wide is each line?

Make it a game · Sampler Detective. A parent shows three or four sampler images from museum websites with the labels hidden. Players study each one and write a guess for the century, the maker’s age, and whether it is a pattern record or a school sampler, giving one piece of evidence each time. Reveal the labels. Score a point for each correct guess with good evidence. The winner chooses the sampler that inspires their own border.

Scripture. “Train up a child in the way he should go: and when he is old, he will not depart from it.” (Proverbs 22:6, KJV)

Training is daily and patient, like counting stitches. The children who stitched samplers often stitched Scripture with them, and many kept those words for life. Training of the hands and training of the heart went together, and Proverbs promises that what is planted early lasts.

Practice: answers

1. From the Old French *essamplaire*, “an example.” It was first a stitched record of patterns and stitches to copy later.
2. To learn marking: stitching initials and numbers on household linens so they could be identified, counted and kept in order. Many also learned their letters this way.
3. $1598 - 1596 = 2$ years old. $1620 - 1598 = 22$ years before the Mayflower.
4. $168 \div 14 = 12$ inches. $9 \times 14 = 126$ stitches.
5. It proves that by 1552 samplers existed in England, that they were called “sampler or set of patterns,” that they were worked on canvas in silk, and that they were valuable enough to list in a king’s inventory. It does not prove who made it, that children made samplers, or when samplers began. Huish chose careful wording because other, earlier records might exist that he had not found; a good historian claims only what the evidence shows.
6. $26 \times 6 = 156$ stitches (the final space can be dropped, giving 155). $156 \div 14 \approx 11.1$ inches, which is more than 9, so it will not fit. Split it into two lines of 13 letters: $13 \times 6 = 78$ stitches (77 without the last space), about 5.5 inches each, centered in the 126-stitch width. (Other sensible splits, such as A-M and N-Z, are also correct.)

2.7 CROSS-STITCH A VERSE

OBJECTIVES

- Work even, correct cross stitch from a chart, with all top stitches slanting the same way.
- Chart a Scripture verse on graph paper, choosing line breaks and centering every line by counting.
- Read Elizabeth Creasey's 1686 sampler verse as a primary source, modernize its spelling, and explain what it shows about education and virtue in her day.

Warm-up. Choose a short KJV verse you would like to see on your wall every day. Write it out, then count its letters and spaces. Guess how many inches wide it would be if every letter took 6 stitches at 14 stitches to the inch. Keep your guess for the practice problems.

Video slot. Video coming. Counted cross-stitch for beginners: reading a chart, finding the center, working rows of half stitches and crossing back, starting without a knot; Berlin woolwork. Search approved channels (Victoria and Albert Museum, Smithsonian, a public-library craft channel); preview first.

KEY TERMS

cross stitch

A counted stitch made of two diagonal stitches that cross in an X over a square of fabric threads; the top stitch always slants the same way.

chart

A grid in which each square stands for one stitch, with a color or symbol showing which thread to use.

Aida cloth

A cotton even-weave fabric woven in clear blocks with holes at each corner, made for counted cross-stitch; sold by count, such as 11, 14, 16 or 18 squares per inch.

counted thread work

Needlework in which every stitch is placed by counting the threads of the fabric rather than following a line drawn on it.

Berlin woolwork

A craze of the 1800s for stitching colored wool on canvas from hand-colored printed charts, first published in Berlin early in the century.

motto

A short saying or verse stitched or printed to hang in a home, school or church as a daily reminder.

CORE IDEAS

The cross stitch is one of the simplest stitches in needlework and one of the most exact. Each stitch is an X made of two diagonal stitches over a square of fabric threads. The rule that separates good work from poor is that every top stitch must slant the same way, usually from lower left to upper right. When the top stitches agree, light falls on the work evenly, and the stitches read as a smooth, solid line; when they do not, the eye sees ragged patches even if it cannot say why. Because each stitch fills one square, cross stitch is **counted thread work**: you follow a **chart** on graph paper, one square per stitch, rather than a line drawn on the cloth.

That grid made cross stitch ideal for lettering. In the 1700s and 1800s, as samplers became school exercises, cross stitch (sometimes called marking stitch) became the main stitch for their alphabets, numerals and verses. Letters built on a grid are clear at a small size, and a well-taught girl could mark linen with initials only a quarter inch tall. Many samplers combine a verse of Scripture or a hymn, a moral couplet, and the maker's name, age and date, all in cross stitch inside a border.

The verses tell us what families valued. Elizabeth Creasey's sampler of 1686, reproduced by Marcus Huish, praises learning and virtue: land and money may vanish, but learning lasts, and virtue keeps one "out of pride." Her spelling ("Then" for *than*, "Excelent," "vertue," "the" for *thee*) is not carelessness. English spelling was not yet fixed by dictionaries in 1686, and children stitched what their teachers set before them. A sampler is therefore evidence both of a child's skill and of the ideas a household and a school wished to plant.

In the 1800s, cross stitch became a popular pastime on a new scale. Publishers in Berlin began selling hand-colored charts printed on graph paper early in the century, and **Berlin woolwork**, worked in brightly dyed wool on canvas, became a fashion across Europe and America by the 1830s and 1840s. Later in the century, many homes hung stitched **mottoes** such as Bible verses or simple blessings, often worked on perforated card. The idea was old: Deuteronomy commands Israel to write God's words "upon the posts of thy house, and on thy gates," so that His Word is before the family's eyes in daily life.

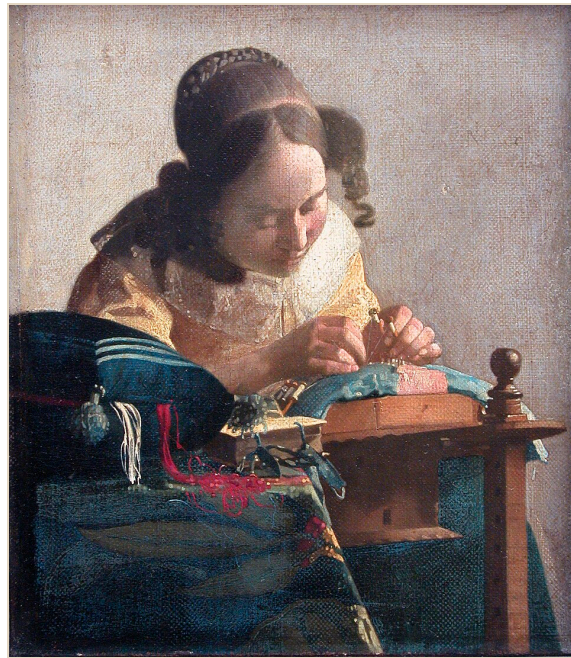
Charting a verse is careful design work. First choose the alphabet: a block letter 5 stitches wide and 7 tall is easy to read and easy to count. Allow 1 stitch between letters and 3 between words. Then break the verse into lines that make sense when read aloud, not merely where the space runs out. Count the stitches in each line, find the widest line, and choose a fabric count that makes it fit. Finally, center each line: subtract the line's width from the total width and divide by two to find where to begin. A mistake of one stitch on the chart becomes a crooked line on the cloth, so experienced stitchers count twice and stitch once.

Fabric count changes everything. On **Aida cloth**, the count is the number of squares per inch, so the same chart grows or shrinks with the cloth: a design 140 stitches wide is 10 inches on 14-count, about 8.75 inches on 16-count, and about 12.7 inches on 11-count. Beginners do best with 14-count Aida and two strands of floss, which cover the squares well.

Work in rows: stitch all the first diagonals across a row, then cross them all on the way back. Start by holding a tail behind the work and catching it under the first few stitches; end by sliding the needle under stitches on the back. Knots make lumps and can pull through.

Stitching a verse slows you down enough to meditate on it. Over the hours it takes to stitch a dozen words, those words become part of you. That, more than decoration, is why generations of Christian families set Scripture before their children in thread.

PICTURE STUDY



The Lacemaker, Johannes Vermeer, c. 1669-1670 · Oil on canvas, mounted on panel · Musée du Louvre, Paris

Wikimedia Commons · Public domain

The Lacemaker is one of the smallest paintings Johannes Vermeer of Delft ever made, only about 9½ by 8¼ inches. A young woman works bobbin lace, crossing and twisting threads around pins on a cushion, in a pose of complete concentration. Vermeer painted the thread between her fingers as a crisp, fine line, but the loose red and white threads spilling from the sewing cushion in front are blurred, as if seen out of focus. Her work is lace, not cross stitch, but it is counted, patient handwork of the same kind: every crossing in its place.

Look closely

- Find the two kinds of thread: the sharp white thread she is working and the blurry threads in the foreground. Why might Vermeer have painted them so differently?
- Where does the light fall most brightly? What does it lead your eye to?
- Find the small book on the table at the left. What might it be?

Talk about it

1. Vermeer shows nothing in the room to distract from the work. What does the painting suggest about the kind of attention fine needlework requires?
2. Compare the lacemaker's concentration with your own as you count a chart. What helps you keep that kind of focus, and what breaks it?

Safety first. Use a blunt tapestry needle for Aida cloth. Keep needles in a needle book, and count them at the end of each session. Take an eye break every 20 minutes and work in strong light; counted work at close range tires the eyes quickly.

HANDS-ON: CHART AND STITCH A VERSE

You will chart a short KJV verse on graph paper and cross-stitch it, either in the verse space you planned on your Stop B6 sampler or as a separate framed motto. Read Elizabeth Creasey's 1686 verse first (Primary source box) and decide what you want your own stitched words to teach.

You will need

- Your Stop B6 sampler, or a 10-by-12-inch piece of 14-count Aida cloth
- Graph paper (10 squares per inch), a pencil and an eraser
- Embroidery floss in one or two dark colors (use 2 strands)
- A blunt tapestry needle (size 24) and a hoop
- A Bible (KJV)

Steps

1. **Choose the verse.** Pick a verse of 8 to 20 words, such as Psalm 90:12, Colossians 3:23 or Proverbs 22:6. Copy it exactly from the KJV.
2. **Draw the alphabet.** On graph paper, draw the letters you need in a 5-by-7 block style. Draw a small reference (the book, chapter and verse) in a smaller 3-by-5 alphabet if you wish.
3. **Break the lines** where the sense pauses. For each line, add 5 stitches per letter, 1 between letters and 3 between words. Write each line's total in the margin.
4. **Fit and center.** Find the widest line. Make sure it fits your stitching width. For every other line, compute $(\text{total width} - \text{line width}) \div 2$ to find the starting square. Leave 3 empty rows between lines.
5. **Find your start.** Mark the center of the verse area on the fabric and count out to the first stitch of the top line.
6. **Stitch.** Work each letter in rows of half stitches, then cross back. Check that every top stitch slants the same way.
7. **Sign it.** Below the verse, stitch your initials and the year, as samplers have for four hundred years.

Check your work

- My chart is counted and every line is centered.

- My verse is copied exactly from the KJV, with the reference.
- All my top stitches slant the same direction, and the back has no knots.
- My initials and the year are stitched below.

FIELD NOTEBOOK

1. **Chart page.** Keep your finished verse chart with each line's stitch count and starting square written in the margin.
2. **Spelling then and now.** Copy Elizabeth Creasey's verse in two columns: her spelling and modern spelling. Circle each change.
3. **Narration.** Write one paragraph explaining why families stitched verses and mottoes into samplers and hung them in their homes, using Deuteronomy 6 and Creasey's sampler as evidence. A parent keeps this page.

Did you know? A single skein of six-strand floss holds about 8.7 yards (8 meters) of thread. In Berlin woolwork, the charts were often colored by hand, square by square, by teams of colorists. Victorian stitchers also worked mottoes on perforated paper (stiff card punched with tiny holes in a grid), and many survive in old frames with sayings such as "God Bless Our Home." Cross stitch is among the oldest counted stitches and appears in folk embroidery from Scandinavia to Eastern Europe and beyond.

Primary source. *Inscription on the sampler of Elizabeth Creasey, 1686, as transcribed by Marcus B. Huish, Samplers and Tapestry Embroideries (Plate VI). Project Gutenberg eBook #41717. Spelling and capitals are hers.*

Look Well to that thou takest in Hand Its Better Worth Then house Or Land When
Land is gone and Money is spent Then learning is most Excelent Let vertue Be
Thy guide and it will keep the out of pride Elizabeth Creasey Her work Done in
the year 1686.

Huish adds that this sampler is remarkable for its design and for its perfect state of preservation. Use this verse in the project and in practice problems 4 and 6.

Go deeper. Ethel Stanwood Bolton and Eva Johnston Coe, *American Samplers* (1921), with a long chapter of verses transcribed from American samplers, free through the Internet Archive. Thérèse de Dillmont, *Encyclopedia of Needlework* (1880s), with its chapter on cross stitch and counted work, free at Project Gutenberg. Online: the Louvre's page on *The Lacemaker*; the Victoria and Albert Museum's pages on Berlin woolwork. Second video topic: "How bobbin lace is made."

Goes deeper in. Literature, "Spelling and the History of English"; Art, "Lettering and Layout"; Arithmetic, "Ratios and Centering" (coming soon).

For families. Sources: Huish, quoted exactly from Project Gutenberg (the Gutenberg transcription splits one word across a line, "kee p"; it is joined here as "keep"); Musée du

Louvre (*The Lacemaker*, about 24 by 21 cm); Victoria and Albert Museum (Berlin woolwork). Berlin charts were published from about 1804; the stop says “early in the century.” Floss length per skein is the common commercial standard. Let the student choose the verse; short verses (under about 60 letters) are best for a first chart, because a line longer than about 9 inches at 14-count will not fit a typical sampler.

PRACTICE

1. **EASY** What is the single most important rule for neat cross stitch, and why does it matter?
2. **EASY** A design is 112 stitches wide. How wide is it on 14-count Aida? On 16-count?
3. **MEDIUM** Using 5-stitch-wide letters, 1 stitch between letters and 3 between words, how many stitches wide is the line FEAR GOD?
4. **MEDIUM** Rewrite the first four lines of Elizabeth Creasey’s 1686 verse in modern spelling. Which words changed?
5. **CHALLENGE** Your stitching area is 126 stitches wide. Your top line is 43 stitches and your second line is 77 stitches. At which stitch (counting from the left edge as stitch 1) should each line start so that it is centered? If the result is not a whole number, what do you do?
6. **CHALLENGE** Creasey’s verse says that land and money can be lost but learning lasts, and that virtue keeps a person “out of pride.” Compare this with Deuteronomy 6:6–9. What do the two have in common as reasons for stitching words into a household object, and how are they different?

Make it a game • Chart Race. Each player gets a strip of graph paper and the same short phrase (for example, LOVE GOD). On “Go,” players chart it in 5-by-7 letters with correct spacing, write the total width, and compute the starting square to center it in a 60-stitch space. The first correct, fully counted chart wins. Swap papers and check each other’s counts; a single miscount loses the round.

Scripture. “And these words, which I command thee this day, shall be in thine heart: ... And thou shalt write them upon the posts of thy house, and on thy gates.” (Deuteronomy 6:6, 9, KJV)

Moses tells Israel to keep God’s words first in the heart and then before the eyes, written on the very doorposts. In between (6:7) he commands parents to teach them diligently to their children. A stitched verse is one small way to obey the spirit of this command: the Word in the heart, taught to the next generation, and placed where the family will see it every day.

Practice: answers

1. Every top stitch must slant the same way. Then light reflects evenly and the stitches look smooth and solid; mixed slants look ragged.
2. $112 \div 14 = 8$ inches. $112 \div 16 = 7$ inches.

3. FEAR: 4 letters $\times$ 5 = 20, plus 3 gaps = 23. GOD: 3 $\times$ 5 = 15, plus 2 gaps = 17. Plus 3 for the word space: 23 + 3 + 17 = 43 stitches.
4. "Look well to that thou takest in hand; it's better worth than house or land. When land is gone and money is spent, then learning is most excellent." Changes: "Its" to "it's," "Then" to "than" (in the second line), "Excelent" to "excellent," and the capitals made regular.
5. Line 1: $(126 - 43) \div 2 = 41.5$, so leave 41 or 42 empty stitches and start at stitch 42 or 43 (choose one rule and use it for every line). Line 2: $(126 - 77) \div 2 = 24.5$, so leave 24 or 25 and start at stitch 25 or 26. When the margin is odd, the line cannot be perfectly centered; put the extra stitch on the same side every time so the lines look aligned.
6. Both put words before the eyes of the household every day so that they would be remembered and taught to children. They differ in source and aim: Creasey's verse is a moral saying praising learning and virtue, while Deuteronomy commands God's own words to be in the heart, taught diligently to children, and written on the house. A Christian stitcher might value Creasey's good advice, but Scripture carries God's authority.

2.8 QUILTS AND THE QUILTING BEE

OBJECTIVES

- Distinguish patchwork (piecing and appliqué) from quilting, and explain the three layers of a quilt and why they are stitched together.
- Explain the quilting bee as both work and fellowship, and how mill-made cotton cloth changed American quilting in the 1800s.
- Piece, layer, hand-quilt and bind a small nine-patch quilt, calculating seam allowances and fabric needs.

Warm-up. Find the oldest quilt or blanket in your family and ask who made it, when, and from what. If there is none, look at a quilt in a store or a museum photo. Count the blocks and look for the tiny quilting stitches that hold the layers together. Write down three things you learned.

Video slot. Video coming. Hand quilting and the quilting frame; piecing a nine-patch block; Harriet Powers’s Bible Quilt at the Smithsonian. Search approved channels (Smithsonian National Museum of American History, International Quilt Museum, a public-library craft channel); preview first.

KEY TERMS

patchwork (piecing)

Sewing small pieces of cloth edge to edge, with seams, to make a larger cloth or quilt top.

appliqué

Sewing cut shapes of cloth on top of a background cloth, turning the edges under (say “ap-lee-KAY”).

batting

The soft middle layer of a quilt (cotton, wool or polyester) that traps air for warmth; older books call it wadding or filling.

quilting

Stitching through all three layers of a quilt (top, batting, backing) to hold the filling in place, usually in a decorative pattern.

seam allowance

The strip of fabric between the cut edge and the stitching line; quilters use a standard $\frac{1}{4}$ inch.

binding

A strip of fabric folded over and sewn around the raw edges of a finished quilt.

CORE IDEAS

People often use “quilt” for any bed cover made of patches, but quilters distinguish two separate crafts. **Patchwork** is the making of the decorative top, either by piecing small shapes together with seams or by appliquéing shapes onto a background. **Quilting** is the stitching that fastens three layers together: the top, a soft middle layer of **batting**, and a backing cloth. Marie Webster, whose 1915 book was one of the first serious histories of the American quilt, put the difference memorably: patchwork comes from the desire for beauty, quilting from the need for warmth (see the Primary source box). Many quilts unite both. A plain whole-cloth quilt, though, is all quilting and no patchwork.

Quilting is old and practical. Quilted, padded garments were worn under armor in medieval Europe, and quilted petticoats and bed covers kept households warm through northern winters. English and Dutch settlers brought the craft to America. In the 1600s and 1700s, imported fabric was expensive, so quilts were often whole-cloth or made from carefully saved pieces, and every worn garment was turned into something else. The mills of the 1800s changed that. As American and British factories turned out cheap printed cotton by the mile, patchwork tops of many fabrics became affordable for ordinary families, and the familiar block quilt, with repeated squares such as the Nine Patch, Log Cabin or Star, became a national art.

Hand quilting is slow. A fine quilter makes 8 to 12 tiny running stitches per inch through all three layers, rocking the needle with a thimble. A bed quilt may hold many thousands of yards of stitching. That is why the **quilting bee** mattered. When a top was finished, it was stretched with its batting and backing in a large wooden frame, and neighbors gathered around it to quilt together. Webster quotes the historian Alice Morse Earle: “Around the outstretched quilt a dozen quilters could sit.” Twelve people working at once could finish in a day or two what would take one person weeks, and they talked, ate and prayed together while they did it. Bees were also held for husking corn, raising barns and spinning; they were how scattered rural families turned hard work into fellowship.

Quilts also served larger causes. Album or friendship quilts, popular from the 1840s, gathered blocks signed by many friends, often as a gift for a family moving west or a minister leaving a church. During the Civil War, women’s aid societies in the North sent huge numbers of quilts and comforters to soldiers through the U.S. Sanitary Commission; estimates run into the hundreds of thousands. Church groups held bees to make quilts for missionaries, orphanages and the poor, following the pattern of Dorcas in Acts 9, whose friends showed Peter “the coats and garments which Dorcas made.”

One of the most remarkable American quilts was made by Harriet Powers (1837–1910), who was born into slavery near Athens, Georgia, and after emancipation farmed with her husband and family in Clarke County. A devout Christian, she made her **Bible Quilt** around 1885–1886 with eleven appliquéd panels telling stories from Scripture: Adam and Eve, Cain and Abel, Jacob’s ladder, the birth of Christ, the Last Supper and the crucifixion among them. She showed it at the Athens Cotton Fair of 1886, where an artist named Jennie Smith asked to buy it. Powers at first refused. Some years later, in hard times, she offered it for ten

dollars; Smith could pay only five, and Powers, after consulting her husband, accepted. Before parting with it, she explained every panel, and Smith wrote her explanations down. The quilt is now in the Smithsonian's National Museum of American History.

Making a quilt rewards planning. Every piece is cut with a **seam allowance** of $\frac{1}{4}$ inch on each side, so a square that will finish at 3 inches is cut at $3\frac{1}{2}$. Seams are pressed, not ironed back and forth, to keep the pieces square. The three layers are basted together with long temporary stitches or safety pins so they will not shift. Quilting usually begins in the center and works outward, smoothing any fullness toward the edges. Last comes the **binding**, which wraps the raw edges and takes the most wear.

A quilt joins many small pieces into one useful whole, and a quilting bee joins many people into one work. Both are good pictures of what this trail has been about: patient handwork, done willingly, for others.

PICTURE STUDY



Bible Quilt, Harriet Powers, c. 1885–1886 · Cotton, pieced and appliquéd; hand and machine stitched · Smithsonian National Museum of American History, Washington, D.C.
Wikimedia Commons · Public domain

Harriet Powers knew the Bible stories well and told them in cloth. Each of the eleven panels is a scene, cut from fabric and sewn onto a background, with small figures, animals, stars and the sun and moon. Jennie Smith recorded Powers's own explanations of the panels, so we know which story each one tells. A second Powers quilt, made in the 1890s and now in the Museum of Fine Arts, Boston, mixes Bible stories with remembered local events such as remarkable storms and the "dark day" of 1780.

Look closely

- Find the panel with Adam and Eve and the serpent. How does Powers show the garden with only a few shapes?
- Find the crucifixion panel. What shapes surround the cross, and what might they mean?
- Look at the way the panels are framed by strips of cloth. Is this quilt mostly piecing, mostly appliqué, or both?

Talk about it

1. Powers used her quilt to tell Scripture to others. Why might pictures in cloth be a powerful way to teach the Bible, especially to people who could not read?
2. Powers parted with her quilt in hard times for five dollars. What does it tell you about her that she insisted on explaining every panel before she let it go?

Safety first. Rotary cutters are razor-sharp: close the blade guard every time you set it down, cut away from your body on a cutting mat, and use one only with a parent present. An iron is hot enough to burn; keep the cord out of the way and set the iron upright when not pressing. Keep pins and needles counted and in a pincushion.

HANDS-ON: A NINE-PATCH MINI QUILT AND A FAMILY BEE

You will piece a nine-patch block, layer it with batting and backing, hand-quilt it, and bind it into a 9-inch mini quilt (a table mat, wall hanging or doll quilt). Then hold a short family quilting bee in which everyone puts in some stitches, as in the scene Webster quotes. If you later wish to sell quilted items (Trail D), a parent must approve and sign off first.

You will need

- Cotton fabric in two contrasting colors, each at least 8 by 12 inches (prewashed)
- A 12-inch square of cotton batting and a 12-inch square of backing fabric
- A ruler, a fabric pencil, and scissors (or a rotary cutter and mat with a parent)
- Pins, a hand-sewing needle (or a short “between” quilting needle), cotton thread, and a thimble
- An iron and ironing board
- A 2-by-42-inch strip of fabric for binding (or two shorter strips sewn together)

Steps

1. **Cut.** Cut five 3½-inch squares of one color and four of the other. Check every square with the ruler.
2. **Piece the rows.** Lay out the squares in a checkerboard. Sew each row with a ¼-inch seam (by hand with small backstitches, or by machine with a parent). Press the seams toward the darker fabric.
3. **Join the rows.** Pin the rows together, matching seams exactly, and sew. Press. The block should measure 9½ inches.

4. **Layer and baste.** Lay the backing face down, the batting on top, and the block face up in the center. Baste with long stitches in a large X and around the edges, or use safety pins.
5. **Quilt.** With a thimble, quilt $\frac{1}{4}$ inch inside each square, working from the center out. Aim for even stitches; count your stitches per inch on one line.
6. **Hold a bee.** Invite family members to add a line of quilting each. Read Acts 9:36–39 aloud while you work, as church sewing circles often did.
7. **Bind.** Trim the layers to the block's edge. Fold the binding strip in half lengthwise, sew it to the front edge, fold it to the back, and hem it down by hand.

Check your work

- My cut squares were $3\frac{1}{2}$ inches and my block measures 9 inches finished.
- My seams match at the corners within about $\frac{1}{8}$ inch.
- My quilting goes through all three layers with even stitches, and I recorded my stitches per inch.
- My binding covers all raw edges, and at least one other person stitched on my quilt.

FIELD NOTEBOOK

1. **Cross-section diagram.** Draw and label the three layers of a quilt, the quilting stitches running through them, and the binding wrapping the edge.
2. **Block design page.** On graph paper, design two more blocks you could make next (for example, a Four Patch and a simple Star). Write the cut size of each piece with seam allowances.
3. **Narration.** Write one paragraph telling the story of Harriet Powers's Bible Quilt: who made it, what it shows, how it left her hands, and why it matters. A parent keeps this page.

Did you know? Quilters have named hundreds of blocks: Bear's Paw, Jacob's Ladder, Churn Dash, Drunkard's Path, Log Cabin, Ohio Star and many more, and the same block often goes by different names in different regions. Marie Webster also designed quilts; her appliqué designs appeared in the *Ladies' Home Journal* in 1911, and she later sold patterns from her home town of Marion, Indiana. A finished bed quilt can contain well over 100,000 hand stitches.

Primary source. *Marie D. Webster, Quilts: Their Story and How to Make Them (New York: Doubleday, Page, 1915). Project Gutenberg eBook #24682. The first passage is Webster's own definition, from the opening pages; the second is from her chapter "The Quilt in America," where she quotes Alice Morse Earle's Home Life in Colonial Days (1898).*

Patchwork—the art of piecing together fabrics of various kinds and colours or laying patches of one kind upon another, is a development of the primitive desire for adornment. Quilting—the method of fastening together layers of cloths in such

a manner as to secure firmly the loose materials uniformly spread between them, has resulted from the need of adequate protection against rigorous climates.

“Around the outstretched quilt a dozen quilters could sit, running the whole together with fanciful set designs of stitchery. Sometimes several quilts were set up, and I know of a ten days’ quilting bee in Narragansett in 1752.”

Use the first passage in practice problem 1 and the second in practice problem 6.

Go deeper. Marie D. Webster, *Quilts: Their Story and How to Make Them* (1915), free at Project Gutenberg. Alice Morse Earle, *Home Life in Colonial Days* (1898), free at Project Gutenberg, with chapters on spinning, weaving and quilting. Online: the Smithsonian National Museum of American History’s page on Harriet Powers’s Bible Quilt; the International Quilt Museum (Lincoln, Nebraska). Second video topic: “Baltimore album quilts.”

Goes deeper in. History, “Colonial Family Life” and “The Civil War Home Front”; Small Business & Economics, “Cloth, Mills and Prices”; Art, “Pattern and Color” (coming soon).

For families. Sources: Webster, quoted exactly from Project Gutenberg (her definition appears in the book’s opening pages; the bee passage is her quotation of Alice Morse Earle); Smithsonian National Museum of American History (Bible Quilt, about 1885–1886; Athens Cotton Fair, 1886; Jennie Smith’s account of the sale); Museum of Fine Arts, Boston (Pictorial Quilt). The year of the sale is given differently in different accounts (around 1890 to 1891), so the stop says “some years later.” Numbers of Sanitary Commission quilts are estimates. Powers’s life in slavery is stated plainly and briefly; parents may add more from the Smithsonian page. Any selling of finished work requires a parent’s sign-off.

PRACTICE

1. **EASY** Using Webster’s definitions, what is the difference between patchwork and quilting, and what need does each answer?
2. **EASY** Name the three layers of a quilt from top to bottom.
3. **MEDIUM** A square should finish at 4 inches. What size should you cut it? What is the cut size of a nine-patch block made of these squares, and its finished size?
4. **MEDIUM** Why did patchwork quilts with many different fabrics become far more common in America during the 1800s?
5. **CHALLENGE** A twin quilt top is to finish at 63 by 81 inches using 9-inch finished blocks. How many blocks across and down, and how many blocks in all? If each block holds about 40 inches of quilting and a quilter sews 10 stitches per inch at 20 stitches a minute, how many hours of quilting are in the blocks?
6. **CHALLENGE** In the passage Webster quotes, a dozen quilters sit around one quilt. Using your answer to problem 5, how long would the 21 hours of quilting take twelve people working together, if the work divides evenly? Name two reasons, beyond speed, that

bees mattered in rural communities, and one reason the work would not divide perfectly in real life.

Make it a game · Name That Block. A parent prints or draws eight traditional quilt blocks (Nine Patch, Four Patch, Log Cabin, Ohio Star, Bear's Paw, Churn Dash, Flying Geese, Jacob's Ladder) with their names on separate cards. Players match each block to its name. Then each player must explain the name of one block: what in the block looks like a churn, a bear's paw or a ladder? Score a point for each match and a bonus for the best explanation.

Scripture. "Then Peter arose and went with them. When he was come, they brought him into the upper chamber: and all the widows stood by him weeping, and shewing the coats and garments which Dorcas made, while she was with them." (Acts 9:39, KJV)

Dorcas (Tabitha) was "full of good works and almsdeeds" (Acts 9:36). When she died, the widows she had clothed showed Peter the garments she had sewn, and God raised her to life through Peter's prayer. Her needlework was remembered because it was given in love. Many church sewing circles and quilting groups have taken her name and followed her example.

Practice: answers

1. Patchwork pieces fabrics together or lays patches on a background to make a decorative top; it answers the desire for adornment (beauty). Quilting fastens layers together with the filling held evenly between them; it answers the need for warmth and protection in cold climates.
2. The top (often patchwork), the batting (filling), and the backing.
3. Cut $4\frac{1}{2}$ inches ($\frac{1}{4}$ inch seam allowance on each side). The block is $3 \times 4 = 12$ inches finished, and $12\frac{1}{2}$ inches before it is sewn into a quilt.
4. Factories in Britain and America began producing printed cotton cheaply and in great quantity, so ordinary families could afford many fabrics instead of saving every scrap of costly imported cloth.
5. $63 \div 9 = 7$ blocks across; $81 \div 9 = 9$ blocks down; $7 \times 9 = 63$ blocks. Quilting: $63 \times 40 = 2,520$ inches $\times 10 = 25,200$ stitches $\div 20 = 1,260$ minutes = 21 hours.
6. $21 \div 12 = 1.75$ hours, about 1 hour 45 minutes. Reasons beyond speed (any two): fellowship and friendship among scattered families, sharing news, teaching younger quilters, prayer and mutual help, making gifts for those in need. It would not divide perfectly because quilters have different speeds and skill, people can only reach part of the frame, the quilt must be rolled as sections are finished, and time goes to meals and talk.

TRAIL 2 BADGE QUIZ

The badge quizzes are optional and open to written or oral answers. Show all work on the number problems. Four correct out of five passes the first badge quiz; five correct out of six passes the second. Badges and the certificate are earned by doing the stops, not by scores.

Badge quiz 1 (Stops 1-5)

1. List the steps from sheep to yarn in order, and explain why spinning was the slowest step in making cloth before the 1760s.
2. How is knitted fabric built differently from woven fabric, and what does that difference explain?
3. Your gauge is 20 stitches in 4 inches. How many stitches do you cast on for an 8-inch-wide scarf?
4. What were the 1917 Red Cross muffler's cast-on, width and length, and why was it knitted in "plain knitting" (garter stitch)?
5. Name the stitch used for the outlines and lettering of the Bayeux Tapestry and the method used to fill large areas. Why is it really an embroidery?

Badge quiz 2 (Stops 6-8)

6. Who stitched the oldest known American sampler, about when, and what makes it special besides its age?
7. How did the purpose of the sampler change between the 1500s and the 1700s?
8. A verse line is 70 stitches wide and the stitching area is 120 stitches wide. How many empty stitches go on each side to center it? How wide is the line on 14-count Aida?
9. Why does Elizabeth Creasey's 1686 sampler spell "than" as "Then" and "virtue" as "vertue"?
10. Name the three layers of a quilt, and explain the difference between patchwork and quilting.
11. Who made the Bible Quilt now in the Smithsonian, about when, and what does it show?

TRAIL CERTIFICATE: MY NEEDLEWORK COLLECTION AND TRAIL B CERTIFICATE

Assemble three finished pieces: the garter-stitch scarf (with its written four-line pattern), the sampler with its cross-stitched verse (with the graph-paper chart), and the hand-quilted nine-patch.

Add a one-page maker's record for each piece: the materials, the measurements and gauge, the hours spent, what you would do differently, and the primary source that inspired it.

Choose your best narration paragraph from the trail and revise it into a polished half-page essay titled "Thread and Faithfulness: What Needlework Teaches." Quote at least one Scripture from the trail (KJV) and one historical source.

When all pieces are finished, a parent reviews the work and signs the Trail B certificate.

- **Craftsmanship:** Stitch counts are consistent; edges are straight; cross stitches slant one way; quilting goes through all layers; ends are hidden and the backs are tidy.
- **Planning and math:** Gauge, yardage, chart counts, centering and seam allowances are calculated correctly and recorded with the work shown.
- **History and sources:** The student explains each craft's history accurately and uses at least three primary sources from the trail with correct attribution.
- **Writing and reflection:** The essay is clear and well organized, uses Scripture accurately, and reflects thoughtfully on patience, service and work done "heartily, as to the Lord."

Answer key

1. Shear, skirt, scour, card (or comb), spin, ply. Every inch of thread had to be twisted by hand on a spindle or wheel, so several spinners were needed to supply one weaver; machines like the spinning jenny and water frame changed this.
2. Knitting is one continuous strand formed into loops pulled through loops; weaving crosses two sets of threads (warp and weft). It explains why knitting stretches in every direction and can unravel from a pulled end.
3. $20 \div 4 = 5$ stitches per inch; $5 \times 8 = 40$ stitches.
4. 50 stitches, at least 11 inches wide, 68 inches long. Garter stitch lies flat, does not curl, looks the same on both sides, and is simple enough for any knitter.
5. Stem (outline) stitch for outlines and lettering; laid and couched work for filling. It is an embroidery because the pictures are stitched onto finished linen, not woven into the cloth.
6. Loara Standish, daughter of Myles Standish of Plymouth Colony, probably in the 1640s. It is also the earliest known sampler anywhere with a stitched verse.
7. In the 1500s and 1600s it was mainly an adult's record of stitches and patterns to copy (a "set of patterns"). By the 1700s and 1800s it was mainly a child's school exercise in stitches, alphabets and numerals for marking linen, with a verse, name, age and date.
8. $(120 - 70) \div 2 = 25$ stitches on each side. $70 \div 14 = 5$ inches.
9. English spelling was not yet standardized by dictionaries in 1686, and children stitched the spellings their teachers set; it is not simply a mistake.
10. Top, batting and backing. Patchwork is making the decorative top by piecing or appliqué; quilting is stitching through all three layers to hold them together.
11. Harriet Powers of Clarke County, Georgia, about 1885-1886. Its eleven appliquéd panels show Bible stories, from Adam and Eve and Cain and Abel to the birth of Christ, the Last Supper and the crucifixion.

CRAFTS AND MAKING ≈ TRAIL C: PAPER AND HAND CRAFTS

The third trail of the Crafts and Making track works with paper and small hand crafts and the history behind each: paper itself, from Egyptian papyrus and Han China to the Italian mill and the wood-pulp machine; origami and the mathematics of the fold; the broad pen and the Western alphabet; cards, stationery and the penny post; paper quilling from convent to colonial Boston; pressed flowers and the botanist's herbarium; bookbinding from scroll to codex; and beading and simple jewelry, with what Scripture says about ornament.

This is the ● **Expert** level, for students 14 and up, at high-school depth. Each stop takes 35 to 50 minutes and stands by itself. A student reads the core ideas alone, works from a primary source where one exists (Jeremiah, Johnston, Lewis Carroll, Matthew, Cockerell and Exodus), makes the project, answers practice questions that include two challenge problems, and writes a one-paragraph narration that the parent keeps. Each stop adds a **sample page** to the Field Notebook, and the projects build toward the track's hand-bound notebook (Stop C7), which can hold the whole trail.

Five stops earn the **Paper and Hand Crafts Expert badge, part 1**; all eight earn part 2 and the **Trail C certificate**. Badges are earned by doing the stops; the badge quizzes below are optional checks.

BEFORE YOU BEGIN

- Read a page of nineteenth-century or King James English and say what it means in your own words.
- Measure in inches and millimeters, work with fractions and decimals, and use the area of a circle ($A = \pi r^2$).

MASTERY CHECKLIST

- ☐ I can trace paper from papyrus and Cai Lun to the Fabriano mill and the paper machine, and explain why some old books crumble.
- ☐ I can fold a crane, read its crease pattern and test a vertex with Maekawa's and Kawasaki's rules.
- ☐ I can write a foundational-hand alphabet with a broad pen and name the main Western book hands in order.
- ☐ I can make a card, envelope, quilled panel, pressed-flower bookmark and a measured bracelet, using grain, measurement and labeling correctly.
- ☐ I have sewn a hand-bound notebook and filled it with eight sample pages and eight narrations.

OPTIONAL BOOKS AND RESOURCES

- **Project Gutenberg: Johnston, Carroll and Cockerell** (<https://www.gutenberg.org>): Free texts used as primary sources: Edward Johnston, *Writing & Illuminating, & Lettering* (#47089); Lewis Carroll, *Eight or Nine Wise Words about Letter-Writing* (#38065); Douglas Cockerell, *Bookbinding, and the Care of Books* (#26672); and Jane Austen, *Sense and Sensibility* (#161) for Stop C5.
- **Robert C. Williams Museum of Papermaking (Georgia Tech)** (<https://paper.gatech.edu>): Online exhibits on papermaking history and the Dard Hunter collection, for Stop C1.
- **British Library: Lindisfarne Gospels and St Cuthbert Gospel** (<https://www.bl.uk>): Free online pages and page images for Stops C3 and C7; search the site for each manuscript.
- **Library of Congress Prints and Photographs Online Catalog** (<https://www.loc.gov/pictures>): Japanese woodblock prints, including Isoda Koryūsai's paper-crane print (Stop C2), and Encyclopédie plates.
- **New York Public Library Digital Collections** (<https://digitalcollections.nypl.org>): Anna Atkins's *Photographs of British Algae* (Stop C6), free to view.
- **Massachusetts Historical Society: Object of the Month** (<https://www.masshist.org>): Mary Woodbury's quillwork scone of about 1730 (February 2024), for Stop C5.

3.1 PAPER: FROM PAPYRUS TO THE PAPER MILL

OBJECTIVES

- Tell papyrus, parchment and true paper apart by how each is made, and say why only one of them is really “paper.”
- Trace paper’s 1,500-year journey from Han China through Samarkand, Baghdad, Spain and Italy to England and Pennsylvania, with dates.
- Explain how the rag shortage, the paper machine and wood pulp changed the cost and the life span of paper.

Warm-up. Tear a sheet of printer paper slowly and hold the torn edge up to a light. Look for the tiny hairs sticking out of the tear. Those are plant fibers, matted together like felt. Now ask: could you make a sheet like this from a plant without tearing it into fibers first? The ancient Egyptians did something like that. Read on to see why it was not quite paper.

Video slot. Video coming. Hand papermaking with a mould and deckle; the history of paper from China to Europe; making papyrus from the papyrus plant. Search approved channels (Robert C. Williams Museum of Papermaking, British Library, Library of Congress, Smithsonian); preview first.

KEY TERMS

papyrus

A writing sheet made in ancient Egypt by laying thin strips of the papyrus reed’s pith in two crossed layers and pressing them until they bond. It is laminated, not pulped, so it is not true paper.

parchment

Animal skin (calf, sheep or goat) soaked in lime, scraped, stretched and dried to make a strong writing surface; the finest calfskin is called vellum.

pulp

Plant fibers beaten apart and floated in water. Every true paper, ancient or modern, begins as pulp.

mould and deckle

The papermaker’s tools: a wooden frame covered with a fine screen (the mould) and a loose rim laid on top (the deckle) that holds the pulp in and sets the sheet’s edges.

watermark

A design made by bending wire onto the mould. The pulp lies thinner over the wire, so the design shows when the sheet is held to the light. Italian mills were using them by the late 1200s.

ream

A papermaker's count of sheets: in the old system 20 quires of 24 sheets (480); today usually 20 quires of 25 (500).

CORE IDEAS

For about three thousand years the Mediterranean world wrote on **papyrus**. The Egyptians cut the tall reed that grew in the Nile marshes, sliced its white pith into strips, laid one layer across another and pressed and dried them. The plant's own sap glued the sheet, and sheets were pasted end to end into rolls. The oldest papyri with writing on them, the logbook of an official named Merer who hauled stone for the Great Pyramid, date to about 2560 BC. Papyrus was light and cheap in Egypt, but it cracked when folded and rotted in damp climates, which is why most ancient papyri survive only in the dry sands of Egypt. The other great writing surface was **parchment**, made from animal skins: tough and long-lasting, but costly. When Jeremiah's scribe Baruch wrote God's words "upon a roll of a book," the roll was papyrus or leather.

True paper is different in kind. To make it, plant fibers are beaten apart into **pulp**, stirred into water, and lifted out on a screen, where they settle and mat together into a sheet. Chinese records credit the court official Cai Lun with presenting the method to the Han emperor in AD 105, using tree bark, hemp, rags and old fishing nets. Archaeologists have since found scraps of hemp paper in China a century or two older, so Cai Lun probably improved and promoted the craft rather than inventing it from nothing. Either way, the Chinese had a cheap, foldable, smooth surface centuries before anyone else, and they used it for books, letters, wrapping, kites and, later, money.

Paper moved west slowly. It reached Samarkand in Central Asia by the 700s. A famous story says Chinese papermakers captured at the Battle of Talas in 751 taught the craft there; historians now treat that as a legend, since paper was already known along the Silk Road. What is certain is that Baghdad had a paper mill by the 790s, under the Abbasid caliphs, and that paper made possible the huge libraries and copying houses of the Islamic world. From there it crossed North Africa to Muslim Spain, where Xàtiva was a papermaking town by the 1100s, and then into Christian Europe.

Italian papermakers at Fabriano, by the late 1200s, made three changes that defined European paper for five hundred years. They used water-powered hammers to beat linen rags into pulp, they sized the sheets with animal gelatin so ink would not bleed, and they bent wire into the mould to make **watermarks**, which served as a mill's trademark. Paper mills followed in Germany (Nuremberg, 1390), England (John Tate in Hertfordshire, about 1490) and English America (William Rittenhouse at Germantown, Pennsylvania, 1690). At each mill a vatman dipped the **mould and deckle** into the vat, gave it a shake to lock the fibers, and handed it to a coucher, who turned the wet sheet out onto felt. A skilled team could form a few thousand sheets in a long day, counted in quires and **reams**.

Paper made printing practical. When Johannes Gutenberg printed his Bible in Mainz around 1455, he made perhaps 180 copies; most were on paper, and about a quarter on vellum. By one common estimate, each vellum copy took the skins of some 170 calves. Without paper,

the printed book would have stayed a luxury. But rag paper had its own limit: there were only so many worn-out shirts and sheets. By the early 1800s, mills in Europe and America advertised for rags and still ran short.

Two inventions broke the bottleneck. The Frenchman Nicolas-Louis Robert built a machine in 1798 that formed paper on an endless moving screen; the Fourdrinier brothers in England financed and improved it in the 1800s, and the paper machine still bears their name. Then, in the 1840s, Friedrich Gottlob Keller in Saxony showed that ground-up wood could replace rags, and chemical wood pulps followed. Paper became cheap enough for daily newspapers, schoolbooks for every child and paper bags. Here is the honest complexity: much nineteenth-century wood-pulp paper was sized with alum and rosin, which made it acidic. Many books from 1850 to 1950 are now yellow and brittle, while rag paper from the 1400s is still white and supple. Since the 1980s most book paper has been made acid-free.

The paper in your hands is the work of many peoples over many centuries. Christians have special reason to care: the Scriptures were copied on papyrus and parchment for fifteen centuries before they were printed on paper, and the Bible itself records a king who tried to destroy God's word by burning it, and failed.

PICTURE STUDY

Papermaking: the vat room, from the Encyclopédie, Engravers of Diderot and d'Alembert's Encyclopédie (the trade plates were drawn largely by Louis-Jacques Goussier), Plates published 1762–1772 · Copper engraving · Many libraries; digitized copies at the Library of Congress, the University of Chicago ARTFL project and Wikimedia Commons

The great French *Encyclopédie*, edited by Denis Diderot and Jean le Rond d'Alembert, set out to describe every art and trade. Its eleven volumes of plates show workshops step by step, often with a numbered key, so that a reader could understand a craft without visiting it. The papermaking plates show a French mill of the 1700s, which worked almost exactly as Fabriano had five hundred years before.

Look closely

- Find the vatman. What is he holding, and which way is he tipping it?
- Find the coucher and the pile of felts. Why must each wet sheet be laid on felt and not on the next sheet?
- Find the press. How much water do you think it squeezes out, and where does the water go?

Talk about it

1. The plate shows people, not machines, doing every step. Which steps did the Fourdrinier machine take over, and which would still need a person?
2. Why might an encyclopedia editor think it worth paying engravers to show a trade in such detail?

Safety first. An adult runs the blender for the pulp and keeps hands out of the jar; unplug it before scraping. Wipe up water on the floor at once, and keep the electric iron (if used for drying) on a low setting with an adult nearby.

HANDS-ON: MAKE PAPER WITH A MOULD AND DECKLE

Pull your own sheets of true paper from recycled scrap, the way a vatman did, and test them against the sheet you tore in the warm-up.

Read the Primary source box first. As your sheets dry, think about what it cost Baruch to write the whole roll a second time.

You will need

- Two matching picture frames or a wooden embroidery hoop (about 5 by 7 inches), with window screen or fine mesh stapled tightly across one frame (the mould); the other frame left open (the deckle)
- Scrap paper without plastic coating (printer paper, envelopes, egg cartons), torn into postage-stamp pieces and soaked in water for an hour or overnight
- A blender (adult use only)
- A plastic tub larger than the frame, half full of water
- Felts: old dish towels, felt squares or cotton fabric; a sponge
- Optional: a twist of thin wire for a watermark, a few flower petals or threads

Steps

1. Have an adult blend a handful of soaked scrap with about four times as much water until it looks like thin oatmeal. Pour it into the tub and stir. More pulp makes a thicker sheet.
2. Optional watermark: bend the wire into your initial and sew it onto the screen with thread.
3. Hold the deckle on top of the mould, screen side up. Slide them down into the far side of the tub, bring them level under the surface and lift straight up.
4. Give the frame a gentle shake side to side and front to back as the water drains. This is the vatman's shake that locks the fibers together.
5. Lift off the deckle. Turn the mould face down onto a damp felt in one firm motion (this is couching), sponge the back of the screen to push out water, and lift the mould away.
6. Lay another felt on top and repeat. Make at least four sheets. Press the stack under a board and some heavy books for ten minutes, then peel each sheet off and dry it flat on a window or a smooth board.
7. When dry, compare your sheet with machine-made paper: hold both to the light, tear both, and write on both with a pen. Record what you see.

Check your work

- I made at least four sheets of true paper from pulp.

- I can name the mould, the deckle, couching and the vatman's shake.
- I compared my sheet with machine paper by light, tear and ink, and wrote down the differences.

FIELD NOTEBOOK

1. **Trail C sample page 1: Paper.** Glue in a small piece of your handmade sheet beside a piece of printer paper. Label each: fibers, edges, watermark (if any), how it took ink.
2. Draw a timeline from 2560 BC to AD 1840 and mark: Merer's papyri, Cai Lun (105), Baghdad mill (790s), Xàtiva (1100s), Fabriano (late 1200s), Nuremberg (1390), Gutenberg (about 1455), Rittenhouse (1690), Robert's machine (1798), Keller's wood pulp (1840s).
3. **Narration (one paragraph; the parent keeps it):** Explain in your own words why papyrus is not true paper, and why the change from rags to wood pulp made paper both cheaper and, for a time, worse.

Did you know? The rough, feathery edge on handmade paper is called a *deckle edge*, from the deckle that sets it. Machine-made paper is sometimes given a fake deckle edge to look old-fashioned. Hold a sheet of laid paper to the light and you may see fine parallel lines (laid lines) and wider-spaced chain lines: the print of the wires of the mould.

Primary source. *Jeremiah 36:2, 4, 23 and 28, King James Version (1611). The prophet Jeremiah dictated God's words to his scribe Baruch; King Jehoiakim had the roll read to him in his winter house about 604 BC.*

Take thee a roll of a book, and write therein all the words that I have spoken unto thee against Israel, and against Judah, and against all the nations, from the day I spake unto thee, from the days of Josiah, even unto this day. ...

Then Jeremiah called Baruch the son of Neriah: and Baruch wrote from the mouth of Jeremiah all the words of the LORD, which he had spoken unto him, upon a roll of a book. ...

And it came to pass, that when Jehudi had read three or four leaves, he cut it with the penknife, and cast it into the fire that was on the hearth, until all the roll was consumed in the fire that was on the hearth. ...

Take thee again another roll, and write in it all the former words that were in the first roll, which Jehoiakim the king of Judah hath burned.

Go deeper. Mark Kurlansky, *Paper: Paging Through History* (2016), a readable world history. Dard Hunter, *Papermaking: The History and Technique of an Ancient Craft* (1947), the classic by an American who made paper by hand himself. The Robert C. Williams Museum of Papermaking (Georgia Tech, paper.gatech.edu) has online exhibits

and pages on the Dard Hunter collection. Second video topic: how modern paper machines and the Fourdrinier wire work.

Goes deeper in. History, “The Ancient Near East and Egypt” and “The Printing Press and the Reformation,” and Small Business & Economics, “Inventions That Lowered Costs” (coming soon).

For families. Sources: British Library and Library of Congress pages on the history of paper; Kurlansky (2016); Hunter (1947). Dates for early Chinese paper, the Talas story, the first Baghdad mill (usually given as about 794–795) and Xàtiva vary a little between historians; the stop gives the common ones and calls the Talas prisoners a legend. The Gutenberg Bible figures (about 180 copies, roughly 135 on paper and 45 on vellum) and the “170 calfskins” per vellum copy are estimates, often repeated, and are used here only for practice. Pliny the Elder describes papyrus making in his *Natural History* (book 13, chapters 21–23, in the Bostock and Riley translation on Project Gutenberg, volume 3, ebook #59131); our tools could not reach that chapter to copy it exactly, so it is recommended rather than quoted. Whether Jeremiah’s roll was papyrus or leather is not stated in Scripture; Jeremiah 36:23 suggests a roll that could be cut and burned in sections.

PRACTICE

1. **EASY** What is the difference between how papyrus and true paper are made?
2. **EASY** Name the three improvements Fabriano’s papermakers made.
3. **MEDIUM** In the Primary source, what did King Jehoiakim do to the roll, and what did God command afterward? What does that show about the word of God compared with the material it is written on?
4. **MEDIUM** Why are many books printed between 1850 and 1950 brittle and yellow, while some books from the 1400s are still in good condition?
5. **CHALLENGE** An old ream was 20 quires of 24 sheets; a modern ream is 20 quires of 25. How many sheets are in each? A printer ordering 50 reams by the old count instead of the new receives how many fewer sheets?
6. **CHALLENGE** Suppose Gutenberg printed 45 copies on vellum and each took about 170 calfskins. How many calves is that? If each of the 135 paper copies used about 340 sheets of paper, how many sheets is that, and what does the comparison suggest about why printing spread on paper?

Make it a game • Paper Road Relay. Lay seven sheets of paper across the floor or yard, each labeled with a stop on paper’s road: China, Samarkand, Baghdad, Spain, Fabriano, Nuremberg, Germantown. A caller reads a clue (for example, “first mill in English America,” “wire watermarks,” “Cai Lun”). The runner must stand on the right sheet within five seconds and call out the date. Correct answers move the runner on; a miss passes the turn. Finish by reading the stops in order with their dates, from memory.

Scripture. “Having many things to write unto you, I would not write with paper and ink: but I trust to come unto you, and speak face to face, that our joy may be full.” (2 John 1:12, KJV)

This is the only verse in the King James New Testament that uses the word “paper” (Isaiah 19:7 speaks of Egypt’s “paper reeds by the brooks”). The Greek word John used meant a sheet of papyrus. John was glad of paper and ink, but he knew their limit: a letter is good, and meeting face to face is better.

Practice: answers

1. Papyrus is strips of reed pith laid in crossed layers and pressed (laminated). True paper is made from fibers beaten into pulp, floated in water and lifted onto a screen, where they mat together.
2. Water-powered hammers for beating rags into pulp, gelatin sizing so ink would not bleed, and wire watermarks.
3. As each three or four leaves were read, the king cut them off with a penknife and burned them until the whole roll was gone. God told Jeremiah to take another roll and write all the former words again. The material could be destroyed; the word was not lost, because God had it written again (and Jeremiah 36:32 says many like words were added).
4. The later books were printed on wood-pulp paper sized with alum and rosin, which is acidic and breaks down the fibers over time. The early books were printed on rag (linen) paper sized with gelatin, which is far more stable.
5. Old ream: $20 \times 24 = 480$ sheets. Modern ream: $20 \times 25 = 500$ sheets. Difference 20 sheets per ream, so $50 \times 20 = 1,000$ fewer sheets.
6. $45 \times 170 = 7,650$ calfskins. $135 \times 340 = 45,900$ sheets of paper. Rag paper could be made by a mill in large, steady quantities from waste cloth, while thousands of calfskins were slow and costly to obtain. Paper made large print runs affordable. (The numbers are estimates.)

3.2 ORIGAMI: THE GEOMETRY OF A FOLDED SQUARE

OBJECTIVES

- Describe the two roots of Japanese paper folding, ceremonial wrapping and recreational folding, and date the first origami book (1797).
- Fold a traditional crane, then unfold it and read its crease pattern.
- Test a crease pattern with Maekawa's and Kawasaki's rules and name two modern uses of folding in engineering.

Warm-up. Take any rectangle of paper and make a perfect square from it using no ruler: fold one short edge down to meet a long edge, crease, and cut off the strip. How do you know the result is square? Write one sentence of proof (hint: what does the diagonal fold tell you about the two sides?).

Video slot. Video coming. How to fold a traditional origami crane step by step; the Miura fold and origami in space engineering. Search approved channels (Smithsonian, NASA, Japan Society, OrigamiUSA); preview first.

KEY TERMS

origami

From Japanese *ori* (fold) and *kami* (paper): the art of folding paper into shapes, usually from one uncut square. Older Japanese names include *orikata* and *orisue*.

washi

Traditional Japanese paper made from the long inner-bark fibers of shrubs such as *kōzo* (paper mulberry); thin, strong and able to hold a crease without cracking.

mountain fold and valley fold

The two kinds of crease. A valley fold makes a trough facing you; a mountain fold makes a ridge. Turn the paper over and each becomes the other.

crease pattern

The map of lines left on a square when a finished model is unfolded; designers now often plan models from the crease pattern first.

base

A standard partly folded shape from which many models start, such as the square (preliminary) base and the bird base used for the crane.

flat-foldable

Able to be pressed completely flat without tearing or adding creases. Maekawa's and Kawasaki's rules tell whether a single vertex is flat-foldable.

CORE IDEAS

Paper came to Japan from China by way of Korea. Japan's early chronicle, the *Nihon Shoki*, says a Korean monk named Damjing brought the skills of paper and ink in 610. Japanese makers then developed **washi** from the bark of the paper mulberry. Its long fibers made a sheet thin enough to see light through yet tough enough to fold again and again, and this matters: brittle, short-fibered paper cracks at the crease. Origami grew in a country that had unusually good paper for it.

The first root of origami was ceremony. Among the samurai class of the 1300s to 1500s, schools of etiquette such as the Ogasawara taught exact ways to fold paper wrappers (*tsutsumi*) for gifts, money and medicine, and the folded token called *noshi* that still decorates gifts today. A wrong fold could be a social mistake. The second root was play. Recreational folding shows up in the 1600s and 1700s; a 1680 verse by the poet Ihara Saikaku is often cited for its folded paper butterflies, and Edo woodblock prints, like the one in the picture study, show people folding cranes. In 1797 a Kyoto publisher issued *Hiden Senbazuru Orikata* ("The Secret of Folding a Thousand Cranes"), the oldest known book of recreational folding. Its 49 designs are all cranes, many joined at the wingtips and cut from a single sheet.

Europe had its own, separate folding traditions: napkin folding at grand dinners in the 1600s, the Spanish *pajarita* (little bird), and paper boats and hats. In the 1830s the German educator Friedrich Froebel, who founded the kindergarten, made paper folding one of his "occupations" for teaching shape and number. When Japan opened to the West in the later 1800s, the two streams met, and the word *origami* came into general use.

The modern art owes most to Akira Yoshizawa (1911–2005), a Japanese folder who designed thousands of new models and, with Western writers Samuel Randlett and Robert Harbin, gave the world a standard set of diagram symbols: dashed lines for **valley folds**, dash-dot lines for **mountain folds**, and arrows for each motion. That system lets a folder in Ohio follow a design from Tokyo without a shared language.

Origami is also mathematics. Unfold a crane and you see its **crease pattern**: a web of lines meeting at points called vertices. Two rules govern any vertex that can be folded flat.

Maekawa's theorem: the number of mountain folds and the number of valley folds always differ by exactly two. **Kawasaki's theorem**: if you go around the vertex, adding every other angle, the sum is 180 degrees. These rules are necessary for one vertex; a whole sheet can still fail if the layers would have to pass through each other, and deciding that in general is a very hard problem. Folding can even do what ruler and compass cannot: in 1980 the Japanese mathematician Hisashi Abe published a method to trisect any angle by folding.

Engineers now borrow from the craft. The astrophysicist Koryo Miura designed a fold of slanted parallelograms (the **Miura fold**) that opens and closes in one pull; it was used for a solar panel on Japan's Space Flyer Unit in 1995. The James Webb Space Telescope, launched in 2021, carried its tennis-court-sized sunshield folded inside its rocket and opened it in

space. Doctors are testing folded stents, and car airbags are packed in careful fold patterns so they open evenly.

There is a lesson for makers here. A crane uses no glue, no scissors and nothing added: only one square and patience. Every model is already present in the square as a set of possible creases, and the folder's skill is to find them in the right order. Precision at step three decides whether step twenty works.

PICTURE STUDY

Children Folding a Paper Crane, Isoda Koryūsai, About 1772–1773 · Color woodblock print · Library of Congress, Prints and Photographs Division (Japanese Fine Prints collection)

Isoda Koryūsai worked in Edo (now Tokyo) in the 1760s to 1780s and was known for prints of everyday city life and for pillar prints, tall narrow sheets made to hang on house posts. The Library of Congress catalog titles this print “Children folding a paper crane,” though the figures look like young women. It was made about twenty-five years before the first origami book was printed, which shows that crane folding was already familiar.

Look closely

- Find the paper. How far along is the crane, and what step might come next?
- Find the hands of each figure. Who is folding and who is watching or helping?
- Find the patterns in the clothing. Are any of them folded-paper or crane shapes?

Talk about it

1. A woodblock print could be sold cheaply to many buyers. What does it tell us that a printmaker chose paper folding as a subject?
2. The print and the 1797 book are both evidence for the history of origami. What can a picture show that a book of instructions cannot, and the other way around?

HANDS-ON: FOLD A CRANE, THEN READ ITS CREASE PATTERN

Fold the traditional crane, then unfold it completely and test the mathematics on the creases it leaves behind.

You will need

- Three or four squares of thin paper, 6 inches (15 cm) or larger; origami paper or squares cut from printer paper
- A pencil, a protractor and two colored pencils (one for mountain folds, one for valley folds)
- Optional: a large 10-inch square for a first try

Steps

1. Fold a square base: valley-fold both diagonals, turn over, valley-fold both midlines, then collapse the paper into a small layered square with the open end toward you.

2. Kite-fold the lower edges of the top layer to the center line, fold the top triangle down over them, and unfold these three folds.
3. Petal-fold: lift the bottom point of the top layer up along the crease, pressing the sides in so they meet in the middle. Turn over and repeat. This is the bird base.
4. Narrow both legs by folding the lower edges to the center on each side. Inside-reverse-fold the two narrow points up to make the neck and tail, then reverse-fold one tip to make the head. Gently pull the wings apart.
5. Now unfold the crane all the way back to a square and smooth it. With colored pencils, trace each crease as mountain or valley as seen from one side.
6. Choose the center vertex and one other vertex. At each, count mountain and valley creases (Maekawa) and measure the angles around it, adding alternate angles (Kawasaki). Write the results.
7. Fold a second crane from a fresh square and time yourself. Compare the neatness of the two.

Check your work

- I folded a crane whose wings spread and whose neck and tail stand up.
- I drew the unfolded crease pattern with mountains and valleys marked.
- I tested at least two vertices with Maekawa's and Kawasaki's rules and recorded the numbers.

FIELD NOTEBOOK

1. **Trail C sample page 2: Origami.** Glue in your colored crease pattern (or a tracing of it). Label the bird base lines and write the counts and angle sums for the vertices you tested.
2. Draw the three diagram symbols: valley fold, mountain fold and "turn over."
3. **Narration (one paragraph; the parent keeps it):** Explain the two roots of origami in Japan, and tell what the crease pattern of your crane showed you about the mathematics hidden in a folded square.

Did you know? In Japan a string of a thousand folded cranes (*senbazuru*) is a traditional gift for a wedding, a new baby or someone who is ill. At three minutes a crane, a thousand take fifty hours. Many folders also tuck the crane's wings and fold it from a square of foil candy wrapper; the smallest cranes folded under a microscope are under a millimeter across.

Go deeper. Robert J. Lang, *Origami Design Secrets* (2nd ed., 2011), by a physicist-turned-folder who explains crease-pattern design. David Lister's essays on origami history, collected by the British Origami Society, which separate documented history from legend. Japan Society and the Library of Congress's Japanese Prints collection (search "Koryusai"). Second video topic: the Miura fold and how NASA engineers fold solar arrays and sunshields.

Goes deeper in. Arithmetic, “Angles and Polygons,” Art, “Japanese Prints,” and Geography, “Japan” (coming soon).

For families. Sources: Library of Congress catalog record for the Koryūsai print; British Origami Society history pages (David Lister); Lang (2011); JAXA and NASA pages on the Space Flyer Unit and Webb sunshield. Early origami history is full of unproved claims (for example, that origami goes back to the first arrival of paper); the stop dates only what is documented: the 1797 book, Edo prints and the 1680 Saikaku verse (the last usually cited, but we could not check the original). No public-domain primary text on origami could be copied exactly for this stop, so there is no Primary source box; the print itself serves as the primary evidence. Maekawa’s and Kawasaki’s theorems are stated for a single flat-folded vertex in the interior of the paper.

PRACTICE

1. **EASY** What do the two parts of the word “origami” mean, and what was the first book of recreational origami?
2. **EASY** Why did the quality of Japanese washi matter for origami?
3. **MEDIUM** Name the two roots of Japanese folding and give one example of each.
4. **MEDIUM** Give two modern uses of folding in engineering.
5. **CHALLENGE** A vertex has 4 creases. By Maekawa’s theorem, how many could be mountains and how many valleys? A vertex has 6 creases: what splits are possible?
6. **CHALLENGE** The angles around a vertex, in order, are 40° , 70° , 140° and 110° . Do they total 360° ? Is the vertex flat-foldable by Kawasaki’s theorem? What if they were 40° , 80° , 130° and 110° ?

Make it a game • Fold Off. Each player has five squares. A caller names a model everyone knows (cup, boat, crane, jumping frog) and starts a timer. Points: 3 for the first finished model that the others agree is neat, 1 for every finished model, and a bonus point for anyone who can name the base it starts from. After three rounds, unfold the winning crane and let the winner point out one vertex and prove Maekawa’s rule on it.

Scripture. “But now, O LORD, thou art our father; we are the clay, and thou our potter; and we all are the work of thy hand.” (Isaiah 64:8, KJV)

A folder turns one plain square into a bird, adding nothing and wasting nothing. Isaiah uses a potter for the same idea: the maker sees what the material can become. We are not paper or clay, but the prophet’s point stands: our shape is in our Maker’s hands.

Practice: answers

1. *Ori* = fold, *kami* = paper. *Hiden Senbazuru Orikata* (“The Secret of Folding a Thousand Cranes”), Kyoto, 1797.
2. Its long bark fibers made paper thin but strong, so it could be creased and refolded without cracking.

3. Ceremonial folding (gift wrappers called tsutsumi, the noshi token, etiquette schools such as the Ogasawara) and recreational folding (cranes, butterflies, the 1797 book).
4. Any two: the Miura-fold solar array on Japan's Space Flyer Unit (1995); the folded sunshield and mirror of the James Webb Space Telescope; car airbags; folded medical stents.
5. Mountains and valleys must differ by 2. With 4 creases: 3 mountains and 1 valley, or 1 mountain and 3 valleys. With 6 creases: 4 and 2, or 2 and 4.
6. $40 + 70 + 140 + 110 = 360$. Alternate sums: $40 + 140 = 180$ and $70 + 110 = 180$, so yes. Second set: $40 + 130 = 170$ and $80 + 110 = 190$; not 180, so it cannot fold flat.

3.3 HAND-LETTERING AND CALLIGRAPHY: THE BROAD PEN AND THE WESTERN ALPHABET

OBJECTIVES

- Trace the main Western book hands in order (Roman capitals, uncial, insular half-uncial, Carolingian minuscule, Gothic, humanist and italic) and say who or what drove each change.
- Explain, with Edward Johnston’s own words, why the broad-edged pen shapes the letters it makes.
- Write a foundational-hand alphabet at a fixed pen angle and letter height measured in nib widths.

Warm-up. Tape two sharpened pencils side by side with their points level. Hold them so an imaginary line through both points slants at about 30 degrees from the line of writing. Without turning your hand, draw a circle, a straight down-stroke and a straight side-stroke. Where is the line thick, and where is it thin? You did not press harder anywhere. What made the difference?

Video slot. Video coming. Broad-edged pen calligraphy for beginners: foundational hand and pen angle; how medieval scribes made the Lindisfarne Gospels. Search approved channels (British Library, The Getty, Victoria and Albert Museum, Society of Scribes); preview first.

KEY TERMS

calligraphy

Greek for “beautiful writing”: letters written with a pen or brush in a set order of strokes. Hand-lettering, by contrast, draws and fills letters like small pictures.

broad-edged pen

A pen (quill, reed or steel) with a flat, chisel-shaped nib. Held at a fixed angle, it makes thick and thin strokes by direction alone.

pen angle

The angle of the nib’s edge to the writing line. Johnston’s foundational hand uses about 30 degrees; Roman-style capitals often use about 30 as well, uncials a flatter angle.

x-height

The height of the body of a small letter such as x, a or o, without ascenders or descenders. Calligraphers measure it in nib widths.

minuscule

A lower-case alphabet; the Carolingian minuscule of the 800s is the ancestor of the small letters you read today.

scriptorium

The writing room of a monastery, where books were copied by hand.

CORE IDEAS

Every letter on this page has a history, and most of it was made by a pen. The Romans gave us the capital letters: their finest form is carved at the base of Trajan's Column in Rome (AD 113). Many scholars believe, following the American priest and letterer Edward Catich, that such letters were first painted on the stone with a flat brush, which is why their curves swell and thin and their strokes end in fine *serifs*. For books, Roman scribes wrote quicker capitals with reed pens on papyrus and parchment.

As Christianity spread, so did the copying of Scripture. From the 300s scribes used **uncial**, a rounded capital hand easy to write on parchment. In Ireland and Northumbria monks developed the **insular half-uncial** of the Book of Kells and the Lindisfarne Gospels, where letters first began to stand above and below the line. Then, under Charlemagne in the late 700s, scholars such as Alcuin of York, who became abbot of Tours in 796, promoted a clear, round, separated small hand: **Carolingian minuscule**. Charlemagne wanted correct texts of the Bible and the Church fathers read the same way across his empire, and a readable script served that goal.

Later scribes squeezed the round letters into the tall, dark, angular **Gothic** or *textura* of the 1100s to 1400s, which saved costly parchment and looked like woven cloth (Latin *textus*). Gutenberg cut his first type to match it. Around 1400 in Florence, Poggio Bracciolini and Niccolò Niccoli, hunting for ancient texts, found old Carolingian books and mistook their script for Roman. They copied it as the *littera antiqua* or humanist hand; Niccoli's quick, slanted version became **italic**. In 1501 the Venetian printer Aldus Manutius issued the first italic type, cut by Francesco Griffo. So our "roman" type is really an Italian copy of a Frankish copy of a Roman ideal.

The tool explains the shapes. A **broad-edged pen** held at a steady **pen angle** makes its thickest line when it moves at right angles to its edge and its thinnest when it moves along its edge. The writer does not press harder for thick strokes; direction does the work. That is why an o written at 30 degrees is thick at the left and right but tilted, with its thin parts at the upper left and lower right. Change the angle and you change the whole family of letters.

By 1900 this knowledge had almost been lost. Victorian "illuminators" drew fancy letters with fine pens and filled them in. The English scribe **Edward Johnston** (1872–1944) went to the British Museum and studied the original manuscripts until he worked out how the broad pen had been cut and held. His book *Writing & Illuminating, & Lettering* (1906) taught a new generation, and his "foundational hand," based on a tenth-century English psalter, is still the first hand most students learn. Johnston also designed the lettering used on the London Underground from 1916, the ancestor of many plain modern typefaces.

Numbers keep a hand consistent. In the foundational hand the **x-height** is about four nib widths, measured by stacking little square marks with the pen turned flat; ascenders and descenders add about three more. Italic is usually written five nib widths high at a steeper angle of about 40 to 45 degrees. A scribe in a **scriptorium** ruled each page with pricked

holes and dry-point lines so every line matched, and a large Gospel book could take a single scribe years.

Calligraphy is slow on purpose. A monk copying the Gospels was serving God and the readers who would come after him, and he knew it; one scribe of Lindisfarne, Eadfrith, is remembered only because a later priest wrote his name in the book. Fine writing honors both the words and the reader. That is still true of a hand-lettered verse or a name on a card.

PICTURE STUDY



The Lindisfarne Gospels: opening of St Matthew's Gospel, "Liber generationis" (folio 27r), Attributed to Eadfrith, bishop of Lindisfarne, About 700–720 · Ink and pigments on vellum · British Library, London (Cotton MS Nero D IV)

Wikimedia Commons · Public domain

The Lindisfarne Gospels were made at the monastery of Lindisfarne, on Holy Island off the coast of Northumbria, in honor of St Cuthbert. In the 900s a priest named Aldred added a note saying that Eadfrith, bishop from 698 to 721, wrote the book, and Aldred also wrote an Old English translation between the Latin lines: the oldest surviving English version of the Gospels. This page opens Matthew 1:1, "Liber generationis Iesu Christi" ("The book of the generation of Jesus Christ").

Look closely

- Find the letters L, I and B. How many different patterns fill them?
- Find the rows of tiny red dots. How many do you think are on the page?
- Find the smaller lettering lower down. Which shapes look like capitals and which look like small letters?

Talk about it

1. Why might a scribe spend weeks decorating the first words of a Gospel, when the plain text alone carries the meaning?
2. Aldred's English words were squeezed in between the Latin lines 250 years later. What does that tell you about how the book was used and valued?

HANDS-ON: A FOUNDATIONAL-HAND ALPHABET AND A VERSE

Use the Primary source box as your instruction: a broad nib, steady angle, no pressure. You will rule guidelines by nib widths, write the alphabet, and letter Habakkuk 2:2.

You will need

- A broad-edged calligraphy marker or dip pen (about 3 to 4 mm wide), or the two pencils taped together from the warm-up
- Smooth paper (printer paper works) and a sheet of thick paper underneath as a cushion
- Ruler, sharp pencil, eraser
- Optional: a printed foundational-hand exemplar from the library or Johnston's book (Project Gutenberg #47089)

Steps

1. Measure your nib: with the pen turned flat (edge vertical), make four small square marks stacked like a ladder. That height is your x-height. Add three more for ascender height.
2. Rule five sets of guidelines with that spacing, leaving a gap between sets.
3. Warm up: rows of o's, then rows of n's, holding the pen at 30 degrees the whole time. Check that the thin parts of each o line up diagonally.
4. Write the alphabet in families: round letters (o, c, e, d, q, b, p), arched letters (n, m, h, r, a), straight letters (i, l, t, f, j), diagonal letters (v, w, x, y, k, z) and s and g last.
5. Circle your three best letters and your three worst. For each worst one, write what went wrong (angle drift, wrong height, wobble).
6. On a fresh ruled sheet, write "Write the vision, and make it plain upon tables, that he may run that readeth it." Space words by about the width of an o.
7. Sign it small in the corner, as a scribe might, with the date.

Check your work

- My guidelines are ruled in nib widths: four for the x-height.
- My pen angle stayed near 30 degrees; my o's lean the same way.
- I wrote the whole alphabet and one verse, and I named my faults honestly.

FIELD NOTEBOOK

1. **Trail C sample page 3: Lettering.** Paste in your best alphabet row. Beneath it, write the letter a in five hands as best you can copy them: Roman capital A, uncial, half-

uncial, Carolingian minuscule and italic.

2. Make a one-line timeline: Trajan (113), uncial (300s), Lindisfarne (about 700–720), Alcuin at Tours (796), textura (1100s–1400s), humanist hand (about 1400), italic type (1501), Johnston (1906).
3. **Narration (one paragraph; the parent keeps it):** Explain how the broad pen makes thick and thin strokes without pressure, using Johnston’s words and your own practice as evidence.

Did you know? Medieval scribes cut their quills from the long flight feathers of geese or swans, and the left wing’s feathers were often preferred because they curve away from a right-handed writer. The word *pen* comes from Latin *penna*, feather. A scribe might recut the nib several times a day with a small knife, the original “penknife.”

Primary source. *Edward Johnston, Writing & Illuminating, & Lettering (London, 1906), page 86 of the original edition; Project Gutenberg ebook #47089. Johnston is explaining why a beginner should practice with a broad nib rather than a fine one.*

A broad nib is used in preference to a narrow one, so that the characteristics of true pen-work are brought out and the faults made clear. A fine, light handwriting is often very pretty, but it is certain to mislead the novice in penmanship (see p. 324).

Go deeper. Edward Johnston, *Writing & Illuminating, & Lettering* (1906), free on Project Gutenberg; read chapters on the pen and the foundational hand. Christopher de Hamel, *Meetings with Remarkable Manuscripts* (2016), twelve great manuscripts told by a librarian who handled them. The British Library’s online pages for the Lindisfarne Gospels (with a page-turning viewer). Second video topic: how a scribe cuts a goose quill.

Goes deeper in. Art, “Medieval Manuscripts and Illumination,” History, “Charlemagne and the Carolingian Renewal,” and Literature, “The English Bible” (coming soon).

For families. Sources: British Library pages on the Lindisfarne Gospels and the Ramsey Psalter (Harley MS 2904, Johnston’s model); Johnston (1906); de Hamel (2016). The Johnston excerpt was checked against the Project Gutenberg text phrase by phrase through our web tools, which could show only short pieces at a time; the page reference “(see p. 324)” is Johnston’s own. Dates for the Lindisfarne Gospels vary among scholars (from about 700 to the 720s), and Eadfrith’s authorship rests on Aldred’s tenth-century note, which most historians accept. Catich’s brush theory of Roman capitals is widely held but not proved. Pen angles and nib-width heights are teaching conventions; scribes varied.

PRACTICE

1. **EASY** Put these hands in order, oldest first: italic, uncial, Carolingian minuscule, Roman capitals, Gothic textura.

2. **EASY** Who was Edward Johnston, and what did he rediscover?
3. **MEDIUM** According to the Primary source, why should a beginner use a broad nib instead of a narrow one? Give his two reasons and explain the second in your own words.
4. **MEDIUM** Why did Charlemagne's scholars want a clear, standard script?
5. **CHALLENGE** Your nib is 3.5 mm wide. Using the foundational proportions (x-height 4 nib widths, ascender and descender each 3 more), how tall is the x-height, and how far is it from the top of an ascender to the bottom of a descender? How many writing lines fit on a page 250 mm tall if each line needs that full height plus a 3.5 mm gap?
6. **CHALLENGE** Explain why our everyday "roman" type is, in the stop's words, "an Italian copy of a Frankish copy of a Roman ideal." Name the people or places at each step.

Make it a game · Name That Hand. A parent prints or shows ten images of handwritten or printed letters from different ages (search the British Library or Getty collections: Roman inscription, uncial, Book of Kells, Carolingian, Gothic, humanist, italic, copperplate, a modern typeface, a child's handwriting). Players write the name of each hand and a century. Score 2 for the hand and 1 for the century within 100 years. The winner chooses the next round's images.

Scripture. "And the LORD answered me, and said, Write the vision, and make it plain upon tables, that he may run that readeth it." (Habakkuk 2:2, KJV)

God told Habakkuk to write plainly, so that anyone could read it quickly, even one running past. Beautiful letters are good, but the first duty of a writer is to be read. The best calligraphy, like the Lindisfarne Gospels, is both beautiful and plain.

Practice: answers

1. Roman capitals, uncial, Carolingian minuscule, Gothic textura, italic.
2. An English scribe (1872–1944) who studied old manuscripts in the British Museum and worked out how the broad-edged pen had been cut and held; he wrote *Writing & Illuminating, & Lettering* (1906) and designed the London Underground lettering.
3. It brings out "the characteristics of true pen-work" and makes "the faults made clear." A broad nib exaggerates every mistake in angle and shape, so the learner can see and fix them; a fine, light hand looks pretty and hides errors.
4. Charlemagne wanted correct, readable copies of the Bible and Christian and classical books used the same way across his empire; a clear, separated minuscule made copying and reading more accurate.
5. $x\text{-height} = 4 \times 3.5 = 14 \text{ mm}$. $\text{Full height} = (3 + 4 + 3) \times 3.5 = 35 \text{ mm}$. Each line with gap = 38.5 mm; $250 \div 38.5 \approx 6.5$, so 6 full lines.
6. Roman capitals (Rome, Trajan's Column) set the ideal. Carolingian scribes at Charlemagne's court and Tours (Alcuin) made a clear minuscule in the Frankish kingdom. Around 1400 Florentine humanists (Poggio, Niccoli) copied that Carolingian script, thinking it ancient Roman, and Italian printers (such as Aldus in Venice) cut type from it.

3.4 CARDS AND STATIONERY: THE PENNY POST AND THE ART OF THE LETTER

OBJECTIVES

- Explain how the Uniform Penny Post of 1840 changed letters, envelopes and greeting cards, with the old and new costs.
- Use paper sizes, weights and grain to plan a folded card that fits a standard envelope.
- Write a letter that follows Lewis Carroll's rules from *Eight or Nine Wise Words about Letter-Writing* (1890).

Warm-up. Take a sheet of printer paper and try folding it in half twice: once the long way and once the short way, on two different sheets. Run your fingernail along each fold. Is one fold crisper and straighter than the other? Paper has a “grain,” like wood. Guess which way it runs in your sheet, and keep the guess for the project.

Video slot. Video coming. The Penny Black and Rowland Hill's penny post; the first Christmas card of 1843; how to score and fold a card neatly. Search approved channels (The Postal Museum London, Smithsonian National Postal Museum, Victoria and Albert Museum); preview first.

KEY TERMS

stationer

Originally a medieval bookseller with a fixed stall (Latin *statio*) near a university or cathedral, as opposed to a traveling peddler; now a seller of paper, pens and envelopes, which are called stationery.

Uniform Penny Post

The British postal reform of 10 January 1840, proposed by Rowland Hill: one penny, paid in advance by the sender, for a letter of up to half an ounce to anywhere in the country.

grain

The direction in which most fibers in a machine-made sheet lie. Paper folds cleanly and lies flat along the grain and cracks or buckles across it.

scoring

Pressing a groove along a fold line with a blunt tool (a bone folder or an empty ballpoint pen) before folding, so thick paper bends cleanly.

basis weight (gsm)

The weight of paper, given in grams per square meter. Ordinary copy paper is about 75–90 gsm; card stock is about 200–300 gsm.

A-series sizes

International paper sizes based on a sheet of one square meter (A0) with sides in the ratio 1 to the square root of 2; each halving (A1, A2, A3, A4 ...) keeps the same shape. A4 is 210

by 297 mm.

CORE IDEAS

The word **stationery** has a curious history. In medieval towns most traders traveled from market to market, but booksellers near universities kept a fixed stall, a *statio*, and so were called *stationarii*, or stationers. London's Company of Stationers received a royal charter in 1557 and for a century and a half controlled who could print books. Over time the stationer came to sell the paper, ink, quills, sealing wax and blotting sand that every literate household needed, and his goods took his name.

Before 1840, sending a letter in Britain was expensive and strange. Postage was usually paid by the person who received it, not the sender, and it was charged by distance and by the number of sheets. A single sheet from London to Edinburgh could cost more than a shilling, a day's wage for many workers. People wrote small, then turned the page sideways and wrote across their own lines (a "crossed letter") to save a sheet. Envelopes were rare, because an envelope counted as a second sheet and doubled the charge; instead, the letter was folded into a packet and sealed with wax.

A schoolmaster named Rowland Hill argued in 1837 that most of the cost of the post lay in handling and collecting money, not in carrying letters. If the sender paid one low price in advance, letters would multiply and the post would still pay. Parliament agreed. The **Uniform Penny Post** began on 10 January 1840, and on 6 May 1840 the world's first adhesive postage stamp, the Penny Black, with the young Queen Victoria's head, came into use. The number of letters in Britain roughly doubled in the first year and kept climbing. Envelopes became normal, and a new trade in printed stationery, mourning paper and notepaper with family crests grew up. Other countries soon copied the system; the United States issued its first national stamps in 1847.

Cheap postage made the greeting card possible. In 1843 Henry Cole, a busy civil servant who had helped Rowland Hill, asked the artist John Callcott Horsley to design a printed card so he would not have to write dozens of Christmas letters by hand. About a thousand were printed and the spare ones sold for a shilling each. Within a generation, Christmas and Valentine cards were a large industry. In Boston, the German-born printer Louis Prang made fine color-lithographed Christmas cards from 1875 and is often called the father of the American Christmas card.

A card that looks right depends on paper you cannot see at first glance. Machine-made paper has a **grain**, because fibers line up as the wet web travels down the paper machine; fold along the grain and the crease is sharp, fold across it and it cracks. Thick paper should be **scored** first. Weight is given in **gsm**. Size matters too: most of the world uses the **A-series**, where A4 (210 × 297 mm) folded in half is A5 with the same shape, because the sides are in the ratio 1 : $\sqrt{2}$. In America the standard sheet is Letter, 8½ by 11 inches. Fold a Letter sheet in quarters and you get a card 4¼ by 5½ inches that fits an "A2" envelope (4¾ by 5¾), with an eighth of an inch to spare on each side.

The words still matter most. Lewis Carroll, the Oxford mathematician who wrote *Alice's Adventures in Wonderland*, sold a little stamp case in 1890 with a booklet of advice, *Eight or Nine Wise Words about Letter-Writing*. It is funny, but its rules are sound: write legibly, answer your friend's last letter, keep to the point, and do not fill pages with apologies. The Primary source box gives two of them in his own words. A handwritten card or letter is now rare, which makes it worth more, not less. It tells the reader that someone gave time to them alone.

PICTURE STUDY



A Lady Writing, Johannes Vermeer, About 1665 · Oil on canvas · National Gallery of Art, Washington, D.C.
Wikimedia Commons · CC BY 2.0

Johannes Vermeer of Delft painted only about thirty-five pictures that survive, and several show people writing or reading letters. The Dutch Republic of his day had one of the highest literacy rates in Europe and a busy postal service between its cities, so the letter was a natural subject. Here the writer has paused and looks up, as if someone has just come into the room.

Look closely

- Find the quill and the sheet of paper. How is she holding the pen? Is she right- or left-handed?
- Find the inkwell and the other objects on the table. What do they tell you about her?
- Find where the light falls. Which parts of the painting are brightest?

Talk about it

1. Vermeer does not let us read the letter. Why might a painter leave its words a mystery?

2. What would change in this picture if it were painted after 1840, in the age of envelopes and stamps?

Safety first. Use a craft knife only with a metal ruler, on a cutting mat, cutting away from your fingers, with an adult nearby. Scissors are fine for every step if you prefer.

HANDS-ON: A CARD, AN ENVELOPE AND A LETTER BY CARROLL'S RULES

Find the grain of your paper, make a quarter-fold card and an envelope that fits it, and write a real letter to a relative or friend using the rules in the Primary source box.

You will need

- Two sheets of Letter or A4 paper, one of card stock (about 200 gsm) if you have it
- Ruler, pencil, scissors, glue stick
- A bone folder or an empty ballpoint pen for scoring
- Colored pencils or the broad pen from Stop C3
- A postage stamp and the address of someone you will write to

Steps

1. Test the grain: cut a 2-inch square from a corner and bend it gently both ways, or wet one edge and see which way it curls. The paper bends more easily along the grain. Mark the grain direction with a small arrow in pencil.
2. Plan a quarter-fold card so the main (spine) fold runs with the grain. Score both fold lines with the ruler and bone folder, then fold.
3. Design the front: a pattern, a lettered verse, or a drawing. Leave the inside blank for writing.
4. Make an envelope: lay the folded card in the middle of a sheet turned like a diamond. Fold the side points in over the card, then the bottom point up, and glue the edges where they overlap. Leave the top flap to fold down. Check that the card slides in with a little room.
5. Write a letter on a separate sheet. Before you start, read the Primary source again: write legibly, begin from the other person's last letter or news, ask a real question, and keep apologies short.
6. Sign the card and letter, address the envelope clearly with the return address in the top left corner, and add the stamp. With a parent's permission, mail it.

Check your work

- I found the grain and folded my card with it.
- My envelope fits the card with a little room on every side.
- My letter is legible, answers or asks something real, and follows at least three of Carroll's rules.

FIELD NOTEBOOK

1. **Trail C sample page 4: Stationery.** Paste in your grain-test square with an arrow, a scrap of card stock and a scrap of copy paper, each labeled with its weight in gsm if known.
2. Draw the A-series: a rectangle labeled A0, halved into A1, then A2, A3 and A4, and write “every half keeps the same shape: $1 : \sqrt{2}$.”
3. **Narration (one paragraph; the parent keeps it):** Explain how Rowland Hill’s penny post changed the way people wrote, sealed and sent letters, and how it led to the Christmas card.

Did you know? The Penny Black had no country’s name on it, because Britain was the only country with stamps. To this day British stamps carry the monarch’s head instead of the word “Britain.” Before stamps, some poor families cheated the old system: the recipient would glance at the outside of a letter, read a code of marks the sender had put there, and then refuse to pay for it.

Primary source. *Lewis Carroll, Eight or Nine Wise Words about Letter-Writing (Oxford: Emberlin and Son, 1890), § 3, “How to go on with a Letter”; Project Gutenberg ebook #38065.*

Here is a golden Rule to begin with. *Write legibly.* The average temper of the human race would be perceptibly sweetened, if everybody obeyed this Rule! A great deal of the bad writing in the world comes simply from writing *too quickly*. Of course you reply, “I do it to save *time*”. A very good object, no doubt: but what right have you to do it at your friend’s expense? Isn’t *his* time as valuable as yours?

...

The best subject, to *begin* with, is your friend’s last letter. Write with the letter open before you. Answer his questions, and make any remarks his letter suggests.

Go deeper. Lewis Carroll, *Eight or Nine Wise Words about Letter-Writing* (1890), free and short on Project Gutenberg; read the whole of it. Simon Garfield, *To the Letter: A Celebration of the Lost Art of Letter Writing* (2013). The Postal Museum, London (postalmuseum.org), and the Smithsonian National Postal Museum (postalmuseum.si.edu) pages on the Penny Black and early postal history. Second video topic: how envelopes are made by machine.

Goes deeper in. History, “Victorian Britain and the Industrial Age,” Literature, “Letters and Letter Writers,” and Small Business & Economics, “Prices, Volume and Profit” (coming soon).

For families. Sources: The Postal Museum (London); Smithsonian National Postal Museum; Victoria and Albert Museum on the 1843 Cole-Horsley card. The pre-1840 London-Edinburgh rate and the “day’s wage” comparison are approximate; rates varied by year and route. The size of the first Christmas card printing is usually given as about 1,000 (some accounts give a larger second printing). The Horsley card shows a family toasting with wine, including children, which some Victorians criticized at the time; we did not use it as the picture study. Carroll’s text was checked sentence by sentence against Project Gutenberg #38065; straight quotation marks and apostrophes are as printed there. The story of families reading codes on the outside of letters is told in Rowland Hill’s own pamphlet and in later histories; it may be partly anecdotal.

PRACTICE

1. **EASY** Where does the word “stationery” come from?
2. **EASY** What two big changes did the Uniform Penny Post of 1840 make?
3. **MEDIUM** Why were envelopes rare before 1840 and common after?
4. **MEDIUM** In the Primary source, what reason does Carroll give for writing legibly, and what does he suggest as the best way to begin the body of a letter?
5. **CHALLENGE** A0 has an area of exactly 1 square meter. What is the area of A4? A4 is 210 × 297 mm; check by multiplying and say how close it is.
6. **CHALLENGE** A sheet of 200 gsm card stock is 8½ × 11 inches (0.0603 m²). What does it weigh? A post office’s first-class letter rate covers up to 1 ounce (28.35 g). If your envelope (copy paper) weighs 5 g and your letter is two sheets of 80 gsm Letter paper, will a quarter-fold card plus the letter go for one stamp?

Make it a game • Post Office. Set up a post office with a kitchen scale, a box of “stamps” (stickers) and a rate chart a parent makes up (for example, 1 stamp up to 28 g, 2 stamps up to 56 g). Each player makes or writes three pieces of mail for others in the house, weighs them, stamps them and posts them in a box. One player is postmaster and checks the weight and the address. Mail that is short-paid goes back to the sender. For a second round, switch to the pre-1840 rules: the receiver pays, by the sheet, and may refuse the letter.

Scripture. “As cold waters to a thirsty soul, so is good news from a far country.” (Proverbs 25:25, KJV)

Before telephones, a letter from far away was the only news of a son at sea or a sister across an ocean. Solomon compared it to cold water for someone who is parched. A card in the mail can still be that kind of gift, and the Gospel is the best news from the farthest country of all.

Practice: answers

1. From medieval stationers (*stationarii*), booksellers who kept a fixed stall (*statio*) instead of traveling; the paper goods they sold took their name.

2. One low price (a penny for a half-ounce letter) for any distance in the country, and payment in advance by the sender, shown by a stamp.
3. Postage was charged by the sheet, and an envelope counted as an extra sheet, doubling the cost. Under the penny post, charges went by weight (up to half an ounce for a penny), so an envelope added almost nothing.
4. Writing badly to save your own time wastes your friend's time, and his time is as valuable as yours. Begin from your friend's last letter: write with it open before you, answer his questions and respond to what he wrote.
5. Each step halves the area: $A1 = \frac{1}{2}$, $A2 = \frac{1}{4}$, $A3 = \frac{1}{8}$, $A4 = \frac{1}{16} \text{ m}^2 = 0.0625 \text{ m}^2 = 62,500 \text{ mm}^2$. $210 \times 297 = 62,370 \text{ mm}^2$, very close (the sizes are rounded to whole millimeters).
6. Card: $200 \times 0.0603 \approx 12.1 \text{ g}$. Letter: $2 \times 80 \times 0.0603 \approx 9.6 \text{ g}$. Total with envelope: $12.1 + 9.6 + 5 \approx 26.7 \text{ g}$, just under 28.35 g, so yes, one stamp, but barely. (A thick or square card may also need extra postage for its shape.)

3.5 PAPER QUILLING: FILIGREE FROM CONVENT TO COLONIAL BOSTON

OBJECTIVES

- Trace paper filigree from the gilded paperrolles of European convents to the quillwork of eighteenth-century England and Boston, separating evidence from legend.
- Roll the basic quilling shapes (tight coil, loose coil, teardrop, marquise, scroll) and combine them into a planned design.
- Use geometry to predict the size of a coil from the length and thickness of its strip.

Warm-up. Cut a strip of printer paper about as wide as a pencil lead is long (about $\frac{1}{8}$ inch) and the full length of the sheet. Wind it tightly around a toothpick, slide it off, and let go. Measure how wide it springs open. Now guess: if the strip were twice as long, would the coil be twice as wide? Write your guess down; you will test it later.

Video slot. Video coming. Paper quilling basics: tight coil, loose coil, teardrop and marquise; eighteenth-century quillwork sconces and paperrolles. Search approved channels (Colonial Williamsburg, Winterthur Museum, Metropolitan Museum of Art, Massachusetts Historical Society); preview first.

KEY TERMS

quilling

Rolling narrow strips of paper into coils and pinched shapes and gluing them on edge to make designs. The name is usually explained by the feather quill that strips were once wound around.

filigree

From Latin *filum* (thread) and *granum* (grain): delicate openwork made of fine twisted wire, usually silver or gold. Paper filigree imitated it, and in Jane Austen’s England quilling was simply called “filigree.”

paperrolles

French for “little rolled papers”: gilded or colored paper coils used, from about the 1600s, by nuns and other religious to frame relics and devotional images.

tight coil

A strip rolled and glued closed without being allowed to relax; the basic solid dot of quilling.

loose coil

A coil allowed to unwind inside a set circle before the end is glued; it can be pinched into a teardrop (one point), a marquise or eye (two points), a square or a crescent.

shadow box

A deep frame with glass in front, used to protect raised quillwork from dust and crushing.

CORE IDEAS

Quilling looks like a modern hobby, but it is at least four hundred years old. Its oldest surviving examples are religious. In convents in France, Italy, Spain and the Low Countries, nuns rolled thin strips of gilded or colored paper into tight spirals and set them around relics, small paintings of saints and the Lamb of God, so that the paper glinted like the gold wire filigree that only cathedrals could afford. The French called them **paperolles**. You may read that monks trimmed the gilded edges off Bible pages for the work; that is often repeated, but there is little evidence for it, and the strips were more likely cut from sheets of gilt paper made for the purpose.

In the 1700s the craft moved from the convent to the drawing room. In England it was called **filigree** or paper filigree, and well-to-do young ladies decorated tea caddies, work boxes, picture frames, cabinets and even small baskets with tiny coils, often set on edge so that only the paper's gilt rim showed. In 1766 Hannah Robertson published *The Young Ladies School of Arts* in Edinburgh, a manual that explains how filigree paper was colored, gilded and cut by bookbinders into narrow strips. Materials were sold by stationers ready for use.

Jane Austen's readers knew the craft well. In *Sense and Sensibility* (1811), the scheming Lucy Steele makes a filigree basket for a spoiled child named Annamaria, and Elinor Dashwood offers to help roll her papers. While their hands are busy at the card table, the two women carry on a quiet, painful conversation that no one else in the room can follow. Austen used a well-known pastime as cover for a private battle of words.

Across the Atlantic, Boston was the center of American quillwork in the 1720s to 1750s. Schoolmistresses advertised lessons in quillwork alongside waxwork, japanning and needlework, and daughters of merchant families made **quillwork sconces**: deep, glass-fronted **shadow boxes** with a candle holder in front, filled with gilded and colored paper coils, wax flowers, and flakes of mica that sparkled in the candlelight. Mary Woodbury of Beverly, Massachusetts, made the scone in the picture study about 1730. Only a few dozen such pieces survive, nearly all from in or near Boston, and they are now in major museums. Such lessons and materials were costly, and a finished scone was a sign of a family's education and means.

The method has hardly changed. A strip, today usually $\frac{1}{8}$ inch (3 mm) wide, is wound around a slotted tool or a needle. Let go and it springs open into a **loose coil**; glue the end and it holds. Pinch one side and you have a teardrop; pinch two opposite sides for a marquise or eye; pinch four corners for a square. Leave the ends unrolled and curl them for scrolls, S-shapes and hearts. Every design, from a snowflake to a Boston scone, is made from a few such shapes repeated with care. The skill is in the sameness: twelve petals of a flower must be the same length and pinched the same way, or the eye catches the odd one at once.

Geometry predicts a coil's size. When a strip is wound tight, its edge becomes a disk whose area roughly equals the strip's length times its thickness, because the paper fills the circle with no gaps. Double the length and you double the area, but a circle's area grows with the

square of its radius, so the diameter grows only by about 1.4 times (the square root of 2). That is why quillers cut strips to set lengths before starting: equal lengths make equal coils.

Quilling teaches patience in small things. A single coil is nothing much. A hundred coils, each rolled with the same care, become something a family might keep for three centuries.

PICTURE STUDY

Quillwork sconce, Mary Woodbury (1717–1748) of Beverly, Massachusetts, About 1730 · Gilded and colored paper quillwork, wax, mica and metal in a gilded wooden shadow-box frame (57.1 × 45.1 × 10 cm) · Massachusetts Historical Society, Boston

Mary Woodbury made this sconce as a young woman, probably at a Boston school that taught ornamental arts. She married Dr. Benjamin Jones in 1737 and died at about thirty in 1748, leaving four young children; the sconce was kept by her family and is now at the Massachusetts Historical Society. Look for its object-of-the-month page (February 2024) on masshist.org. Similar American sconces are at the Metropolitan Museum of Art, Winterthur and Colonial Williamsburg.

Look closely

- Find a single flower. How many different coil shapes can you see in it?
- Find the mica. Where is it, and why would it matter when the candle was lit?
- Find the line of symmetry. Is the left side a mirror of the right?

Talk about it

1. Why would a family keep a fragile paper ornament for nearly three hundred years?
2. Quillwork was taught to young women of well-off families as a mark of refinement. What other skills might a school have taught alongside it, and why?

HANDS-ON: A QUILLED PANEL FROM PLANNED STRIPS

Cut your own strips, test the coil geometry, then make a small symmetrical design (a flower, a snowflake or a monogram) in a shadow-box style frame or on card stock.

You will need

- Printer paper in two or three colors (or purchased 1/8-inch quilling strips)
- Ruler, pencil and scissors, or a paper trimmer used by an adult
- A slotted quilling tool, or a round toothpick or large needle with a blunt end
- White glue in a small dish and a toothpick to apply it
- Card stock for a backing; optional shallow box lid or frame
- A circle template (or coins and bottle caps of known size) to make loose coils the same size

Steps

1. Cut strips $\frac{1}{8}$ inch wide along the long side of the sheet (11 inches for Letter paper). Cut half the strips in two to make $5\frac{1}{2}$ -inch strips.
2. Test the geometry: roll a tight coil from a $5\frac{1}{2}$ -inch strip and one from an 11-inch strip. Glue the ends and measure each diameter. Was your warm-up guess right?
3. Practice each basic shape twice: tight coil, loose coil, teardrop, marquise, square, and an open S-scroll and heart.
4. Plan a design on paper first. Draw it full size and count how many of each shape you need. Make all matching petals from strips of the same length, and let each loose coil relax in the same circle of the template.
5. Glue the shapes on edge to the card, working from the center out, with a touch of glue on the bottom edge only.
6. Mount the finished panel in a box lid or frame. On the back, write your name, the date and the number of strips used.

Check your work

- I measured my two test coils and compared them with the prediction.
- My design was planned and counted before I glued anything.
- Matching shapes in my design are the same size and pinched alike.

FIELD NOTEBOOK

1. **Trail C sample page 5: Quilling.** Glue in one sample of each basic shape and label it. Beside them, write the strip length and the measured diameter of your two test coils.
2. Sketch the Woodbury scone's outline and mark its line of symmetry, the candle arm and where the mica is.
3. **Narration (one paragraph; the parent keeps it):** Tell the story of paper filigree from the convent to Boston, and say which part of the usual story (the gilded Bible edges) is not well proved and why.

Did you know? Quillwork has a cousin with the same name: Native American porcupine quillwork, in which the hollow quills of the porcupine are softened, flattened, dyed and stitched onto hide, bark or cloth. It is a separate craft, much older in North America than paper quilling. If you search museum collections for "quillwork," you will find both.

Go deeper. Jane Austen, *Sense and Sensibility* (1811), Volume II, chapters 1-2, for Lucy Steele's filigree basket; free on Project Gutenberg (#161). Massachusetts Historical Society, "Object of the Month," February 2024: Mary Woodbury's quillwork scone (masshist.org). The Metropolitan Museum of Art's online collection: search "quillwork scone" for several Boston examples from 1720-1740. Second video topic: how paperrolles reliquaries were made in French and Flemish convents.

Goes deeper in. Literature, "Jane Austen," History, "Colonial New England," and Arithmetic, "Circles: Area and Radius" (coming soon).

For families. Sources: Massachusetts Historical Society object page on the Woodbury sconce; Metropolitan Museum of Art collection records for American quillwork sconces; Hannah Robertson, *The Young Ladies School of Arts* (Edinburgh, 1766; some sources give 1767 for a later edition). The convent origins of paperrolles are well documented from the 1600s onward; earlier dates and the gilded-Bible-edge story are not, and the stop says so. We meant to give the *Sense and Sensibility* passage as a Primary source, but our tools could not reach that chapter of the Project Gutenberg file to copy it exactly, so it is summarized instead; read the scene with your student at the end of Volume II, chapter 1, and in chapter 2 (chapters 23–24 in editions numbered straight through). The coil formula treats the paper as filling the circle completely; real coils are a little looser, and the tool leaves a small hole in the middle.

PRACTICE

1. **EASY** What were paperrolles, and who made them?
2. **EASY** Name four basic quilling shapes and say how each is made from a loose coil.
3. **MEDIUM** Why did makers of quillwork sconces add mica, and why was a sconce a sign of a family's means?
4. **MEDIUM** In *Sense and Sensibility*, how does Austen use the filigree basket in the story?
5. **CHALLENGE** A strip is 280 mm long and 0.1 mm thick. Rolled tight, its area is about length $\times$ thickness. Find the coil's area and its diameter (area of a circle = πr^2). Then predict the diameter for a 560 mm strip.
6. **CHALLENGE** You cut $\frac{1}{8}$ -inch strips along the 11-inch side of an $8\frac{1}{2} \times 11$ -inch sheet. How many strips do you get? A snowflake needs 6 large teardrops (one full strip each), 12 small teardrops (half a strip each) and 6 tight coils (half a strip each). How many full strips does it take, and how many snowflakes can one sheet make?

Make it a game • Coil Match. Each player secretly rolls five loose coils from strips of lengths chosen from a list (3, $5\frac{1}{2}$, 8 or 11 inches) and lets them relax freely, without a template. Mix all the coils on a tray. Players take turns picking two coils they think came from strips of the same length; the owners say whether they did. A correct pair scores a point. Afterward, discuss which lengths were easiest to tell apart and why the bigger coils differ by less than you would expect.

Scripture. “For who hath despised the day of small things? for they shall rejoice, and shall see the plummet in the hand of Zerubbabel with those seven; they are the eyes of the LORD, which run to and fro through the whole earth.” (Zechariah 4:10, KJV)

The Jews rebuilding the temple after the exile were tempted to despise their small beginnings. God said not to. Quilling is all small things: one coil at a time. The finished work, like the rebuilt temple, comes from faithful care in each small step.

Practice: answers

1. Rolled coils of gilded or colored paper used, from about the 1600s, by nuns and other religious in European convents to frame relics and holy images.
2. Any four: teardrop (pinch one point), marquise or eye (pinch two opposite points), square (pinch four corners), crescent (pinch two points and curve), and the tight coil (rolled and glued without relaxing). Scrolls and hearts leave the ends open.
3. Mica flakes sparkled and reflected the candle's light, multiplying the glow. The schooling, gilt paper, wax and frame were costly, and a girl needed time free from household work to make one.
4. The work at the card table lets Lucy Steele and Elinor sit side by side, busy with their hands, so they can carry on a private, tense conversation that others in the room cannot follow. The craft is cover for what really matters in the scene.
5. $\text{Area} = 280 \times 0.1 = 28 \text{ mm}^2$. $r^2 = 28 \div 3.14 \approx 8.9$, so $r \approx 3.0 \text{ mm}$ and the diameter $\approx 6 \text{ mm}$. Doubling the length doubles the area to 56 mm^2 : $r^2 \approx 17.8$, $r \approx 4.2 \text{ mm}$, diameter $\approx 8.4 \text{ mm}$, about 1.4 times larger, not twice.
6. $8\frac{1}{2} \div \frac{1}{8} = 68$ strips. Snowflake: $6 + (12 \times \frac{1}{2}) + (6 \times \frac{1}{2}) = 6 + 6 + 3 = 15$ strips. $68 \div 15 = 4$ snowflakes, with 8 strips left over.

3.6 PRESSED-FLOWER BOOKMARKS: THE HERBARIUM AND THE SCIENCE OF DRYING

OBJECTIVES

- Explain how the herbarium, from Luca Ghini in the 1540s to Linnaeus and today's great collections, made pressed plants a tool of science.
- Press flowers correctly, label them like a botanist, and explain why some colors last and others fade.
- Make a sealed bookmark that pairs a pressed specimen with a lettered verse.

Warm-up. Pick two flowers or leaves from the yard (with permission): one thin and flat, one thick and juicy. Weigh each on a kitchen scale if you have one, or simply squeeze each between two paper towels. Which leaves a wet mark? A fresh petal can be more than four-fifths water. Where must that water go before the flower can be kept?

Video slot. Video coming. How botanists press and mount herbarium specimens; Anna Atkins and the first cyanotype photographs of plants. Search approved channels (Royal Botanic Gardens Kew, Smithsonian National Museum of Natural History, Natural History Museum London, New York Botanical Garden); preview first.

KEY TERMS

herbarium

A collection of pressed, dried plants mounted on sheets and labeled for study; also the building that houses one. The old Latin name was *hortus siccus*, “dry garden.”

specimen label

The record that makes a pressed plant useful to science: name, place (as exact as possible), date, habitat and collector.

blotter

Thick, absorbent paper (or newspaper, or plain paper towels) placed on both sides of a plant in the press to draw out water.

anthocyanins

The plant pigments that make many reds, purples and blues. They change with acidity and fade in light, so these colors often turn brown or pale when pressed.

carotenoids

The pigments of yellow and orange flowers (and carrots). They are more stable than anthocyanins, so yellows usually keep their color well.

cyanotype

A photographic print in white on deep blue, made by laying an object on paper coated with iron salts and setting it in sunlight; invented by Sir John Herschel in 1842.

CORE IDEAS

People have tucked flowers between the pages of books for as long as there have been books, but pressing plants became a science in sixteenth-century Italy. The physician **Luca Ghini** (about 1490–1556), who taught medicine and botany at Bologna and Pisa, is credited with being the first to dry plants under pressure, glue them onto paper and bind them as a book for study. Medicine then depended on plants, and a doctor needed to know the true plant from its look-alikes in winter as well as in summer. Ghini's students carried the method across Europe, and the **herbarium**, or dry garden, became as important to botanists as the living garden.

Over the next two centuries naturalists sailed with explorers and brought back pressed plants by the thousand. The Swedish botanist Carl Linnaeus (1707–1778), who gave plants their two-part Latin names in *Species Plantarum* (1753), made one sensible change: he kept specimens on loose sheets in a cabinet instead of in bound books, so they could be reordered as new kinds were found. Nearly every herbarium in the world still works that way. The largest, such as those of the Muséum national d'Histoire naturelle in Paris and the Royal Botanic Gardens at Kew, each hold several million sheets. Scientists still use them to name new species, to trace where plants grew a century ago, and even to extract DNA.

A pressed plant is only as useful as its **specimen label**. A beautiful pressed violet with no place or date tells a botanist almost nothing; a plain one labeled "wet roadside ditch, 2 miles north of the church, 12 May 1885" can show how a region has changed. The same habit will make your bookmark a record and not just a decoration.

Pressing is a race between drying and decay. A fresh petal may be more than 80 percent water. If it dries slowly, mold grows and the cells' own enzymes turn it brown. So the plant is laid flat between **blotters** that soak up the water, and the stack is weighted so the cells collapse flat instead of shriveling. Changing the blotters after two or three days speeds the drying. Thin flowers with flat faces (pansies, violets, ferns, cosmos, single petals of larger blooms) press best; thick ones like roses or daisies with fat centers should be split or pressed petal by petal. Pick in dry weather after the dew has gone, and press within an hour.

Color depends on chemistry. Yellows and oranges come from **carotenoids**, which are stable, so buttercups and goldenrod stay bright for years. Many reds, purples and blues come from **anthocyanins**, which change with acidity and break down in light; they often fade or turn brown, though some blues, such as larkspur and lobelia, hold well. White petals tend to turn cream or tan. Green leaves fade as chlorophyll breaks down. The one rule for every color: keep finished work out of direct sunlight.

One woman joined the herbarium to the new art of photography. **Anna Atkins** (1799–1871), the daughter of a scientist at the British Museum, had collected and pressed seaweeds for years. When her family's friend Sir John Herschel invented the **cyanotype** in 1842, she laid her pressed algae directly on the light-sensitive paper and set them in the sun. From 1843 she issued *Photographs of British Algae: Cyanotype Impressions* in parts, with handwritten text also printed by the same process. It is often called the first book illustrated with

photographs. The poet Emily Dickinson, as a girl in the 1840s, made a herbarium of more than four hundred specimens, now at Harvard. Pressing and labeling plants trained both women to look closely.

There are rules of good conduct. Pick only common plants, never protected or rare ones; ask permission on private land; take nothing from national parks, where it is forbidden; and follow the botanist's rule of taking no more than one plant in twenty from a patch. Jesus told His disciples to "consider the lilies," to look closely at what God has made. A pressed flower in a Bible is a small way of doing just that.

PICTURE STUDY



*A plate from Photographs of British Algae: Cyanotype Impressions, Anna Atkins, 1843–1853 · Cyanotype (photographic print made in sunlight with iron salts) · Copies at the British Library, the Natural History Museum (London), the New York Public Library and a few other libraries
Wikimedia Commons · Public domain*

Each plate was made by laying a pressed and dried seaweed on paper brushed with a solution of iron salts, covering it with glass, and leaving it in the sun. Where the plant blocked the light the paper stayed white; everywhere else it turned Prussian blue when washed in water. Atkins made thousands of these prints by hand for a small number of copies of her book, which she sent to friends and scientific societies.

Look closely

- Find the finest branch of the seaweed. How thin is it? Could a drawing show it as well?
- Find the name written below. How did Atkins make the writing white too?
- Find any place where fronds overlap. What happens to the color there?

Talk about it

1. Why would a botanist trust this print more than a drawing of the same plant, and what can it not show that the real specimen can?
2. Atkins first pressed and dried the plant, then photographed it. How does her method join an old craft to a new invention?

Safety first. Learn to recognize poison ivy, poison oak and stinging nettle before collecting, and do not press plants that are poisonous to handle or eat (for example foxglove or lily of the valley) if small children are in the house. Wash hands after collecting. Use scissors or a craft knife carefully, with an adult nearby.

HANDS-ON: A PRESSED-FLOWER BOOKMARK WITH A VERSE AND A LABEL

Session 1 (today): collect, press and label. Session 2 (in one to three weeks): assemble and seal the bookmark, lettering the Primary source verse on it in the hand you learned at Stop C3.

You will need

- Small flat flowers and leaves, gathered with permission: pansies, violas, ferns, clover, cosmos, larkspur, single petals
- A flower press, or a heavy book with newspaper or plain paper towels as blotters, and more books for weight
- Pencil and small slips of paper for field labels
- Card stock cut to 2 × 7 inches (5 × 18 cm)
- Clear self-adhesive laminating sheets or clear contact paper; tweezers; a small brush; white glue thinned with a few drops of water
- Optional: a hole punch and ribbon

Steps

1. Collect after the dew has dried. Take a few more than you need, choosing the flattest and freshest. Keep them in a paper bag out of the sun and press within an hour.
2. Lay each plant flat on a blotter, spread the petals and leaves with the brush, cover with a second blotter and close the book or press. Slip a field label in beside each one: common name, place, date, your name.
3. Weight the book with more books and leave it in a dry place. After two or three days, change the blotters carefully. Check again after a week; specimens are ready when they feel papery and cool to the touch.
4. Session 2: letter Matthew 6:28 (or part of it) at the top of the card strip. Arrange the pressed pieces below with tweezers before gluing anything.
5. Fix each piece with tiny dots of thinned glue. Write the specimen label small on the back: name, place, date, collector.
6. Seal both sides with laminating sheet, smoothing from the center out to push out air. Trim, leaving a clear margin of $\frac{1}{8}$ inch. Punch a hole and add a ribbon if you like.

Check your work

- My flowers were dried flat without mold and kept their shape.
- My bookmark has a full specimen label on the back.
- The verse is lettered neatly, and the seal is smooth with no bubbles.

FIELD NOTEBOOK

1. **Trail C sample page 6: Pressed flowers.** Mount one extra pressed specimen as a botanist would, with a strip of paper tape and a full label in the lower right corner.
2. Make a color record: for each flower you pressed, note its color fresh and after pressing, and whether its pigment is likely carotenoid (yellow/orange) or anthocyanin (red, purple, blue).
3. **Narration (one paragraph; the parent keeps it):** Explain why a pressed plant with a good label is useful to science, and what Anna Atkins added to the old craft of pressing plants.

Did you know? Herbarium specimens are often stored with a few crystals of insect repellent or frozen for several days when they arrive, because tiny cigarette beetles and other pests love dried plants. Some specimens in European herbaria are over four hundred years old. Scientists have used old sheets to learn when trees leafed out and flowers bloomed in past centuries, by reading the dates on the labels.

Primary source. *Matthew 6:28-29, King James Version (1611). From the Sermon on the Mount: Jesus teaches His disciples not to be anxious about food and clothing.*

And why take ye thought for raiment? Consider the lilies of the field, how they grow; they toil not, neither do they spin: And yet I say unto you, That even Solomon in all his glory was not arrayed like one of these.

Go deeper. Royal Botanic Gardens, Kew, pages on the Kew Herbarium and how to press plants (kew.org). The New York Public Library's digital collections include Anna Atkins's *Photographs of British Algae* (digitalcollections.nypl.org). Houghton Library, Harvard, has digitized Emily Dickinson's herbarium. A good wildflower field guide for your region (such as a Peterson or Newcomb's guide from the library), to name what you press. Second video topic: how to make cyanotype "sun prints" of leaves at home.

Goes deeper in. Life Science, "Plants: Structure and Classification," Gardening & Animals, "Flowers and the Garden Year," and Art, "Botanical Illustration" (coming soon).

For families. Sources: Royal Botanic Gardens, Kew; Natural History Museum, London; New York Public Library on Anna Atkins; Houghton Library on the Dickinson herbarium. Ghini's place as the first to make a herbarium is the usual account, though no herbarium of his own survives; those of his students do. Collection sizes are rounded (several million specimens each). "More than 80 percent water" is typical of petals, which vary. Whether

Atkins's work or Talbot's *The Pencil of Nature* (1844–1846) should be called the first photographically illustrated book depends on definitions; Atkins began first, but her book was privately issued in very few copies. Rules on picking plants differ by state and on public lands; check before collecting.

PRACTICE

1. **EASY** What is a herbarium, and who is usually credited with making the first one?
2. **EASY** Name the four or five things a good specimen label records.
3. **MEDIUM** Why do yellow flowers usually keep their color when pressed while many red and purple ones fade or brown?
4. **MEDIUM** In the Primary source, what does Jesus tell His disciples to do, and what comparison does He make? How does pressing a flower carefully fit His command?
5. **CHALLENGE** A fresh flower weighs 2.0 g and is 85% water. When fully pressed it has lost nearly all its water. About how much will it weigh? If you change blotters every 3 days and the flower takes 2½ weeks to dry, how many blotter changes is that?
6. **CHALLENGE** A patch of violets has 60 plants. By the one-in-twenty rule, how many may you take? Why does the rule exist, and why might a botanist refuse to collect at all from a patch of 15 rare orchids?

Make it a game · Botanist's Label. A parent hides five pressed or fresh leaves around the house or yard, each with a card giving one clue (where it grew, what month it was picked). Players find each one and write a full specimen label for it: name (if they can find it in a field guide), place, date, habitat and collector. The best, most complete set of labels wins; a missing place or date costs a point, just as it would cost a real herbarium its usefulness.

Scripture. “The grass withereth, the flower fadeth: but the word of our God shall stand for ever.” (Isaiah 40:8, KJV)

Even the best-pressed flower fades in time; colors go and petals crumble. Isaiah set that fading against God's word, which does not. A pressed flower kept in a Bible holds both truths between two pages.

Practice: answers

1. A collection of pressed, dried, labeled plants mounted for study (a “dry garden”); Luca Ghini, in sixteenth-century Italy.
2. The plant's name, the place (as exact as possible), the date, the habitat and the collector's name.
3. Yellows and oranges come from carotenoids, which are chemically stable. Many reds and purples come from anthocyanins, which change with acidity and break down in light.
4. He tells them to “consider the lilies of the field, how they grow,” and says that Solomon in all his glory was not dressed like one of them. Pressing and labeling a flower means looking closely at how God has made and clothed it, which is what “consider” asks; and it reminds us that God provides.

5. Dry matter = 15% of 2.0 g = 0.3 g, so it will weigh about 0.3 g. 2½ weeks = 17-18 days; $17 \div 3 \approx 5.7$, so about 5 changes (on days 3, 6, 9, 12 and 15).
6. $60 \div 20 = 3$ plants. The rule leaves enough plants to set seed and keep the patch alive. With only 15 plants of a rare species, even one taken is a large share, and the rule would allow less than one plant; many rare plants are also protected by law.

3.7 SIMPLE BOOKBINDING: FROM SCROLL TO CODEX TO YOUR OWN NOTEBOOK

OBJECTIVES

- Explain why the codex replaced the scroll and why early Christians adopted it so quickly.
- Calculate leaves and pages for folio, quarto and octavo sheets, and plan a signature with the grain running parallel to the spine.
- Sew a hand-bound notebook with a five-hole pamphlet stitch, judging it by Douglas Cockerell's standard for a good binding.

Warm-up. Take a sheet of printer paper and fold it in half, then in half again, then in half a third time, keeping the folds stacked like a little booklet. Number the pages 1, 2, 3 ... without cutting the folds. Now unfold the sheet. Where did page 1 end up, and which pages are upside down? Printers had to plan this for every sheet of every book.

Video slot. Video coming. How to sew a five-hole pamphlet stitch notebook; how medieval books were sewn on cords; the St Cuthbert Gospel. Search approved channels (British Library, Library of Congress conservation, Folger Shakespeare Library, Victoria and Albert Museum); preview first.

KEY TERMS

codex

A book of folded leaves fastened at one edge, as opposed to a scroll; Latin for a block of wood, from the wooden writing tablets that came first.

signature

A group of sheets folded together to be sewn as one unit (also called a gathering or section). A book is a stack of signatures sewn to each other.

folio, quarto, octavo

Sizes named for how many times a printed sheet is folded: once (folio, 2 leaves), twice (quarto, 4 leaves) or three times (octavo, 8 leaves).

leaf and page

A leaf is one piece of paper in a book; it has two pages, front (recto) and back (verso).

kettle stitch

The linking stitch near the head and tail of the spine that chains each signature to the one below it when a book of many signatures is sewn.

awl

A sharp, pointed tool for piercing sewing holes through folded paper.

CORE IDEAS

For most of ancient history a book meant a scroll. A roll of papyrus might be 20 or 30 feet long; to find a passage near the end, a reader unrolled the whole of it with one hand while rolling up the other. Romans also used wooden tablets coated with wax, hinged together for notes. By the first century AD some Romans were folding parchment sheets and fastening them at one edge into a **codex**, and the poet Martial praised pocket editions in this new form. It held writing on both sides, packed more text into less space, and let a reader turn straight to any page.

The surprising fact is who adopted it first. Among surviving Greek literary manuscripts of the second century, the great majority are still scrolls. Among Christian copies of the Scriptures from the same century, nearly all are codices. Scholars still debate why. A codex could hold all four Gospels or all of Paul's letters in one volume; it was easier to search during worship and teaching, to compare passages, and to carry on missionary journeys. Paul himself asked Timothy to bring "the books, but especially the parchments" (2 Timothy 4:13). Whatever the reason, by about AD 400 the codex had won, and the Bible was the book that carried it.

The oldest bindings that survive come from Egypt: the leather-covered codices found at Nag Hammadi, from the 300s, and Coptic books sewn with a chain stitch through the folds. The oldest European book still in its original binding is the **St Cuthbert Gospel**, a small copy of the Gospel of John made in Northumbria around 700 and placed in St Cuthbert's coffin; its tooled red leather cover is still intact. The British Library bought it in 2012. Medieval binders later sewed signatures onto raised cords of leather, laced the cords into heavy wooden boards, and added metal clasps to keep the parchment from cockling.

Every book begins as sheets folded into **signatures**. Fold a sheet once and it makes 2 leaves, 4 pages: a **folio**. Fold it twice: 4 leaves, 8 pages, a **quarto**. Three times: 8 leaves, 16 pages, an **octavo**. Each fold doubles the leaves. Printers laid out the pages on each side of the sheet so that after folding they came in the right order (the arrangement is called imposition). The grain of the paper must run parallel to the spine, or the pages will not lie flat and the book will fight to stay shut.

Sewing is the heart of binding. A single signature can be sewn on its own with a **pamphlet stitch** through three or five holes in the fold. A thick book needs many signatures sewn one after another, each joined to the last with a **kettle stitch** at head and tail, and often onto cords or tapes across the spine. Glue holds the cover on; sewing holds the book together. In the 1820s English binders began covering books in cloth over boards made separately (the "case"), and by the 1850s machines could fold, sew and case books by the thousand. Today many paperbacks are not sewn at all but glued at the cut edge, which is why their pages fall out.

Douglas Cockerell (1870–1945), who trained under T. J. Cobden-Sanderson at the Doves Bindery and taught at London's Central School of Arts and Crafts, wrote the standard handbook *Bookbinding, and the Care of Books* in 1901. He judged bindings by plain tests: Does the book open freely? Are the leaves held in order? Will the cover protect it for

centuries? His opening paragraph is in the Primary source box. Many bindings in his day failed those tests because of cheap acid leather and weak structure, and he said so bluntly.

A hand-bound notebook is not a museum piece, but it obeys the same rules. Grain parallel to the spine, holes evenly spaced, thread pulled snug but not cutting the paper, and a cover that guards the pages. A book made that way can be used hard for years.

PICTURE STUDY



The Bookbinder (Der Buchbinder), from the *Book of Trades*, Jost Amman (woodcut), with verses by Hans Sachs, 1568 · Woodcut, from *Eygentliche Beschreibung aller Stände auff Erden* (Frankfurt: Sigmund Feyerabend) · Many libraries and print rooms; digitized copies on Wikimedia Commons and at major libraries

Wikimedia Commons · Public domain

Jost Amman, a Swiss-born artist working in Nuremberg, made more than a hundred woodcuts of trades for this book, each with a short rhyming verse by the shoemaker-poet Hans Sachs in which the craftsman describes his own work. The *Book of Trades* was printed only about a century after Gutenberg, when the demand for bound books was rising fast.

Look closely

- Find the press. What is clamped in it, and what might the binder be doing to the edges?
- Find the second worker. What step of binding might that be?
- Find any finished books. Are they thick or thin? Do you see clasps or cords on the spines?

Talk about it

1. Amman shows the trade as a workshop with more than one worker. Which steps of binding need a second pair of hands?

2. Why might a book about trades, printed in 1568, have been popular with buyers in a growing city like Frankfurt or Nuremberg?

Safety first. Pierce holes with the awl into a phone book, old magazine or folded cardboard, never toward your other hand. Use a blunt-tipped needle if you can, and keep needles in a pincushion when not in use. A craft knife, if used to trim the cover, needs a metal ruler, a cutting mat and an adult nearby.

HANDS-ON: A HAND-BOUND NOTEBOOK (FIVE-HOLE PAMPHLET STITCH)

Bind a 24-page notebook for your Field Notebook from one signature, then test it against Cockerell's standard in the Primary source box. A second, optional signature lets you try a two-section book.

You will need

- 6 sheets of Letter or A4 paper (for the pages) and 1 sheet of card stock or decorative heavy paper (for the cover)
- A bone folder or the back of a spoon
- An awl or a pushpin, and an old magazine or phone book to pierce into
- A blunt bookbinding or tapestry needle
- Waxed linen thread, or strong cotton thread run across a candle stub or beeswax, about 3 times the height of the book
- Ruler, pencil, binder clips or clothespins

Steps

1. Find the grain of the paper (bend test, as in Stop C4). The fold you make must run with the grain.
2. Fold each sheet in half and nest the six together inside the folded cover. This is one signature: 6 sheets, 12 leaves, 24 pages. Crease the fold firmly with the bone folder and clip the edges so nothing shifts.
3. Make a hole guide from a strip of scrap paper the height of the book: mark the center, then points 1 inch from the head and tail, then points halfway between. Open the signature to its middle, lay it over the magazine with the fold in the gutter, and pierce all layers at the five marks.
4. Sew from the inside: start at the center hole (3) leaving a 3-inch tail inside. Go out at 3, in at 2, out at 1, back in at 2; then, inside, skip over 3 and go out at 4 (this makes the long inside stitch from 2 to 4). Go in at 5, out at 4, and come back in through 3. Check the spine: the outside thread should now cover every gap from hole 1 to hole 5.
5. Make sure the tail and the needle end lie on opposite sides of the long inside stitch. Tie them in a square knot over that stitch, so that the knot traps it. Pull snug along the fold first, then tie. Trim the ends to half an inch.
6. Test your book: open it flat at the middle and at page 2; close it; shake it gently by the cover. Write your name, the date and the words "Bound by hand" on the last page.

7. Optional: make a second signature and link it to the first with a kettle stitch at each end hole, for a two-section book.

Check your work

- My fold runs with the grain, and the book opens and closes without springing.
- The five holes are evenly spaced, and the thread is snug without tearing the paper.
- The knot is inside, around the long center stitch, and the ends are trimmed.

FIELD NOTEBOOK

1. **Trail C sample page 7: Bookbinding.** Draw the path of the five-hole pamphlet stitch, numbering the holes and the order of the thread.
2. Make a three-row table: folio, quarto, octavo. For each, record folds, leaves and pages, and draw how the sheet is folded.
3. **Narration (one paragraph; the parent keeps it):** Explain why the codex replaced the scroll and why Christians used it so early, then tell how your notebook meets or falls short of Cockerell's two reasons for binding a book.

Did you know? The little letters and numbers (A, A2, B, B2 ...) at the foot of some pages in old books are *signature marks*. They told the binder which folded sheet was which, so the signatures could be gathered in the right order. Turn to the bottom of a page in an old hymnal or Bible and you may still find them.

Primary source. *Douglas Cockerell, Bookbinding, and the Care of Books (first published 1901), Chapter I, Introduction, opening paragraph; Project Gutenberg ebook #26672 (from a later printing edited by W. R. Lethaby).*

The reasons for binding the leaves of a book are to keep them together in their proper order, and to protect them. That bindings can be made, that will adequately protect books, can be seen from the large number of fifteenth and sixteenth century bindings now existing on books still in excellent condition. That bindings are made, that fail to protect books, may be seen by visiting any large library, when it will be found that many bindings have their boards loose and the leather crumbling to dust.

Go deeper. Douglas Cockerell, *Bookbinding, and the Care of Books* (1901), free on Project Gutenberg (#26672); read chapters on folding and sewing. Keith A. Smith, *Non-Adhesive Binding* (vol. 1, *Books without Paste or Glue*), a clear modern guide to sewn structures. The British Library's web pages on the St Cuthbert Gospel and its binding. Second video topic: sewing a multi-signature book with the kettle stitch.

Goes deeper in. History, "The Early Church" and "The Printing Press and the Reformation," and Arithmetic, "Doubling and Powers of Two" (coming soon).

For families. Sources: Cockerell (1901), checked phrase by phrase against Project Gutenberg #26672; British Library on the St Cuthbert Gospel (Add MS 89000); C. H. Roberts and T. C. Skeat, *The Birth of the Codex* (1983), for the Christian preference for the codex. The figures for second-century manuscripts are drawn from surviving finds, mostly from Egypt, so they show a strong trend rather than an exact count, and scholars still debate the reasons. The date of the St Cuthbert Gospel is given by the British Library as the early 700s. The Amman woodcut is described from the usual reproductions; details of the figures vary slightly between printings.

PRACTICE

1. **EASY** Give two advantages of a codex over a scroll.
2. **EASY** According to the Primary source, what are the two reasons for binding a book?
3. **MEDIUM** What evidence does Cockerell give that good bindings can be made, and what evidence that bad ones are made? What would a library visitor see?
4. **MEDIUM** Why must the paper's grain run parallel to the spine?
5. **CHALLENGE** A printer folds each sheet as an octavo. How many leaves and pages does one sheet make? How many sheets are needed for a 320-page book? If each sheet were folded four times (a sextodecimo), how many sheets would that book need?
6. **CHALLENGE** Your notebook has one signature of 6 nested sheets. Which page numbers are printed on the very center sheet (the innermost one)? Which pages share the outermost sheet with page 1?

Make it a game · Scroll or Codex Race. Write the numbers 1 to 30 in order on a long strip of paper taped into a roll, and the same numbers on the pages of a folded booklet. A caller names a number; one player must find it in the scroll and another in the codex, and the first to point to it wins the round. After ten rounds, total the wins. Then talk about why early Christian teachers, looking up passages in the Gospels or the Prophets, might have preferred the codex.

Scripture. “And further, by these, my son, be admonished: of making many books there is no end; and much study is a weariness of the flesh.” (Ecclesiastes 12:12, KJV)

The Preacher wrote this long before printing, and it is truer now than ever. He does not forbid books; he warns that books are endless and study tires us, so we must choose what is worth our time, beginning with the words of the wise “given from one shepherd,” which he calls “goats” and “nails” in the verse before. A notebook you bind yourself deserves the best words you can put in it.

Practice: answers

1. Any two: writing on both sides; more text in less space; you can turn straight to any page; easier to carry; a whole set of texts (such as the four Gospels) fits in one volume.
2. To keep the leaves together in their proper order, and to protect them.

3. Good: many fifteenth- and sixteenth-century bindings still protect their books in excellent condition. Bad: in any large library, many bindings have loose boards and leather “crumbling to dust.”
4. Paper folds cleanly and bends easily along the grain. If the grain runs across the spine, the fold cracks, the pages resist turning and do not lie flat, and the covers may warp.
5. Octavo: 3 folds, 8 leaves, 16 pages. $320 \div 16 = 20$ sheets. Four folds: 16 leaves, 32 pages per sheet, so $320 \div 32 = 10$ sheets.
6. With 24 pages, the innermost sheet carries the middle four pages: 11, 12, 13 and 14. The outermost sheet carries pages 1, 2, 23 and 24 (page 1 and page 24 on one side, 2 and 23 on the other). The two pages on the same side of a sheet always add to 25.

3.8 BEADING AND SIMPLE JEWELRY: ORNAMENT, TRADE AND RESTRAINT

OBJECTIVES

- Describe how beads served as ornament, offering, money and prayer-counters, from ancient Israel and Egypt to Venice and colonial New England.
- Make a strung piece with a crimped clasp and a wire-wrapped simple loop, sized by measurement.
- Weigh, from Scripture, both the giving of ornaments to God and the warning against trusting in outward adorning.

Warm-up. Measure around your wrist with a strip of paper and mark where the end meets. Lay the strip on a ruler. Now gather ten beads, buttons or dried peas of the same size and line them up against the ruler. How many would it take to go around your wrist, with a little room to spare? Write your estimate before you count.

Video slot. Video coming. How to make a simple wire loop with round-nose pliers and how to crimp a clasp on beading wire; the history of Venetian glass beads and wampum. Search approved channels (Smithsonian, Corning Museum of Glass, Metropolitan Museum of Art, Plimoth Patuxet Museums); preview first.

KEY TERMS

bead

A small object pierced for stringing. The word comes from Old English *gebed*, “prayer,” because strings of beads were used to count prayers; the name moved from the prayer to the bead.

faience

Ancient Egyptian glazed ceramic made from crushed quartz, shaped into beads and amulets and fired to a glossy blue-green.

seed beads

Tiny, uniform glass beads sized by an old “aught” system: the larger the number, the smaller the bead (11/0 is about 2 mm, 6/0 about 4 mm).

wampum

Tubular beads of white whelk shell and purple quahog shell made by the peoples of the northeastern woodlands, woven into belts to record agreements; colonists also used it as money.

findings

The small metal parts that make jewelry work: clasps, jump rings, crimp beads, head pins, eye pins and ear wires.

simple loop

A wire bent into a small round eye with round-nose pliers, used to hang a bead from a chain or join beads into links.

CORE IDEAS

Beads are among the oldest things people made that were not strictly needed for food or shelter. Archaeologists have found small pierced sea shells, worn smooth by a string and sometimes colored with red ochre, in caves in South Africa, Israel and Morocco. From the beginning, it seems, people have wanted to adorn themselves and to give one another something small, beautiful and portable.

In the ancient world jewelry also carried wealth. When Abraham's servant found Rebekah at the well, he gave her "a golden earring of half a shekel weight, and two bracelets for her hands of ten shekels weight of gold" (Genesis 24:22): a gift worth carrying across the desert, and a pledge of the household's honor. Egypt made beads by the million from **faience**, and its jewelers strung wide collars of carnelian, turquoise and lapis lazuli, the deep blue stone that came by trade from the mountains of Afghanistan, more than two thousand miles away. A string of beads was a map of a civilization's trade.

Israel's jewelry had a holier use as well. At Sinai, the people who had carried Egyptian gold out of slavery gave their bracelets, earrings, rings and tablets for the making of the tabernacle (Exodus 35:22, in the Primary source box). The high priest's breastplate held twelve stones in four rows, each engraved with the name of a tribe (Exodus 28:17-21). Ornament was not wrong in itself; given to God it became worship. Yet the same people had melted earrings into a golden calf only a few chapters before (Exodus 32:2-4). The same gold can be offered or idolized, and Scripture shows both.

In the Middle Ages the bead took its English name. Christians counted repeated prayers on strings of beads, and the Old English word *gebed*, prayer, came to mean the beads themselves. Meanwhile Venice became the bead capital of Europe. In 1291 the city moved its glassmakers to the island of Murano, partly to protect the city from fire and partly to guard their secrets. Venetian makers learned to draw molten glass into long hollow canes and slice them into thousands of uniform **seed beads**, and to layer colors into the striped chevron bead. Glass beads became a trade good across the world, carried by Portuguese, Dutch and English ships to West Africa and the Americas.

In New England, the coastal peoples drilled tiny tubes of white whelk and purple quahog shell into **wampum**, using it in belts that recorded treaties and in ceremonies. Because coin was scarce, English colonists accepted wampum as money; Massachusetts made it legal tender in small payments in 1637 and ended the practice in 1661. When Dutch and English settlers began to make wampum with steel drills, the supply rose and its value fell, a lesson in inflation that Trail D will return to.

Simple jewelry today uses the same three ideas: a bead, a strand and a fastening. Beads are strung on flexible beading wire, silk or cord, and fastened with **findings**. A crimp bead, flattened with pliers, grips the wire beside the clasp. A **simple loop** turned in a head pin hangs a bead from an earring or chain. Fine pearls are traditionally strung on silk with a

knot between each pearl, so they do not rub, and so that if the strand breaks only one pearl is lost. Good jewelry is measured, not guessed: a bracelet is usually the wrist size plus about half an inch to an inch, and standard necklace lengths run from a 16-inch choker to a 30-inch opera length.

Christians have always held ornament with a loose hand. Peter told believing women that their true adorning should not be outward braiding of hair, gold and fine clothes, but “the hidden man of the heart,” a meek and quiet spirit, which is “in the sight of God of great price” (1 Peter 3:3–4). That does not forbid a bracelet; Rebekah wore hers gladly. It puts the bracelet in its place. Beauty made with care is a good gift; character is a better one.

PICTURE STUDY



A Goldsmith in His Shop (possibly Saint Eligius), Petrus Christus, 1449 · Oil on oak panel · The Metropolitan Museum of Art, New York (Robert Lehman Collection)
Wikimedia Commons · CC0

Petrus Christus worked in Bruges, a rich trading city of the Low Countries, and signed and dated this panel in 1449. The goldsmith may represent Saint Eligius, the patron saint of goldsmiths, and the painting may have been made for the goldsmiths’ guild of Bruges. The young couple appear to be choosing a ring. The shelves show a fifteenth-century jeweler’s stock in close detail.

Look closely

- Find the shelves at the right. How many kinds of material can you see: pearls, coral, crystal, metal, strung beads?
- Find the balance in the goldsmith’s hand. Why would a jeweler weigh what he sells?
- Find the convex mirror on the counter. What does it show, and why might a painter include it?

Talk about it

1. A guild of goldsmiths valued honest weights and fair dealing. How does the painting show trust between seller and buyers?
2. Compare this shop with the Primary source: in one, gold is bought and sold; in the other, it is given away. What makes the difference?

Safety first. Beads and findings are a choking hazard: work at a table away from toddlers and pets, and count small parts back into their box when you finish. Cut wire with the free end pointed down into a bag or held with a finger, and wear glasses or safety glasses, because snipped ends can fly. File or tuck in sharp wire ends.

HANDS-ON: A MEASURED BRACELET AND A PAIR OF SIMPLE-LOOP CHARMS

Design and make a bracelet from a measured plan, close it with a crimped clasp, and turn simple loops to make two small charms or earrings. Price your materials as practice for Trail D. If you plan to sell anything, a parent must sign off first.

You will need

- Beads: about 30 beads of 6 mm, or a mix of sizes, plus a few seed beads
- Flexible beading wire (about 10 inches) or strong elastic cord
- 2 crimp beads, a clasp (lobster or toggle) and 2 jump rings
- 2 head pins and 2 ear wires or small jump rings
- Round-nose pliers, flat- or chain-nose pliers, and wire cutters
- A ruler or tape measure, a bead tray or a towel to stop beads rolling, and safety glasses

Steps

1. Measure your wrist snugly. Add $\frac{3}{4}$ inch for comfort. Subtract the length of your clasp. The answer is the length of beads you need.
2. Divide that length (in millimeters) by the bead size to find how many beads you need. Lay out the pattern on the towel and check its length against the ruler before stringing.
3. Thread a crimp bead and one half of the clasp onto the wire, loop the wire back through the crimp bead, pull snug and flatten the crimp with flat-nose pliers.
4. String the beads in your planned order, sliding the wire tail into the first few beads. Add the second crimp and the other half of the clasp, loop back, take up slack (leave a hair of room so the bracelet bends), crimp and trim.
5. Charms: slide a bead onto a head pin, bend the wire 90 degrees above the bead, trim to about $\frac{3}{8}$ inch, grip the tip with round-nose pliers and roll it into a small round loop. Open the loop sideways (never pull it apart outward), hang it on an ear wire or jump ring and close it.
6. Price it: list every material with what it cost, divide to find the cost per bead and per finding, and add up the material cost of your bracelet. Keep the sheet for Trail D.

7. If you want to sell your work, show your price sheet and a sample to a parent. Parent sign-off before any sale: _____

Check your work

- My bracelet fits: snug but not tight, with the clasp included in the length.
- Both crimps hold when I tug the bracelet gently, and no wire ends scratch.
- My simple loops are round, closed and centered over the bead.
- I wrote down the material cost of what I made.

FIELD NOTEBOOK

1. **Trail C sample page 8: Beading.** Draw your bracelet to scale with each bead, and write its measurements and bead count. Tape in a seed bead and a crimp bead and label them.
2. Draw a timeline of beads: shell beads in caves; Egyptian faience; Exodus 35 at Sinai; Murano (1291); wampum as Massachusetts currency (1637–1661).
3. **Narration (one paragraph; the parent keeps it):** Using Exodus 35:22, Exodus 32 and 1 Peter 3:3–4, explain how Scripture can both welcome jewelry and warn against trusting in it.

Did you know? A single Venetian bead could travel farther than most people of its day. Glass beads made on Murano have been found in West Africa, on Pacific islands and at Native American village sites across North America. Archaeologists use the shape and color of trade beads like a calendar, because styles changed from decade to decade and help to date the places where they are found.

Primary source. *Exodus 35:22, King James Version (1611). Moses has asked the people for free-will offerings to build the tabernacle in the wilderness of Sinai.*

And they came, both men and women, as many as were willing hearted, and brought bracelets, and earrings, and rings, and tablets, all jewels of gold: and every man that offered offered an offering of gold unto the LORD.

Go deeper. Lois Sherr Dubin, *The History of Beads: From 100,000 B.C. to the Present* (revised ed., 2009), a large illustrated history. The Corning Museum of Glass (cmog.org) on how Venetian glass beads were made. The Metropolitan Museum of Art's page for Petrus Christus, *A Goldsmith in His Shop* (metmuseum.org), with a zoomable image. Second video topic: how wampum was drilled and woven into belts.

Goes deeper in. Small Business & Economics, "Money, Trade and Inflation," History, "Colonial New England," and Art, "Northern Renaissance Painting" (coming soon).

For families. Sources: Metropolitan Museum of Art (Petrus Christus, 1975.1.110); Corning Museum of Glass; Dubin (2009); Massachusetts colonial records as summarized

by the Massachusetts Historical Society and Plimoth Patuxet Museums. The ancient shell beads are dated by most archaeologists to roughly 75,000 to 100,000 years ago; families who hold a young-earth view will read those dates differently, so the stop gives the finds without a number. The shekel varied over time; about 11 to 12 grams is a common modern estimate, used in Practice 5 only as an approximation. The identification of the goldsmith as Saint Eligius is traditional, not certain. Seed-bead sizes differ slightly between makers. The selling line is there because Trail D teaches pricing; no sale should happen without a parent.

PRACTICE

1. **EASY** Where does the English word “bead” come from?
2. **EASY** Why did Venice move its glassmakers to Murano in 1291?
3. **MEDIUM** In the Primary source, who brought the offerings, what did they bring and in what spirit? How does Exodus 32:2–4 make this verse more striking?
4. **MEDIUM** Why did wampum lose value as money after colonists began making it with steel drills?
5. **CHALLENGE** Rebekah’s bracelets weighed ten shekels of gold and the earring half a shekel (Genesis 24:22). If a shekel was about 11.4 grams, how many grams of gold is that in all? How many troy ounces (31.1 g)?
6. **CHALLENGE** A wrist measures $6\frac{1}{4}$ inches. You add $\frac{3}{4}$ inch for comfort, and the clasp with its jump rings takes up 1 inch. How many 6 mm beads do you need (1 inch = 25.4 mm)? If 100 beads cost \$4.50, a clasp \$0.60 and two crimps \$0.10, what is the material cost of the bracelet?

Make it a game • Pattern Relay. Make three short sample strands with a repeating pattern of colors and sizes (for example, red-red-blue-large gold). Players race in turns to copy a strand by sight only, laying the beads in a line on a towel. Score 1 point for each bead in the right place, minus 1 for each error, plus 2 for a player who can say the pattern’s repeat length and how many full repeats fit in 7 inches. Count every bead back into its box at the end.

Scripture. “And they shall be mine, saith the LORD of hosts, in that day when I make up my jewels; and I will spare them, as a man spareth his own son that serveth him.” (Malachi 3:17, KJV)

Through Malachi, God calls those who fear Him His own jewels, gathered and kept as a jeweler gathers his treasures. A bracelet is strung with care, bead by bead; God knows and keeps His people with far greater care.

Practice: answers

1. From Old English *gebed*, “prayer,” because beads were used to count prayers; the word moved from the prayer to the bead.
2. To protect the city from fires in the glass furnaces and to keep the glassmakers’ secrets.

3. Both men and women, as many as were “willing hearted,” brought bracelets, earrings, rings and tablets, all gold, as a freely given offering to the LORD. Only a few chapters earlier the people gave their earrings to make the golden calf; now the same kind of gold is given for the true worship of God.
4. Steel tools made wampum much faster, so the supply grew quickly. When something used as money becomes plentiful, each piece buys less: its value falls (inflation). Massachusetts stopped accepting it as legal tender in 1661.
5. $10.5 \text{ shekels} \times 11.4 \text{ g} \approx 119.7 \text{ g}$, about 120 g. $119.7 \div 31.1 \approx 3.85$ troy ounces. (The weight of a shekel is an estimate.)
6. Finished length $6\frac{1}{4} + \frac{3}{4} = 7$ inches; minus 1 inch of clasp = 6 inches = 152.4 mm. $152.4 \div 6 \approx 25.4$, so 25 beads (26 if you want it a little looser). Cost: $25 \times \$0.045 = \1.125 , plus $\$0.60 + \$0.10 =$ about \$1.83.

TRAIL 3 BADGE QUIZ

The badge quizzes are optional. The student answers in writing, in full sentences, and may use the Field Notebook but not the stop pages. Show work on number problems. Four right out of five on quiz 1 and five right out of six on quiz 2 are good marks. Badges and the certificate are earned by doing the stops, not by scores.

Badge quiz 1 (Stops 1-5)

1. Explain why papyrus is not true paper, and name three improvements made by the papermakers of Fabriano.
2. A flat-folded vertex has 6 creases. By Maekawa's theorem, how many mountains and valleys can it have? What is the oldest known book of recreational origami, and when was it printed?
3. How does a broad-edged pen make thick and thin strokes without changing pressure? Why did Charlemagne's scholars promote Carolingian minuscule?
4. What did Rowland Hill's Uniform Penny Post (1840) change, and why did envelopes become common afterward?
5. A tight coil from a 300 mm strip has a diameter of about 6 mm. About what diameter would a coil from a 600 mm strip of the same paper have, and why not 12 mm?

Badge quiz 2 (Stops 6-8)

6. Why do pressed yellow flowers usually keep their color while many reds and purples fade? What must every herbarium label record?
7. What did Anna Atkins do with pressed plants that had never been done before?
8. Give Douglas Cockerell's two reasons for binding a book. How many pages does one sheet folded as a quarto make, and how many sheets make a 128-page quarto book?
9. Why did early Christians favor the codex over the scroll? Give two reasons.
10. In Exodus 35:22, who brought gold ornaments and for what? How does 1 Peter 3:3-4 put jewelry in its place?
11. A 7-inch bracelet has a 1-inch clasp. How many 8 mm beads are needed (1 inch = 25.4 mm)?

TRAIL CERTIFICATE: MY HAND-BOUND TRAIL C NOTEBOOK AND CERTIFICATE

Bind your eight Trail C sample pages and your eight narration paragraphs into the notebook you sewed at Stop C7, or sew a larger two-signature book to hold them. Add a title page lettered in the foundational hand: "Paper and Hand Crafts," with your name and the dates.

Include one finished piece from each stop, or a photograph of it: handmade paper, a crane and its crease pattern, a lettered verse, a card and envelope, a quilled panel, a pressed-flower bookmark, the notebook itself, and a bracelet with its material-cost sheet.

Write a closing page (about 250 words) answering: Which craft taught you the most about patience and precision, and how did the history behind it change the way you see the finished work?

When the notebook is complete, a parent reviews it with the rubric and signs the Trail C certificate.

- **Workmanship:** Each finished piece is measured, square and clean: folds follow the grain, coils and beads match, stitches are even, and nothing is rushed.
- **History and sources:** Narrations give correct dates, people and places, quote or cite the primary sources accurately, and separate what is known from what is legend.
- **Numbers:** Calculations (reams, nib widths, A-series areas, coil sizes, signatures, bead counts and costs) are shown and correct.
- **Reflection:** The closing page and narrations connect the crafts to Scripture and to good work done heartily, in clear, well-organized paragraphs.

Answer key

1. Papyrus is strips of reed pith laminated in crossed layers; true paper is made from fibers beaten into pulp and formed on a screen. Fabriano added water-powered beating hammers, gelatin sizing and wire watermarks.
2. 4 and 2, or 2 and 4 (they differ by 2). *Hidden Senbazuru Oriката* ("The Secret of Folding a Thousand Cranes"), Kyoto, 1797.
3. Held at a fixed angle, the nib makes its widest line when moving at right angles to its edge and its thinnest when moving along it, so the direction of the stroke controls the thickness. Charlemagne wanted correct, readable, uniform copies of the Bible and other books across his empire.
4. A single low price of a penny for a half-ounce letter anywhere in Britain, paid in advance by the sender with a stamp. Before, letters were charged by the sheet and an envelope counted as an extra sheet; after, charges went by weight, so an envelope cost almost nothing extra.
5. About 8.5 mm (6×1.41). Doubling the length doubles the coil's area, and the diameter grows with the square root of the area, so it increases by about 1.4 times, not 2.
6. Yellows come from stable carotenoids; many reds and purples come from anthocyanins, which change with acidity and break down in light. Name, place, date, habitat and collector.
7. She laid pressed algae on cyanotype paper in sunlight to make photographic prints and issued them, from 1843, as *Photographs of British Algae: Cyanotype Impressions*, often called the first book illustrated with photographs.
8. To keep the leaves together in their proper order and to protect them. A quarto sheet makes 4 leaves, 8 pages; $128 \div 8 = 16$ sheets.
9. Any two: a codex could hold all four Gospels or all of Paul's letters in one volume; it was easier to search and compare passages in worship and teaching; it was compact and easy to carry on journeys; it used both sides of the page.
10. Men and women, as many as were willing hearted, brought bracelets, earrings, rings and tablets of gold as an offering to the LORD for the tabernacle. Peter teaches that a Christian's true adorning is not outward gold and fine clothes but the hidden person of the heart, a meek and quiet spirit, which God values greatly.
11. 6 inches = 152.4 mm; $152.4 \div 8 \approx 19$, so 19 beads.

CRAFTS AND MAKING ≈ TRAIL D: MAKE IT, PRICE IT, SELL IT

The last trail of the Crafts and Making track turns handwork into a small, honest business. It begins with Bezaleel and Aholiab, the first craftsmen named in Scripture, and then follows one product from start to finish: choosing it, costing its materials and time, setting a fair price, inspecting its quality, labeling and packaging it, selling it at a craft-fair table or a family “shop,” and keeping the books to find the real profit. Along the way students read Exodus, Leviticus and Deuteronomy on skill and just measures, Adam Smith on markets, Benjamin Franklin on time and accounts, and William Morris on the joy of good work, and they study Rembrandt’s cloth inspectors, Holbein’s merchant and Petrus Christus’s goldsmith.

This is the  **Expert** level, for ages 14 and up. Each stop takes 35 to 50 minutes and stands by itself, but the trail works best in order, because each project adds a page to the student’s **Maker’s File**: product decision, cost sheet, price list, quality checklist, label and logo, table plan and tally sheet, and finally a ledger and profit sheet. Each stop includes a primary source, a written narration paragraph for the parent to keep, and practice problems with real numbers. Any real selling requires a parent’s signed approval and an adult at the table.

Five stops earn the **Maker and Merchant badge, part 1**; eight stops earn part 2 and the **Trail D certificate**. Finishing all four trails completes the Crafts and Making track.

BEFORE YOU BEGIN

- Make at least one simple handmade item well (from Trails A–C or elsewhere), such as a pincushion, card, bookmark or notebook.
- Work confidently with decimals, percents and unit rates, and use a calculator or simple spreadsheet.

MASTERY CHECKLIST

- ☐ I can explain from Exodus 31 and 35 why skilled handwork is a gift and calling from God, and why it should be taught.
- ☐ I can choose a product with a weighted decision matrix and calculate its full unit cost, including materials, labor and overhead.
- ☐ I can set a fair price using cost, market and value, and calculate markup, margin and break-even.
- ☐ I can write a specification and inspection checklist, and design an honest label, packaging and logo.
- ☐ I can run a selling table and keep a ledger and profit sheet that show my real net profit.

OPTIONAL BOOKS AND RESOURCES

- **U.S. Small Business Administration: Plan Your Business**
(<https://www.sba.gov/business-guide/plan-your-business>): Free, plain guides to costs, pricing and basic records. Useful for Stops D2–D4 and D8 (parents read alongside).
- **Federal Trade Commission: Threading Your Way Through the Labeling Requirements Under the Textile and Wool Acts** (<https://www.ftc.gov/business-guidance>): The official plain-language guide to fiber-content and care labels for Stop D6; search the FTC’s business-guidance pages for “Threading Your Way.”
- **U.S. Consumer Product Safety Commission: Business Education**
(<https://www.cpsc.gov/Business--Manufacturing>): Rules for children’s products and small makers; read before selling anything meant for children (Stops D2 and D5).
- **Project Gutenberg: Adam Smith, The Wealth of Nations, and William Morris, Hopes and Fears for Art** (<https://www.gutenberg.org/ebooks/3300>): Free full texts of two of this trail’s primary sources (Morris is eBook #3773). Franklin’s “Advice to a Young Tradesman” is in eBook #40236.
- **Khan Academy: Percent, Unit Rates and Income Statements**
(<https://www.khanacademy.org>): Free practice for the arithmetic in Stops D3, D4 and D8.
- **Richard J. Maybury, *Whatever Happened to Penny Candy?***
(<https://www.worldcat.org>): A short, readable economics book for teens on prices and money. Look for it at the library.

4.1 BEZALEL AND AHOIAB, THE FIRST NAMED CRAFTSMEN

OBJECTIVES

- Read Exodus 31:1–6 and 35:30–35 closely and list the gifts, skills, materials and duties God gave to Bezaleel and Aholiab.
- Use the numbers in Exodus 38 to estimate the scale of the tabernacle project and explain why it needed organized, skilled workers.
- Argue from the text that skilled handwork is a calling from God, and that teaching it to others is part of that calling.

Warm-up. Write down every craft you can think of that would be needed to build a large, richly furnished tent: metalwork, sewing, carving and so on. Then guess: in the Bible, who is the first person God names as being filled with His Spirit for a particular task? Keep your list and your guess for the end of the stop.

Video slot. Video coming. The tabernacle in the wilderness: its materials, furniture and craftsmen; a scale model of the tabernacle. Search approved channels (a Bible-lands museum, a tabernacle scale-model exhibit, The Bible Project for overview only); preview first.

KEY TERMS

tabernacle

The portable sanctuary, a tent of curtains on a wooden frame within a fenced court, that Israel carried through the wilderness as the place where God met His people (Exodus 25–40).

wise hearted

The KJV's phrase for people with practical skill. In Hebrew "wisdom" (*chokmah*) can mean skill of the hands as well as good judgment.

cunning work

In the English of 1611, "cunning" means skillful and knowing, not sly. "Cunning work" is expert, finely designed workmanship.

talent and shekel

Hebrew units of weight. Exodus 38:25–26 shows that one talent equaled 3,000 shekels; a shekel weighed roughly 11 to 12 grams.

apprenticeship

Learning a craft by working under a master. Exodus 35:34 says God put it in Bezaleel's and Aholiab's hearts "that he may teach."

vocation

From the Latin for "calling." The Christian idea that ordinary work, done for God and neighbor, can be a calling as real as any other.

CORE IDEAS

When God gave Moses the plans for the tabernacle on Mount Sinai, He did not only describe the building. He also named the builders. “See, I have called by name Bezaleel the son of Uri, the son of Hur, of the tribe of Judah” (Exodus 31:2). Bezaleel (often spelled Bezalel) is the first person in Scripture of whom God Himself says, “I have filled him with the spirit of God.” The gift is not for prophecy or battle but for “all manner of workmanship”: gold, silver and brass, cutting and setting stones, and carving timber. Beside him God set **Aholiab** (Oholiab) of the tribe of Dan, whose specialty, by Exodus 38:23, was engraving, design and embroidery in blue, purple, scarlet and fine linen.

Notice the four words in Exodus 31:3: **wisdom, understanding, knowledge** and **workmanship**. A good craftsman needs all four. Knowledge is knowing the materials: how gold hammers, how linen takes dye. Understanding is seeing how parts fit together. Wisdom, in Hebrew *chokmah*, is the same word used for the skill of the hands; the KJV calls skilled workers “**wise hearted**.” Workmanship is the doing of it. The verse also mentions design: they were “to devise cunning works,” that is, to plan as well as to make. In this trail you will do the same: choose and design a product, then make it well.

The tabernacle was a large project, and the Bible gives the numbers. Exodus 38 records the metal used: 29 talents and 730 shekels of gold, 100 talents and 1,775 shekels of silver, and 70 talents and 2,400 shekels of brass. The text lets us check the arithmetic. Each of the 603,550 men counted gave half a shekel of silver; half of 603,550 is 301,775 shekels, and since a **talent** is 3,000 **shekels**, that is exactly 100 talents and 1,775 shekels. The gold comes to 87,730 shekels. At roughly 11 to 12 grams a shekel, that is on the order of a metric ton of gold, worked into a lampstand, an ark, overlays and rings by hand.

No two men could do all that alone. Exodus 31:6 says God put wisdom “in the hearts of all that are wise hearted,” and Exodus 36 shows a workforce: every skilled man, and women who spun blue, purple, scarlet and goat’s hair with their own hands (35:25–26). Bezaleel and Aholiab were master craftsmen and foremen. Most striking of all, Exodus 35:34 says God “put in his heart that he may teach.” The gift was not to be hoarded. This is the oldest picture we have of **apprenticeship**: masters passing on skill to others who will carry the work forward.

The materials were not bought with taxes or plunder taken by force; they were freely given. The people brought gold, linen, skins and wood “with a willing heart,” and they brought so much that the craftsmen came to Moses and said there was more than enough, so Moses told the camp to stop giving (Exodus 36:5–7). Here is an early lesson for anyone who makes things for others: good work rests on honest supply. The craftsmen reported plainly what they had and what they needed.

There is also some honest complexity. The tabernacle was not a business, and Bezaleel was not selling anything. His work was worship, built to a pattern God gave (Exodus 25:9). Yet Christians through the centuries, especially since the Reformation, have drawn from these chapters the idea of **vocation**: that a weaver, a carver or a metalworker can serve God with

skilled hands, and that such skill is a gift from Him, not merely a talent we invented. The name is still honored among craftsmen; Israel's national art academy, founded in Jerusalem in 1906, is called Bezalel.

So the first named craftsmen in the Bible teach three lessons for this whole trail. First, skill comes from God and should be done well, to His pattern and for His glory. Second, a maker must plan and count materials carefully, as Exodus 38 does. Third, skill is meant to be shared and taught. When you sell a pincushion or a notebook at a family table later in this trail, you stand, in a small way, in a long line of "wise hearted" people.

PICTURE STUDY



Bezalel (The Goldsmith), James Tissot, c. 1896–1902 · Gouache on board · The Jewish Museum, New York
Wikimedia Commons · Public domain

James Tissot was a French painter who first became famous for fashionable scenes of Paris and London society. In the 1880s he returned to the Christian faith and spent the rest of his life illustrating the Bible, traveling to the Holy Land to study landscapes, clothing and faces. His Old Testament series, left unfinished at his death in 1902 and completed by assistants, includes this small picture of Bezalel at his metalwork. It is only about 8 by 4½ inches.

Look closely

- Find Bezalel's tools. Which tools can you name, and which do you think are for hammering, cutting or shaping?
- Look at his posture and hands. How does Tissot show concentration and patience?
- What did Tissot leave plain, and what did he paint in fine detail? Why might he have chosen that?

Talk about it

1. Exodus 31:3 says Bezaleel was filled with “wisdom, ... understanding, ... knowledge, and ... all manner of workmanship.” Which of these four can you see in the picture, and which can you not see?
2. Tissot painted from research in the Holy Land, but no one knows what Bezaleel looked like. Is it right to call this a “history” painting? What makes it valuable anyway?

HANDS-ON: THE TABERNACLE WORKSHOP CHART

Use the primary source box to turn Exodus 31 and 35 into an organization chart of the tabernacle workshop, then do the metal arithmetic from Exodus 38.

You will need

- The KJV text in the Primary source box (and a Bible open to Exodus 35–38)
- A large sheet of paper or two facing notebook pages
- Colored pencils
- A calculator

Steps

1. Read Exodus 31:1–6 and 35:30–35 aloud. Underline every material (gold, silver, brass, stones, timber, blue, purple, scarlet, fine linen) in one color and every skill (devise, cut, set, carve, engrave, embroider, weave, teach) in another.
2. Draw an organization chart. At the top: “The LORD gave the pattern.” Below: Moses. Below him: Bezaleel (Judah) and Aholiab (Dan). Below them: boxes for each team of skills you found. Write the verse number in each box.
3. Add a box for “all that are wise hearted” (31:6) and a box for the spinners of Exodus 35:25–26.
4. Do the arithmetic. Using 1 talent = 3,000 shekels, convert the gold (29 talents 730 shekels), silver (100 talents 1,775 shekels) and brass (70 talents 2,400 shekels) to shekels. Then multiply each by 11.4 grams and convert to kilograms. Label your answers as estimates.
5. Check the silver: does half a shekel from each of 603,550 men equal your silver total?
6. Under the chart, write two sentences: what does the passage say a craftsman needs, and what does it say a craftsman owes to others?

Check your work

- Every box on my chart cites a verse.
- My conversions are correct and labeled as estimates.
- My two sentences use words from the KJV text.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph of 8–10 sentences, tell who Bezaleel and Aholiab were, what God gave them, what they made, and why their story

matters to anyone who makes things with their hands. Quote at least two phrases from the KJV. A parent dates and keeps the page.

2. Start the **Trail D Maker's File**: a folder or notebook section that will hold your product plan, cost sheet, price list, quality checklist, label, table plan and ledger. On page one, write "Workshop Rule 1: Skill is a gift; do the work well and teach it."
3. Sketch one tool from Tissot's picture and label what it does.

Did you know? Moses had to tell the people to stop giving: "the stuff they had was sufficient for all the work to make it, and too much" (Exodus 36:7). The tabernacle's lampstand was "of beaten work," hammered rather than cast, and it and its tools together used "a talent of pure gold" (Exodus 25:31, 39), about 34 kilograms by the estimate used in this stop.

Primary source. *Exodus 31:1-6 and 35:30-35, King James Version (1611).*

31:1 And the LORD spake unto Moses, saying,
2 See, I have called by name Bezaleel the son of Uri, the son of Hur, of the tribe of Judah:
3 And I have filled him with the spirit of God, in wisdom, and in understanding, and in knowledge, and in all manner of workmanship,
4 To devise cunning works, to work in gold, and in silver, and in brass,
5 And in cutting of stones, to set them, and in carving of timber, to work in all manner of workmanship.
6 And I, behold, I have given with him Aholiab, the son of Ahisamach, of the tribe of Dan: and in the hearts of all that are wise hearted I have put wisdom, that they may make all that I have commanded thee; ...

35:30 And Moses said unto the children of Israel, See, the LORD hath called by name Bezaleel the son of Uri, the son of Hur, of the tribe of Judah;
31 And he hath filled him with the spirit of God, in wisdom, in understanding, and in knowledge, and in all manner of workmanship;
32 And to devise curious works, to work in gold, and in silver, and in brass,
33 And in the cutting of stones, to set them, and in carving of wood, to make any manner of cunning work.
34 And he hath put in his heart that he may teach, both he, and Aholiab, the son of Ahisamach, of the tribe of Dan.
35 Them hath he filled with wisdom of heart, to work all manner of work, of the engraver, and of the cunning workman, and of the embroiderer, in blue, and in purple, in scarlet, and in fine linen, and of the weaver, even of them that do any work, and of those that devise cunning work.

Go deeper. Read Exodus 35-40 straight through, the account of the building, and compare it with the instructions in chapters 25-31. Gene Edward Veith, *God at Work: Your Christian Vocation in All of Life* (2002), a readable introduction to the doctrine of vocation. The Jewish Museum, New York, has Tissot's Old Testament pictures in its online

collection. Second video topic: “How a gold lampstand is chased and hammered from one sheet.”

Goes deeper in. Small Business & Economics, “Work and Vocation,” and History, “Israel in the Wilderness” (coming soon).

For families. Sources: the KJV text above; Exodus 36–38 for the workforce and metal totals. The weight of a shekel is not known exactly; archaeological weights suggest roughly 11 to 12 grams, so the stop uses 11.4 grams and calls every result an estimate. “Bezaleel” and “Aholiab” are the KJV spellings; many modern Bibles use Bezalel and Oholiab. The claim that Bezaleel is the first person God says He filled with His Spirit is phrased carefully, because Pharaoh earlier describes Joseph as a man “in whom the Spirit of God is” (Genesis 41:38). Picture: Tissot, *Bezalel* (also catalogued as *The Goldsmith*), The Jewish Museum, New York.

PRACTICE

1. **EASY** Name the two craftsmen God called by name in Exodus 31, with each one’s father and tribe.
2. **EASY** What does “cunning” mean in “cunning works” (Exodus 31:4)?
3. **MEDIUM** Which verse shows that teaching was part of their calling, and why does that matter for a craft?
4. **MEDIUM** From Exodus 31 and 35, list four materials and four skills named in the passages.
5. **CHALLENGE** Exodus 38 says the gold was 29 talents and 730 shekels. With 1 talent = 3,000 shekels and 1 shekel $\approx$ 11.4 grams, find the weight in kilograms. Then show that 603,550 half-shekels equal 100 talents and 1,775 shekels.
6. **CHALLENGE** Someone says, “Craft is just a hobby; it has nothing to do with God.” Write a reasoned reply using at least three phrases from Exodus 31 or 35.

Make it a game • Workshop Teams. Write the skills from Exodus 35:35 on cards (engraver, cunning workman, embroiderer, weaver, spinner, carver, stone-setter, metalworker) and the tabernacle items on other cards (lampstand, ark, curtains, veil, priests’ garments, altar, breastplate stones, boards). Players race to match each item to the team or teams who would make it. Score a point for each match you can defend with a reason; look up Exodus 25–28 to settle arguments.

Scripture. “Then wrought Bezaleel and Aholiab, and every wise hearted man, in whom the LORD put wisdom and understanding to know how to work all manner of work for the service of the sanctuary, according to all that the LORD had commanded.” (Exodus 36:1, KJV)

The plans became real work. Bezaleel and Aholiab did not work alone, and they did not work to their own pattern; they built “according to all that the LORD had commanded.” Skill serves best when it is offered to God.

Practice: answers

1. Bezaleel, son of Uri (son of Hur), of the tribe of Judah; Aholiab, son of Ahisamach, of the tribe of Dan.
2. Skillful, expertly designed. In 1611 English “cunning” meant knowing and skilled, not sly or deceitful.
3. Exodus 35:34: God “put in his heart that he may teach.” A craft survives only if masters train others; teaching multiplied the workforce for the tabernacle and passes skill to the next generation.
4. Materials (any four): gold, silver, brass, stones, timber or wood, blue, purple, scarlet, fine linen. Skills (any four): devising designs, working metal, cutting and setting stones, carving wood, engraving, embroidering, weaving, teaching.
5. Gold: $29 \times 3,000 = 87,000 + 730 = 87,730$ shekels; $87,730 \times 11.4 \text{ g} = 1,000,122 \text{ g} \approx 1,000 \text{ kg}$ (about one metric ton). Silver: $603,550 \div 2 = 301,775$ shekels = $100 \times 3,000 + 1,775$, so 100 talents and 1,775 shekels.
6. A strong answer notes that God “called by name” particular craftsmen, “filled [them] with the spirit of God,” gave them “wisdom ... understanding ... knowledge ... all manner of workmanship,” and “put in his heart that he may teach.” Skilled handwork was the means by which God’s commanded sanctuary was built, so Scripture treats it as a gift and calling to be done well, not a trifle.

4.2 CHOOSE A PRODUCT

OBJECTIVES

- Test a product idea against four questions: skill, demand, margin and time, plus safety and the law.
- Build a weighted decision matrix to choose among three to five product ideas.
- Explain from Adam Smith why the size of a market shapes what a maker should specialize in.

Warm-up. List every handmade thing you have learned to make in this track or elsewhere (a pincushion, a scarf, cards, bookmarks, a notebook, beaded jewelry). Put a star by the two you make best and a check by the two you think other people would most want to buy. Are they the same items?

Video slot. Video coming. How to choose a craft product to sell: market research, prototypes and product lines for young makers. Search approved channels (U.S. Small Business Administration, SCORE, a 4-H or Junior Achievement channel, a university extension small-business channel); preview first.

KEY TERMS

product

A specific thing offered for sale, with a defined size, materials, design and price.

“Bookmarks” is a category; “a 2-by-7-inch pressed-flower bookmark, laminated, with a ribbon tassel” is a product.

demand

How much of a product people are willing and able to buy at a given price. Demand is shown by what people actually buy, not by what they say they like.

prototype

A first working sample made to test a design, the materials and the time it takes before making more.

product line

A small family of related products, usually one main item in a few variations and price points.

decision matrix

A table that scores several choices against the same weighted criteria so that a decision rests on reasons rather than mood.

division of labour

Adam Smith’s term (1776) for splitting work into specialties, so that each worker or trade concentrates on what it does best and trades for the rest.

CORE IDEAS

Most young makers choose a product by asking only one question: “What do I like to make?” That is a good start, but a product that sells has to pass four tests. **Skill**: can you make it well, and make it the same way every time? **Demand**: does someone want it, and why, and when? **Margin**: can you make it for clearly less than a buyer will pay? **Time**: can you make enough of it in the hours you actually have? A fifth test sits underneath the others: is it safe and lawful to sell? An idea that fails any one test should be changed or dropped.

The demand test is the hardest to judge honestly. Friends and relatives are kind, and they will say they love your work. Kindness is not **demand**. Demand is shown by money and behavior: people pick it up, ask the price, and pay. So test ideas the way businesses do. Make a **prototype**, show it to ten people outside your household, and ask a specific question: “Would you buy this for \$6?” Better still, take three or four pre-orders. Watch for clues: people buy handmade goods most often as gifts, so items that are small, giftable and easy to carry (cards, bookmarks, ornaments, notebooks, soap, small pouches) tend to sell better at fairs than large items that need fitting, like sweaters.

The margin test requires numbers, which you will work out fully in Stops D3 and D4. For now use a rough rule: if the materials for one item cost more than about a quarter of what similar items sell for, the margin will probably be too thin once your time, packaging and table fee are counted. A hand-knit hat may use \$12 of good wool and take eight hours; even at \$40 the maker earns very little per hour. A pressed-flower bookmark may use 40 cents of materials and take fifteen minutes. Neither is wrong to make, but they are very different businesses.

Adam Smith, the Scottish philosopher who wrote *The Wealth of Nations* in 1776, noticed that what a worker can specialize in depends on the size of the market. His excerpt is in the Primary source box. In the thinly settled Highlands, he wrote, “every farmer must be butcher, baker, and brewer, for his own family,” because there were too few customers for any one trade to live by. In a city, by contrast, a person could make nothing but pins or nothing but brushes. This is the **division of labour**, and Smith’s point was that it “must always be limited by the extent of the market.” A one-day church craft fair is a small market. A small market favors a short **product line**: one main item you make very well, in two or three variations, rather than twenty different things in ones and twos.

A **decision matrix** turns all of this into a choice. List three to five ideas down the side. Across the top write the criteria and give each a weight: for example, demand $\times 3$, margin $\times 3$, skill $\times 2$, time $\times 2$, materials easy to get $\times 1$. Score each idea from 1 to 5 on each criterion, multiply by the weight, and add. Suppose bookmarks score 4, 5, 4, 5, 5 and knitted scarves score 3, 2, 3, 1, 3. Bookmarks total $12 + 15 + 8 + 10 + 5 = 50$; scarves total $9 + 6 + 6 + 2 + 3 = 26$. The matrix does not make the decision for you, but it shows plainly why you are making it.

Safety and law are real limits, even for a small family table. In the United States, items made for children twelve and under fall under federal children’s-product safety rules (enforced by

the Consumer Product Safety Commission) about lead, small parts and labeling, so toys and baby items are a poor first product. Textile goods such as scarves may need a fiber-content label. Food and cosmetics have their own state rules. Designs belong to their creators: you may not sell items printed with cartoon characters, sports logos or another maker's pattern without permission, even if you made them by hand. Original designs and public-domain patterns are safe ground.

Here is the honest complexity. The item that sells best may not be the item you most enjoy making, and a maker must sometimes choose between the two. There is no shame in making what people need; Paul made tents (Acts 18:3), and the woman of Proverbs 31 made girdles to sell to merchants. Yet love of the work shows in the work, and buyers can tell. The wise choice is usually a product you can make well, enjoy making in quantity, and sell at a fair price to people who truly want it. Choose one now, and you will carry it through the rest of this trail.

PICTURE STUDY



The Brush Maker (Der Bürstenbinder), from the *Book of Trades*, Jost Amman (woodcut), with verses by Hans Sachs, 1568 · Woodcut, printed in a book · Published in Frankfurt am Main; copies in many libraries, including the Deutsche Fotothek, Dresden
Wikimedia Commons · Public domain

In 1568 the Frankfurt publisher Sigmund Feyerabend printed a little book showing more than a hundred trades of the German-speaking world, each with a woodcut by the Swiss-born artist Jost Amman and a short rhyme by the Nuremberg shoemaker-poet Hans Sachs. It is usually called the *Ständebuch*, or *Book of Trades*. Each maker in it has chosen one product and built a whole living on it: brushes, combs, buttons, spectacles, pins, playing cards.

Look closely

- Find the finished products in the workshop. How does the brush maker show his goods to passers-by?
- Find his tools and raw materials. What would he have to buy before he could make anything?
- How many different products does this maker seem to offer? One, or a small line?

Talk about it

1. Why could a brush maker live by brushes alone in Frankfurt or Nuremberg but not in a lonely Highland glen? Use Adam Smith's reasoning.
2. If you were in the *Book of Trades*, what would your woodcut show, and what would your one-line rhyme say?

HANDS-ON: CHOOSE AND PROTOTYPE YOUR PRODUCT

Pick the one product you will carry through Trail D, using evidence rather than guesswork.

You will need

- Your warm-up list
- Notebook, ruler and pencil (or a simple spreadsheet)
- Materials for one prototype of your top idea
- A timer or clock

Steps

1. Choose three to five product ideas. For each, write a precise description: size, materials, colors, how it is used.
2. Draw a decision matrix with these weighted criteria: demand $\times 3$, margin $\times 3$, skill $\times 2$, time $\times 2$, materials easy to get $\times 1$. Add a pass/fail column for "safe and lawful."
3. Score each idea from 1 to 5 on each criterion, multiply and total. Strike out any idea that fails "safe and lawful."
4. Make one prototype of the winner. Time yourself from start to finish and write down every material you used.
5. Show the prototype to at least five people outside your household. Ask, "Would you buy this for \$___?" (choose a price) and "What would make it better?" Record the answers honestly.
6. Write a one-paragraph product decision: what you will make, the two or three variations in your line, and the evidence for your choice. File it in your Maker's File.

Check your work

- My matrix shows weights, scores and totals.
- I timed my prototype and listed its materials.
- My decision cites what real people said, not only what I like.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, explain which product you chose and why, using at least three of the five tests (skill, demand, margin, time, safe and lawful) and one idea from Adam Smith. A parent dates and keeps the page.
2. Draw your prototype from the front and side with measurements, and label each material.
3. Draw your own “Book of Trades” woodcut: you at your bench with your product.

Did you know? Adam Smith opened *The Wealth of Nations* with a pin factory. One untrained worker, he wrote, could hardly make twenty pins in a day, but ten workers who split the job into about eighteen steps could make upward of forty-eight thousand pins a day between them, some 4,800 each. A small product made in steps can be made much faster in a batch, a lesson you will use in Stop D3.

Primary source. *Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations (1776), Book I, Chapter III, “That the Division of Labour is Limited by the Extent of the Market.”* Text from Project Gutenberg, eBook #3300.

As it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market. When the market is very small, no person can have any encouragement to dedicate himself entirely to one employment, for want of the power to exchange all that surplus part of the produce of his own labour, which is over and above his own consumption, for such parts of the produce of other men’s labour as he has occasion for. ...

In the lone houses and very small villages which are scattered about in so desert a country as the highlands of Scotland, every farmer must be butcher, baker, and brewer, for his own family. In such situations we can scarce expect to find even a smith, a carpenter, or a mason, within less than twenty miles of another of the same trade. The scattered families that live at eight or ten miles distance from the nearest of them, must learn to perform themselves a great number of little pieces of work, for which, in more populous countries, they would call in the assistance of those workmen.

Go deeper. Leonard E. Read, *I, Pencil* (1958), a short essay (free from the Foundation for Economic Education) on how many hands and materials go into one simple product. Jean Merrill, *The Toothpaste Millionaire* (1972), a novel about a boy who chooses, costs and sells a product. The Deutsche Fotothek and many libraries show the full 1568 *Ständebuch* online; compare five trades. Second video topic: “How a craftsperson tests a product with a prototype.”

Goes deeper in. Small Business & Economics, “What Should I Make? Supply, Demand and Choosing a Product,” and History, “The Age of Guilds and Trades” (coming soon).

For families. Sources: Smith, *Wealth of Nations*, Project Gutenberg #3300 (Book I, chs. I and III); U.S. Consumer Product Safety Commission guidance on children's products; Federal Trade Commission guidance on the Textile Fiber Products Identification Act. Legal rules vary by state and change; the stop names the main areas (children's products, textiles, food and cosmetics, copyrighted designs) without giving legal advice, and a parent should check current rules before any sale. The "one-quarter" materials rule is a rough classroom guide, not an industry standard. Picture: Jost Amman, *Der Bürstenbinder*, from *Eygentliche Beschreibung aller Stände auff Erden* (Frankfurt: Feyerabend, 1568).

PRACTICE

1. **EASY** Name the four tests for a product idea in this stop, and the fifth test underneath them.
2. **EASY** Why is "My friends all said they love it" weak evidence of demand?
3. **MEDIUM** According to Adam Smith, why must a Highland farmer be "butcher, baker, and brewer" for his own family?
4. **MEDIUM** Give two reasons a maker should not sell hand-sewn pillows printed with a famous cartoon character.
5. **CHALLENGE** Weights: demand 3, margin 3, skill 2, time 2, materials 1. Greeting cards score 4, 4, 5, 4, 5. Beaded bracelets score 3, 4, 3, 3, 2. Find both totals and say which wins and by how much.
6. **CHALLENGE** Use Smith's idea that "the division of labour ... must always be limited by the extent of the market" to advise a student choosing between selling 20 different products and selling one product in 3 variations at a small church fair. Then say when the advice might change.

Make it a game · The Investors' Table. Each player has two minutes to pitch a product idea to a panel of family "investors" with play money (say \$100 each). The pitch must name the product, who will buy it, the materials, the time to make one and a proposed price. Investors may ask one hard question each and then invest any amount in any pitch. The idea with the most investment wins; then everyone explains which of the five tests made them invest or hold back.

Scripture. "She maketh fine linen, and selleth it; and delivereth girdles unto the merchant." (Proverbs 31:24, KJV)

The wise woman of Proverbs 31 chose products she could make well and that buyers wanted: fine linen and girdles. Making to sell is not beneath a godly household; Scripture praises it.

Practice: answers

1. Skill, demand, margin and time; underneath them, whether it is safe and lawful to sell.
2. Friends are kind and may not be typical buyers. Demand is shown by people actually willing to pay a stated price, such as pre-orders or sales to strangers.

3. Because the market is very small and scattered: there are too few customers nearby for anyone to live by one trade, so each family must do many kinds of work itself.
4. The character's design belongs to its owner (copyright and trademark), so selling it without permission is taking someone else's property; and the maker could face legal action or have the goods removed. It also does not build the maker's own designs or name.
5. Cards: $12 + 12 + 10 + 8 + 5 = 47$. Bracelets: $9 + 12 + 6 + 6 + 2 = 35$. Cards win by 12 points.
6. A small market cannot support much specialization of each item; few buyers will want any one of twenty products, and making each in ones and twos is slow and costly. One product in three variations lets the maker specialize, batch the work, keep quality high and still give buyers a choice. The advice could change in a larger market (a big regional fair or online shop), where more buyers can support a wider line, or once the first product has proved itself.

4.3 COSTING MATERIALS AND TIME

OBJECTIVES

- Calculate the unit cost of materials from bulk prices, including a waste allowance.
- Value your labor with an hourly rate and show how batching and practice lower the labor cost of each item.
- Separate variable costs from fixed costs, and explain Franklin’s idea that “time is money” as opportunity cost.

Warm-up. Take the prototype you made in Stop D2. Without looking at any receipts, guess what it cost to make. Write your guess in the corner of a notebook page and fold the corner over. By the end of this stop you will know the real figure.

Video slot. Video coming. How to calculate the cost of a handmade product: materials per unit, labor per hour, overhead. Search approved channels (U.S. Small Business Administration, SCORE, a university extension small-business channel, Khan Academy for unit rates); preview first.

KEY TERMS

unit cost

The cost of one item, found by dividing a total cost by the number of items it covers. A \$8 ream of 500 sheets has a unit cost of $\$8 \div 500 = \0.016 a sheet.

variable cost

A cost that rises with each item made, such as paper, thread and the maker’s time on that item.

fixed cost

A cost that stays the same however many items you make, such as a table fee at a fair or a tool you buy once.

overhead

Costs of running the business that are not part of any one item (tools, table fees, signs, card-reader fees), spread across the items you expect to sell.

batch production

Making several items at once, step by step, rather than one from start to finish. It saves set-up time on each item.

opportunity cost

The value of the best thing you gave up to do something else. An hour spent sewing is an hour not spent on paid work, study or rest.

CORE IDEAS

Every handmade item has two kinds of cost bound up in it: the things it is made of and the time it took to make. Beginners almost always count the first and forget the second, and even the first they usually count too low. Jesus asked, “which of you, intending to build a tower, sitteth not down first, and counteth the cost?” (Luke 14:28). A maker who does not count the cost cannot set an honest price and will soon either lose money or quit.

Start with materials. Most supplies are bought in bulk, so you must find the **unit cost**. Take a simple hand-stitched notebook. A ream of 500 sheets of paper costs \$8.00, so each sheet costs \$0.016; the notebook uses 12 sheets, or \$0.19. A pack of 50 cardstock covers costs \$10.00, so one cover costs \$0.20. Waxed linen thread costs \$6.00 for 50 yards, or \$0.12 a yard; half a yard costs \$0.06. Decorative paper and a ribbon add \$0.15. The total is \$0.60. Then add a **waste allowance**, often about 10 percent, for spoiled sheets and trimmings: \$0.66. Do not leave out materials that came “free” from the family craft drawer. Someone paid for them, and you will have to buy more when they run out.

Next comes time. To count your labor, give it an hourly rate. A reasonable starting point is what you could earn at an ordinary job open to someone your age, such as babysitting or yard work; this stop uses \$10 an hour. Time yourself honestly from setting out the materials to tidying up. Your first notebook may take 40 minutes, which is \$6.67 of labor. But labor cost falls in two ways. Practice makes you faster: makers find that each doubling of the number they have made cuts the time noticeably. And **batch production** saves set-up time: fold twelve sets of pages, then punch them all, then stitch them all. Ten notebooks made in a batch might take four hours, or 24 minutes each, which is \$4.00 of labor apiece.

Some costs do not belong to any one item. A bookbinding awl (\$5) and a bone folder (\$7) are tools you buy once; a fair charges \$20 for a table. These are **fixed costs**: they do not change whether you make 5 notebooks or 50. Paper, thread and your minutes are **variable costs**: each new notebook adds more. To include fixed costs in a unit cost, spread them as **overhead** over the number you expect to sell. If the tools will last for 60 notebooks, they add $\$12 \div 60 = \0.20 each. If you expect to sell 25 at the fair, the table adds $\$20 \div 25 = \0.80 each. Now the full unit cost is $\$0.66 + \$4.00 + \$0.20 + \$0.80 = \$5.66$. Many beginners would have guessed under a dollar.

Benjamin Franklin put the cost of time into a famous sentence in 1748: “Remember that *time* is money.” His full excerpt is in the Primary source box. A man who can earn ten shillings a day and spends half the day idle, Franklin said, has not only spent the sixpence he paid for amusement; he has “thrown away, five shillings besides.” Economists now call this **opportunity cost**: the true cost of any choice includes the best thing you gave up. If you could earn \$12 an hour mowing lawns, then three hours spent making bookmarks cost you \$36 of possible earnings, plus the materials.

Here is the honest complexity. Should a young maker count labor at all? Many hobbyists do not, and sell items at the cost of materials. That feels generous, but it has three effects. It hides whether the work is worth doing as a business; it sets a price you cannot keep up once

your time becomes scarce; and it makes it harder for other makers, some of whom support families by their craft, to charge a fair price. There is also a fair objection on the other side: time you would have spent on a hobby anyway is not the same as time taken from paid work, and opportunity cost depends on your real alternatives. The wise course is to *know* your full cost, including labor, and then decide freely how to price, which is the subject of Stop D4.

Costing is not about loving money. It is about stewardship. God gives each person a measure of time, strength and materials, and the parable of the talents (Matthew 25:14–30) praises the servants who used what they were given well and could give an account of it. A cost sheet is simply an honest account of what one item asks of you.

PICTURE STUDY



The Tailor's Workshop, Quiringh van Brekelenkam, 1661 · Oil on canvas · Rijksmuseum, Amsterdam
Wikimedia Commons · Public domain

Quiringh van Brekelenkam worked in Leiden in the mid-1600s and painted tailors' workshops many times. Tailors sat on their worktables to sew, close to the window for light, because every stitch was done by hand and every hour of daylight was precious. A tailor's price had to cover the cloth, the thread, the rent of the workshop and the long hours of himself and his helpers.

Look closely

- Count the workers. Who seems to be the master, and who the helpers? How can you tell?
- Find the light. Why do all the workers sit as close to the window as they can?
- Find the tools and materials. Which are used up with each garment, and which are kept for years?

Talk about it

1. Sort what you see into variable costs (used up with each garment) and fixed costs (paid whatever the number of garments).
2. In 1661 there were no sewing machines. What does that tell you about how much of a coat's price was labor?

HANDS-ON: THE COST SHEET

Build a full cost sheet for your chosen product. It will be the foundation for your price in Stop D4.

You will need

- Your D2 prototype and its materials list
- Receipts, catalog prices or store websites for each material (a parent helps)
- A calculator, notebook or simple spreadsheet
- A timer

Steps

1. List every material in one item. For each, write the package price, the package quantity and the amount one item uses. Calculate the unit cost to the nearest cent.
2. Add the materials and add a 10 percent waste allowance.
3. Make a batch of at least three items, step by step. Time the whole batch and divide to find minutes per item. Compare it with your prototype time.
4. Choose an hourly rate with a parent and explain it in one sentence. Calculate labor cost per item.
5. List fixed costs (tools, table fee, signs). Estimate how many items they will be spread over and calculate overhead per item.
6. Add materials, labor and overhead for your full unit cost. Unfold your warm-up guess and compare. Write one sentence about what surprised you.
7. Read Franklin's excerpt in the Primary source box. Below your sheet, write your opportunity cost: what else could you have done with the hours of your batch?

Check your work

- Every material has a package price, quantity and unit cost.
- My labor cost comes from a timed batch, not a guess.
- My sheet shows fixed and variable costs separately and a full unit cost.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, explain how you found the full cost of one of your products, what the biggest part of the cost turned out to be, and what Franklin meant by "time is money." A parent dates and keeps the page.

2. Draw a pie chart of your unit cost: materials, labor and overhead, each as a percentage.
3. File your cost sheet in your Maker's File.

Did you know? Franklin's "Advice to a Young Tradesman" first appeared in 1748 in *The American Instructor*, a handbook for young workers that Franklin and his partner David Hall printed in Philadelphia. That same year, at 42, Franklin stepped back from daily work in his printing house and left it in Hall's hands as partner, with the profits shared for the next eighteen years.

Primary source. *Benjamin Franklin, "Advice to a Young Tradesman" (1748), as printed in Memoirs of Benjamin Franklin, vol. 2 (New York: Harper & Brothers, 1860). Text from Project Gutenberg, eBook #40236.*

To my Friend A. B. As you have desired it of me, I write the following hints, which have been of service to me, and may, if observed, be so to you. Remember that *time* is money. He that can earn ten shillings a day by his labour, and goes abroad or sits idle one half of that day, though he spends but sixpence during his diversion or idleness, ought not to reckon *that* the only expense; he has really spent, or, rather, thrown away, five shillings besides.

Go deeper. Richard J. Maybury, *Whatever Happened to Penny Candy?* (Bluestocking Press), a short economics book for teens that explains prices and costs plainly. Henry Hazlitt, *Economics in One Lesson* (1946), chapter 1, "The Lesson," on seeing hidden costs. The Rijksmuseum's online page for *The Tailor's Workshop* lets you zoom into the tools. Second video topic: "Batch production versus one-at-a-time in a small workshop."

Goes deeper in. Small Business & Economics, "Costs: Fixed, Variable and Opportunity," and Arithmetic, "Unit Rates and Percentages" (coming soon).

For families. Sources: Franklin text from Project Gutenberg #40236 (the 1860 Harper edition modernizes some of the 1748 capitalization); publication in George Fisher's *The American Instructor* (Philadelphia: Franklin and Hall, 1748). All prices in the notebook example are round illustrative figures; families should use their own receipts. The hourly rate is a family decision; the stop suggests tying it to work realistically open to the student. The 10 percent waste allowance is a common rule of thumb, not a standard. Picture: Brekelenkam, *The Tailor's Workshop*, Rijksmuseum SK-C-112.

PRACTICE

1. **EASY** A skein of embroidery floss costs \$0.48 and contains 8 yards. What is the cost per yard? What does 3 yards cost?
2. **EASY** Sort into fixed or variable: thread, a table fee, a pair of fabric shears, felt, the time to sew one item.

3. **MEDIUM** A pincushion uses \$1.20 of fabric and stuffing. With a 10 percent waste allowance, what is the materials cost? If it takes 30 minutes at \$10 an hour, what is the materials-plus-labor cost?
4. **MEDIUM** In Franklin's example, a man who can earn ten shillings a day sits idle half the day and spends sixpence. What is the total cost of his idleness? (12 pence = 1 shilling.)
5. **CHALLENGE** Making bookmarks one at a time takes 15 minutes each. In a batch of 20, set-up takes 30 minutes once and each bookmark then takes 8 minutes. At \$10 an hour, find the labor cost per bookmark both ways and the savings on 20 bookmarks.
6. **CHALLENGE** A student makes drawstring bags. Materials \$2.40 each, labor 45 minutes at \$10 an hour, a \$30 sewing-machine tune-up spread over 40 bags, and a \$25 fair table expected to sell 20 bags. Find the full unit cost. If only 10 bags sell, what is the true table cost per bag sold?

Make it a game • Guess the Real Cost. A parent lays out three simple handmade items and the packages their materials came from, with prices showing. Each player secretly writes a guess of the full cost of one item (materials, waste and 20 minutes of labor at \$10 an hour). Then everyone works it out together on paper. Closest guess wins; anyone who forgot labor loses a point.

Scripture. "For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it?" (Luke 14:28, KJV)

Jesus used ordinary building costs to teach about counting the cost of following Him. The illustration only works because everyone knew that wise builders sit down and count first. A careful maker does the same.

Practice: answers

1. $\$0.48 \div 8 = \0.06 a yard; 3 yards cost \$0.18.
2. Variable: thread, felt, the time to sew one item. Fixed: the table fee and the shears (a tool bought once).
3. $\$1.20 \times 1.10 = \1.32 materials; labor \$5.00; total \$6.32.
4. Five shillings of lost earnings plus sixpence spent: 5 shillings 6 pence, or 66 pence.
5. One at a time: 15 min = \$2.50 each; 20 cost \$50.00. Batch: $30 + 20 \times 8 = 190$ minutes for 20, or 9.5 minutes each = \$1.58 (to the nearest cent); 20 cost \$31.67. Savings: about \$18.33 on 20 bookmarks.
6. Materials \$2.40 + labor \$7.50 + tune-up \$0.75 + table \$1.25 = \$11.90. If only 10 sell, the table costs $\$25 \div 10 = \2.50 per bag sold, so the full cost of each bag sold rises to \$13.15.

4.4 SETTING A FAIR PRICE

OBJECTIVES

- Set a price by three methods (cost-plus, market comparison and value to the buyer) and choose a price within the range they give.
- Calculate markup, profit margin and a break-even quantity.
- Explain the biblical and classical idea of a just price from Leviticus 25 and from medieval Christian teaching.

Warm-up. Look at three handmade or small-batch items in your home or at a store's website. For each, guess what it cost to make and write down what it sells for. Why do you think the price is set where it is?

Video slot. Video coming. How to price handmade products: cost-plus pricing, wholesale and retail, break-even. Search approved channels (U.S. Small Business Administration, SCORE, a university extension small-business channel, Khan Academy for percent and markup); preview first.

KEY TERMS

price floor

The lowest price you can accept without losing money, usually your full unit cost.

markup

The amount added to cost to reach the price, often given as a percent of cost. Cost \$5, price \$8: the markup is \$3, or 60 percent.

profit margin

Profit as a percent of the price. Cost \$5, price \$8: the margin is $\$3 \div \$8 = 37.5$ percent.

break-even point

The number of sales needed for income to cover all costs: $\text{fixed costs} \div (\text{price} - \text{variable cost per item})$, rounded up.

wholesale and retail

Retail is the price paid by the final buyer; wholesale is the lower price a shop pays the maker so that it can resell at retail. Shops often expect to buy at about half of retail.

just price

A price that is fair to both buyer and seller: in medieval Christian teaching, roughly the common estimate of a thing's worth in an honest market, without fraud or taking advantage of need.

CORE IDEAS

A price is a promise in numbers: it says what the maker believes the item is worth and what the buyer must give up to have it. Scripture treats pricing as a moral matter. "A false balance

is abomination to the LORD: but a just weight is his delight” (Proverbs 11:1). In Leviticus 25 God gave Israel rules for selling land between jubilee years, the fiftieth years when land returned to its family. The price had to rise or fall with “the number of years of the fruits,” because the buyer was really buying harvests, not soil. Read the passage in the Primary source box. The principle is simple and lasting: the price should match what the buyer actually receives, and “ye shall not oppress one another.”

There are three common ways to set a price, and a wise maker uses all three. **Cost-plus pricing** starts from your full unit cost (Stop D3) and adds a markup. Your cost is your **price floor**: below it, every sale loses money. **Market pricing** looks at what similar items sell for at fairs, in shops and online. **Value pricing** asks what the item is worth to the buyer: a hand-lettered card with a person’s name, or a notebook bound in a family’s old fabric, is worth more to that buyer than a plain one. The three methods usually give a range, and your price belongs somewhere inside it.

Work an example. In Stop D3 a hand-bound notebook had a full unit cost of \$5.66, of which \$0.66 was materials, \$4.00 labor and \$1.00 overhead. Similar handmade notebooks at local fairs sell for about \$8 to \$15. A price of \$10 is above the floor and in the middle of the market. At \$10, the profit beyond all costs, including your wages, is $\$10.00 - \$5.66 = \$4.34$. The **markup** is $\$4.34 \div \5.66 , about 77 percent of cost. The **profit margin** is $\$4.34 \div \10.00 , or 43 percent of the price. Markup and margin describe the same dollars but divide by different numbers, so always say which you mean.

Next find the **break-even point**. The table fee of \$20 is a fixed cost. Each notebook sold brings in \$10 but uses \$0.66 of materials, so it contributes \$9.34 toward the fee. $\$20 \div \$9.34 \approx 2.1$, so you must sell 3 notebooks before you have earned back the table. If you also want to be paid \$4.00 of wages per notebook, each one contributes only \$5.34 and you need $\$20 \div \$5.34 \approx 3.7$, or 4 sales. Knowing this number before the fair helps you decide whether the fair is worth attending at all. Notice, too, the **wholesale** problem: if a gift shop offers to stock your notebooks, it will want to pay about \$5 so it can sell them for \$10. That is below your \$5.66 cost. Many makers discover that a price that works at their own table does not work in shops.

Christians have thought hard about fair prices for a long time. Medieval theologians, most famously Thomas Aquinas in his *Summa Theologica* (about 1270), taught that it is sinful to use deceit to sell something for more than its **just price**, or to hide a defect the buyer cannot see. Aquinas also recognized that the just price is not a single exact figure but a reasonable range, estimated by what goods commonly sell for, and that a seller may charge more if parting with the item truly costs him more. What he condemned was taking advantage of a buyer’s ignorance or desperate need. These ideas have shaped Western commercial ethics ever since.

Now some honest complexity. Underpricing feels kind, but it is not always so. A price below cost cannot last, and it trains customers to think handmade work is worth little, which hurts other makers. Overpricing is the opposite danger: a high price with ordinary quality is a kind of false promise. Should friends get a discount? Should you haggle? Many makers choose

one clear price for everyone, posted on the table, with any generosity given openly as a gift rather than hidden in confusing prices. Pricing for a charity sale is different again, because buyers are partly giving. And round prices (\$5, \$8, \$10) are easier at a cash table than \$7.99, which leaves you hunting for pennies.

A fair price, then, is one you can explain honestly: it covers your true costs, sits within what such things commonly sell for, reflects real quality and value, and takes no advantage of anyone. If you can say all that out loud to a buyer, you have probably found it.

PICTURE STUDY



The Moneylender and His Wife, Quentin Matsys (Quinten Metsys), 1514 · Oil on panel · Musée du Louvre, Paris

Wikimedia Commons · Public domain

Quentin Matsys was a leading painter of Antwerp, then the busiest trading city in northern Europe. A money changer's job was to test and weigh coins, because coins of many countries passed through the port and some were clipped or light. Early descriptions record that the painting's original frame bore a line from Leviticus 19:36, "Let the balance be just and the weights equal." The wife's book is a devotional book with a picture of the Virgin and Child, which turns the painting into a quiet question about money and faith.

Look closely

- Find the balance. Is the man weighing carefully or carelessly? How can you tell?
- Find the wife's book. Where are her eyes looking: at the book or at the money?
- Find the little convex mirror. What, or who, is outside the window it reflects?

Talk about it

1. The frame's inscription asked for just weights. How does the painting show both honest business and its temptations?
2. What would a "just balance" look like in pricing your own product? Give two examples.

HANDS-ON: THE PRICE CARD AND PRICE LIST

Set the price for each item in your product line, show your reasoning, and make the price list you will use at your table in Stop D7. Use Leviticus 25 in the Primary source box as your test of fairness.

You will need

- Your cost sheet from Stop D3
- Prices of at least five similar items (from fairs, shops or websites; a parent helps online)
- A calculator
- Cardstock and a fine marker

Steps

1. Write your full unit cost (the price floor) for each item in your line.
2. List at least five comparable items with their prices. Find the lowest, the highest and the middle (median) price.
3. Write one sentence about value: does your item offer anything special (personalized, unusual material, better finish) that would justify a price above the middle?
4. Choose a price for each item. Calculate the markup and the profit margin for each.
5. Calculate your break-even quantity for your expected table fee, first counting materials only and then counting materials and wages.
6. Apply the Leviticus test: in two sentences, explain why your price matches what the buyer receives and does not "oppress" the buyer or undercut your own work.
7. Letter a neat price list on cardstock with item names and prices. File a copy in your Maker's File.

Check your work

- Every price is above my full unit cost, or I have written why it is not (for example, a charity sale).
- I show markup, margin and break-even with the arithmetic.
- My Leviticus paragraph gives reasons, not just feelings.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, explain how you set the price of your main product, using the three pricing methods and at least one idea from Leviticus 25 or from the medieval teaching on the just price. A parent dates and keeps the page.

2. Draw a number line from \$0 to the highest market price you found. Mark your cost, the market middle and your chosen price.
3. Copy Proverbs 11:1 in your best hand-lettering beneath the number line.

Did you know? Many store prices end in 99 cents because shoppers tend to read the left-hand digit first, so \$9.99 “feels” nearer \$9 than \$10. At a cash table this habit is a nuisance: you need a pile of pennies and dimes for change. Most craft-fair sellers use whole dollars.

Primary source. *Leviticus 25:14–17, King James Version (1611). The law of selling land between jubilee years.*

14 And if thou sell ought unto thy neighbour, or buyest ought of thy neighbour's hand, ye shall not oppress one another:

15 According to the number of years after the jubile thou shalt buy of thy neighbour, and according unto the number of years of the fruits he shall sell unto thee:

16 According to the multitude of years thou shalt increase the price thereof, and according to the fewness of years thou shalt diminish the price of it: for according to the number of the years of the fruits doth he sell unto thee.

17 Ye shall not therefore oppress one another; but thou shalt fear thy God: for I am the LORD your God.

Go deeper. Henry Hazlitt, *Economics in One Lesson* (1946), the chapters “How the Price System Works” and “Saving the X Industry.” Thomas Aquinas, *Summa Theologica*, Second Part of the Second Part, Question 77, “Of Cheating, Which Is Committed in Buying and Selling” (the English Dominican translation is on Project Gutenberg as eBook #18755); read Article 1 with a parent. The Louvre’s online collection page for *The Moneylender and His Wife*. Second video topic: “Wholesale versus retail: why shops buy at half price.”

Goes deeper in. Small Business & Economics, “Prices, Profit and the Just Price,” and Arithmetic, “Percent, Markup and Margin” (coming soon).

For families. Sources: the KJV text above; Aquinas, *Summa Theologica* II-II q. 77 a. 1, summarized rather than quoted. The “about half of retail” wholesale figure is a common rule in gift and craft retail (sometimes called keystone pricing), but terms vary. The original frame inscription on Matsys’s painting is known from a seventeenth-century description; the frame itself is lost. Families may reasonably differ on discounts and bargaining; the stop recommends one posted price as the simplest honest practice. Picture: Matsys, *The Moneylender and His Wife*, Louvre, Paris.

PRACTICE

1. **EASY** Name the three pricing methods in this stop.
2. **EASY** In Leviticus 25:15–16, what made the price of land go up or down?

3. **MEDIUM** A pincushion costs \$4.00 to make and sells for \$7.00. Find the profit, the markup (as a percent of cost) and the margin (as a percent of price).
4. **MEDIUM** A gift shop offers to buy your \$12 cards at wholesale, about half of retail. Your full cost is \$5.20 a card. Should you accept? Show why.
5. **CHALLENGE** Fair table: \$30. Bookmarks sell for \$4 and use \$0.50 of materials. (a) How many must sell to cover the table, counting materials only? (b) If you also pay yourself \$1.50 labor per bookmark, how many must sell? (c) What profit beyond wages do you make if you sell 40?
6. **CHALLENGE** A buyer at the end of the day says, "I really need a birthday gift in ten minutes, and you're the only table left." A classmate says you should double the price. Using Leviticus 25:14 and the medieval teaching on the just price, give a reasoned answer.

Make it a game • The Price Is Fair. A parent shows five handmade or small-batch items with their cost sheets (real or made up). Each player writes a price for each item, then must defend it in one sentence using cost, market or value. The parent reveals a "market price" card for each. Players score 2 points for a price within \$1 of the market card that is still above cost, and lose 2 points for any price below cost.

Scripture. "A false balance is abomination to the LORD: but a just weight is his delight." (Proverbs 11:1, KJV)

In Bible times the balance was how a price was measured out. God cares about honest measures and fair prices, not only about worship. A just price is a small way to delight Him.

Practice: answers

1. Cost-plus pricing (cost plus a markup), market pricing (what similar items sell for) and value pricing (what the item is worth to the buyer).
2. The number of years of harvests ("the years of the fruits") left until the jubilee: more years, higher price; fewer years, lower price.
3. Profit \$3.00; markup $\$3 \div \$4 = 75$ percent; margin $\$3 \div \$7 \approx 42.9$ percent.
4. Half of \$12 is \$6.00. That is above the \$5.20 cost, so each card still earns \$0.80. It can be accepted, though the profit is much smaller than the \$6.80 earned at your own table.
5. (a) Each contributes \$3.50; $\$30 \div \$3.50 \approx 8.6$, so 9 bookmarks. (b) Each contributes \$2.00; $\$30 \div \$2 = 15$ bookmarks. (c) $40 \times \$2.00 = \$80 - \$30 = \50 profit beyond wages.
6. A strong answer says no: the item is worth the same as it was an hour before, and raising the price because the buyer is desperate is taking advantage of need, which Leviticus forbids ("ye shall not oppress one another") and which Aquinas condemned. A just price reflects the thing's common worth and your real costs, not the buyer's distress. You may still decline a lower offer, but you should charge the posted price.

4.5 QUALITY CONTROL: WOULD YOU BUY IT?

OBJECTIVES

- Write a product specification with measurable standards and tolerances.
- Inspect a batch with a checklist, calculate a defect rate, and decide what to do with seconds.
- Explain from history (the guild inspectors) and from William Morris why quality is both a duty to the buyer and a joy to the maker.

Warm-up. Pick up the best-made object you own and the worst-made. Write three things that make the first one good and three that make the second one poor. Which of your six reasons could be measured with a ruler, a scale or a test?

Video slot. Video coming. Quality control for handmade goods: checklists, tolerances, seam strength tests; the Amsterdam drapers' guild and Rembrandt's Syndics. Search approved channels (Rijksmuseum, a university extension or 4-H sewing channel, a museum conservation channel); preview first.

KEY TERMS

quality

How well a product does what it promises, and how consistently: fitness for its purpose, sound construction, careful finish and safety.

specification (spec)

A written description of exactly what the finished product must be: size, materials, construction and finish.

tolerance

The allowed amount of variation from a specification, such as "7 inches long, plus or minus 1/8 inch."

defect rate

The share of items that fail inspection: $\text{defects} \div \text{items inspected}$, usually given as a percent.

seconds

Items with small flaws that do not affect safety or use, sold openly as flawed at a lower price.

guild

An association of masters in one craft in a town, which trained apprentices, set standards and inspected goods. Guilds flourished in Europe from the Middle Ages to the 1700s.

CORE IDEAS

The simplest quality test is a question: *Would I buy this, at this price, if a stranger had made it?* It is harder to answer honestly than it sounds. Makers love their own work and remember how hard it was; buyers see only the result. So professional makers do not trust their feelings. They write down what “good” means, check every item against it, and deal honestly with the ones that fall short.

Begin with a **specification**. For a drawstring bag it might read: finished size 8 by 10 inches, plus or minus 1/4 inch; seams sewn at 8 to 10 stitches per inch with a 1/2-inch seam allowance; all raw edges finished; casing even; drawstring runs freely and ends are knotted or sealed; no loose threads over 1/4 inch; no marks or stains. The “plus or minus” is the **tolerance**. No handmade item is perfectly identical to another, and that is part of its charm, but a tolerance says how much difference is acceptable. Notice that most of the spec can be measured. Good **quality** is fitness for purpose (the bag holds things and closes), sound construction (it will not come apart), careful finish (it looks right) and safety.

Then inspect. Use a checklist drawn from the spec and look at every item, front and back, in good light. Test function, not just appearance: pull firmly on each seam, open and close the bag ten times, flex the notebook spine, wash one sample of anything that will be washed. Count the failures. If 3 bags out of 24 fail, the **defect rate** is $3 \div 24 = 12.5$ percent. Then ask *why*. If all three failures are crooked casings, the fix is in your method (perhaps a pressed fold line before sewing), not in working harder. It is nearly always cheaper to prevent a defect than to repair it after the item is finished, which is why the old rule says, “Measure twice, cut once.”

What do you do with the items that fail? A flaw that affects safety or use means the item is not sold. Repair it if you can, or scrap it and count the loss honestly in your costs. A small cosmetic flaw, such as a slightly uneven stitch or a tiny mark, can make the item a **second**, sold openly as flawed at a lower price. What you must never do is hide a flaw and sell a second as a first. Medieval Christian moralists, Thomas Aquinas among them, taught that a seller who knowingly hides a defect the buyer cannot see sins against his neighbor.

Quality control is old. In the towns of medieval and early modern Europe, the craft **guilds** appointed inspectors who checked the goods of every member. In Amsterdam the drapers’ guild chose officials called *staalmeesters*, “sample masters,” who examined dyed cloth against approved samples and marked it with lead seals that showed its grade. Rembrandt painted five of them in 1662, in the picture study for this stop. A bad seal could ruin a cloth merchant’s name, and a good one let a buyer trust cloth he had never seen made. Guild inspection could also be used to shut out competitors, and many guild rules were later swept away for that reason, but the purpose of inspection, protecting the buyer, was sound.

William Morris, the English designer of the 1800s whose fabrics you will meet in Stop D6, argued that quality is not only a duty to the buyer but also a joy to the maker. Read his words in the Primary source box. Ornament and fine finish, he said, “give people pleasure in the things they must perforce *use*” and also “pleasure in the things they must perforce *make*.”

Real art, to Morris, was “the expression by man of his pleasure in labour.” A maker who takes care over a hem or a spine is not only protecting a customer but also doing work that is worth doing.

Here is the honest complexity. Perfectionism can be its own trap: a maker who will not sell anything until it is flawless may never sell at all, or may spend so long on each item that it costs far more than anyone will pay. The aim is not perfection but a clear, honest standard that the item meets every time, at a price that fits. Scripture sets the motive: “whatsoever ye do, do it heartily, as to the Lord, and not unto men” (Colossians 3:23). Work done for the Lord is done carefully even where no buyer would notice, and it is offered honestly where a buyer would.

PICTURE STUDY



The Syndics of the Drapers' Guild (De Staalmeesters), Rembrandt van Rijn, 1662 · Oil on canvas ·
Rijksmuseum, Amsterdam
Wikimedia Commons · Public domain

Every year the Amsterdam drapers' guild chose a board of sample masters to judge the quality of dyed cloth. Rembrandt painted the board of 1662 for their meeting room. It is a group portrait, a type of painting in which every sitter usually paid and expected to be clearly seen. Rembrandt made it lively by painting the men as if they had looked up from their work all at once. The man without a hat is generally identified as the guild's servant.

Look closely

- Count the men. Which one seems to be rising from his chair? What might have interrupted them?
- Find the open book. What might inspectors of cloth have written or kept in it?

- Look at the carpet. Why might Rembrandt have put such a fine, richly made textile in a painting about cloth inspectors?

Talk about it

1. These men's judgment could make or break a cloth merchant. What qualities of character would you want in a quality inspector?
2. How is your own inspection checklist like the work of the staalmeeesters, and how is it different?

Safety first. Pull tests and wash tests are done on your own products, gently and with a parent's permission. Keep needles, pins and shears in their places while inspecting, and press seams with an iron only with a parent present. Anything meant for babies or young children needs a parent's check against current safety rules before it is given or sold.

HANDS-ON: SPEC, CHECKLIST AND INSPECTION REPORT

Write the standard for your product, inspect your batch, and report the results like a guild sample master.

You will need

- Your product (at least five finished items, from your D3 batch or new ones)
- A ruler or tape measure and a kitchen scale (if weight matters)
- Good light and a magnifier if you have one
- Notebook or a simple spreadsheet
- The Morris excerpt in the Primary source box

Steps

1. Write a specification for your main product: size with tolerance, materials, construction details and finish. Include at least six measurable items.
2. Turn the spec into a checklist with a box for each item, plus "function test" and "safety" lines.
3. Inspect every finished item. Mark pass or fail on each line and note the reason for any failure.
4. Calculate your defect rate. Group the failures by cause and write one change to your method that would prevent the most common one.
5. Decide each failed item's fate: repair, second (with a clearly marked lower price) or scrap. Add any scrap loss to your cost sheet.
6. Hand one passed item to a family member who did not watch you make it and ask, "Would you buy this at my price? Why or why not?" Record the answer.
7. Write a two-sentence "sample master's seal" statement: what promise your passed items carry. Use one phrase from Morris.

Check your work

- My spec has at least six measurable standards with tolerances.
- I inspected every item and calculated a defect rate.
- I decided honestly what to do with each failed item.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, explain how you decided whether your products were good enough to sell, what your defect rate was, what you changed, and why quality matters to a Christian maker. Use Colossians 3:23 or Morris. A parent dates and keeps the page.
2. Draw a close-up “quality diagram” of your product with arrows pointing to each place you inspect.
3. File your spec, checklist and report in your Maker’s File.

Did you know? The Dutch word *staal* in *staalmeesters* means “sample.” The cloth inspectors compared each piece with a standard sample. Lead seals stamped by guilds and towns to mark cloth quality are found in large numbers by archaeologists and metal-detectorists along rivers and in old trading towns.

Primary source. William Morris, *“The Lesser Arts”* (a lecture of 1877) and *“The Art of the People”* (1879), both printed in *Hopes and Fears for Art* (1882). Text from Project Gutenberg, eBook #3773.

... forms and intricacies that do not necessarily imitate nature, but in which the hand of the craftsman is guided to work in the way that she does, till the web, the cup, or the knife, look as natural, nay as lovely, as the green field, the river bank, or the mountain flint. To give people pleasure in the things they must perforce *use*, that is one great office of decoration; to give people pleasure in the things they must perforce *make*, that is the other use of it. Does not our subject look important enough now?

That thing which I understand by real art is the expression by man of his pleasure in labour. I do not believe he can be happy in his labour without expressing that happiness; and especially is this so when he is at work at anything in which he specially excels.

Go deeper. The Rijksmuseum’s online page for *The Syndics* (SK-C-6), with a zoomable image. William Morris, *Hopes and Fears for Art* (1882), free on Project Gutenberg; read the first lecture, “The Lesser Arts.” Matthew B. Crawford, *Shop Class as Soulcraft* (2009), on the satisfaction of skilled handwork (for older students; parents preview). Second video topic: “How a factory quality inspector checks seams and stitching.”

Goes deeper in. Small Business & Economics, “Quality, Reputation and the Customer,” and Art, “Rembrandt and the Dutch Golden Age” (coming soon).

For families. Sources: Morris text from Project Gutenberg #3773 (from the 1919 Longmans edition); Rijksmuseum notes on *De Staalmeesters* for the role of the sample masters and the servant; Aquinas, *Summa Theologica* II-II q. 77 a. 3 (on hidden defects), summarized, not quoted. Morris was a socialist in his later years; this stop uses only his writing on craftsmanship. Specification numbers (stitches per inch, tolerances) are typical home-sewing values, not a standard. Picture: Rembrandt, *The Syndics of the Amsterdam Drapers' Guild*, Rijksmuseum SK-C-6.

PRACTICE

1. **EASY** What is a tolerance? Give an example for a bookmark.
2. **EASY** What were the staalmeesters of Amsterdam, and what did they inspect?
3. **MEDIUM** You inspect 30 greeting cards and 4 fail. What is the defect rate? If your goal is under 5 percent, how many failures would be the most you could allow in 30?
4. **MEDIUM** A pincushion has a slightly uneven top stitch; another has a seam that opens when pulled, letting stuffing out. What should happen to each?
5. **CHALLENGE** Bags cost \$6.00 each to make and sell for \$14. A batch of 20 has a 10 percent defect rate; half the failures can be sold as seconds for \$8 and half must be scrapped. Find (a) the number of firsts, seconds and scraps, (b) total income, (c) profit on the batch. Then find the profit if a better method cuts defects to 5 percent, all of them sellable as seconds.
6. **CHALLENGE** Using both Morris excerpts, explain the two “uses” of good decoration and finish he names, and argue whether a maker who sells only to strangers he will never see again still has reasons to care about quality.

Make it a game • Sample Masters. A parent makes or gathers six similar items, a few with hidden flaws (a loose thread, a crooked edge, a weak seam, a smudge). Players act as the guild board: each inspects silently for two minutes and writes pass, second or fail for each item with a reason. Reveal the flaws. Score a point for each flaw found and lose a point for failing a good item. The highest scorer receives a homemade “lead seal” (a foil-covered cardboard disk).

Scripture. “And whatsoever ye do, do it heartily, as to the Lord, and not unto men;” (Colossians 3:23, KJV)

Paul wrote these words to servants doing ordinary work. The best reason for quality is not inspection or profit but that the Lord sees the work. A stitch done heartily is done for Him.

Practice: answers

1. The allowed variation from a specification. Example: 2 inches wide by 7 inches long, plus or minus 1/16 inch.
2. The “sample masters” of the drapers’ guild, officials who judged the quality of dyed cloth against standard samples and marked it with seals.
3. $4 \div 30 \approx 13.3$ percent. Under 5 percent of 30 is under 1.5, so at most 1 failure.

4. The uneven stitch is cosmetic: sell it as a clearly marked second at a lower price, or keep it. The open seam affects use (and could be a hazard if pins or stuffing come out): repair it and re-inspect, or do not sell it.
5. (a) 10% of 20 = 2 failures: 18 firsts, 1 second, 1 scrap. (b) $18 \times \$14 + 1 \times \$8 = \$252 + \$8 = \$260$. (c) Cost $20 \times \$6 = \120 ; profit \$140. At 5 percent: 19 firsts and 1 second: $\$266 + \$8 = \$274$; profit \$154, which is \$14 more. Preventing defects pays.
6. Morris names pleasure for the user ("pleasure in the things they must perforce use") and pleasure for the maker ("pleasure in the things they must perforce make"), and he calls real art "the expression by man of his pleasure in labour." So even with strangers, quality matters: the buyer deserves a sound, pleasing thing for the price (honesty and love of neighbor), and the maker is shaped by doing good work. A Christian adds Colossians 3:23: the work is done "as to the Lord," who sees it even when no buyer returns.

4.6 LABELS, PACKAGING AND A SIMPLE LOGO

OBJECTIVES

- Design a label that tells the truth: maker, product, materials, care and quantity, and know which U.S. rules apply to textile goods.
- Design packaging that protects, displays and informs, and add its cost to the unit cost.
- Design a simple logo that works small and in one color, and explain why a maker's mark is only as good as the maker's name.

Warm-up. Find five labels or tags in your house: on clothing, a jar, a box of tea, a book, a tool. For each, list every piece of information it gives. Which information is there to help you, which is there because the law requires it, and which is there to persuade you to buy?

Video slot. Video coming. Designing a simple logo and product label for handmade goods; William Morris and Strawberry Thief block printing at Merton Abbey. Search approved channels (Victoria and Albert Museum, William Morris Society, a university extension small-business channel); preview first.

KEY TERMS

label

Information attached to a product: who made it, what it is, what it is made of, how to care for it, and how much there is.

fiber content

The kinds and percentages of fibers in a textile, such as “100% cotton” or “80% wool, 20% nylon.” U.S. law requires it on most textile products offered for sale.

logo

A simple mark, made of letters, a picture or both, that identifies a maker or business.

brand

The name and reputation that buyers connect with a maker. A logo points to a brand; only the maker's work and honesty build it.

maker's mark

A stamp or sign showing who made an object. Hallmarks on silver, potters' stamps and weavers' tags are maker's marks.

packaging

Whatever holds, protects and presents a product: a bag, box, sleeve, band or tag.

CORE IDEAS

Makers have been marking their work for thousands of years. Roman brick-makers stamped their bricks; medieval masons cut their marks into stones; potters pressed their names into

the bottoms of plates. In England a statute of King Edward I in 1300 required silver to be tested and stamped with a leopard's head before it could be sold. Later, the testing took place at Goldsmiths' Hall in London, which is why such a stamp is called a **hallmark**, and why the word now means any mark of genuine quality. A **maker's mark** does two things at once: it tells the buyer who stands behind the work, and it binds the maker to stand behind it.

Your **label** should answer the buyer's honest questions. Who made it? (Your shop name and town, or a contact.) What is it? (The product name and size.) What is it made of? How do I care for it? How much is there, if quantity matters, as with soap or tea? For textile goods sold in the United States, the Textile Fiber Products Identification Act, enforced by the Federal Trade Commission, generally requires a label showing **fiber content** by percentage, the country where it was made, and the maker's or seller's identity; clothing also needs care instructions under the FTC's Care Labeling Rule. Some small or decorative items are exempt, so a parent should check the FTC's plain-language guide before selling textiles.

Above all, a label must be true. Moses told Israel, "Thou shalt not have in thy bag divers weights, a great and a small," but "a perfect and just weight" (Deuteronomy 25:13-15). Read the full passage in the Primary source box. A label is a kind of weight and measure: it tells the buyer what they are getting. Calling acrylic yarn "wool," saying "hand-dyed" of store-dyed thread, or printing "4 oz" on a 3-ounce bar of soap is the modern form of a false weight. So is a picture or word that suggests something untrue, such as "organic" when it is not.

Packaging has three jobs: protect, display and inform. A card in a clear sleeve stays clean; a bookmark on a backing card does not bend; a pouch tied with a band and tag looks like a gift. But packaging costs money and adds to the unit cost you calculated in Stop D3. Suppose a notebook gets a kraft tag (\$0.06), a length of twine (\$0.02), a clear sleeve (\$0.10) and a logo sticker (\$0.05): that is \$0.23 more per item, or \$5.75 on 25 notebooks. Choose packaging that does its jobs with as little cost and waste as possible. Plain kraft paper and a well-designed stamp often look better than glossy plastic.

A **logo** is a small, permanent drawing that must work in hard conditions: stamped in one ink color, printed one inch wide on a tag, photocopied, seen across a table. So the rules are simple. Keep it to one idea: a monogram, a single object, or your shop name in clear letters. Make it work in black and white first. Test it at one inch and at three inches. Use no more than two lettering styles. Make it yours: do not copy another company's mark, and search to make sure your shop name is not already used by another seller of similar goods. A rubber stamp of your logo, bought or carved from an eraser, can mark tags, bags and stickers for pennies each.

William Morris, whose words you read in Stop D5, understood that a good design and a good name grow together. His firm, Morris & Co., sold wallpapers and fabrics that buyers recognized at a glance. *Strawberry Thief*, this stop's picture, was designed in 1883 after Morris watched thrushes raiding the strawberry beds at his country house. It was printed by the slow, costly indigo-discharge method at his works at Merton Abbey, and it sold well

despite its price because buyers trusted the quality behind the name. The pattern is recognizable from a scrap: that is the mark of good design.

Here is the honest complexity. Branding can be used to cover poor work with clever packaging, and much modern advertising sells feelings rather than goods. A Christian maker should design a beautiful label and logo without pretending they are the substance. “A good name is rather to be chosen than great riches” (Proverbs 22:1), but a good name cannot be drawn; it is earned, one honest sale at a time. Your logo will mean whatever your work and your dealing teach buyers it means.

PICTURE STUDY



Strawberry Thief, William Morris (designer); Morris & Co. (maker), Designed 1883 · Indigo-discharge and block-printed cotton · Victoria and Albert Museum, London, and many other collections
Wikimedia Commons · Public domain

William Morris (1834–1896) was a designer, poet and craftsman who believed ordinary household things should be both useful and beautiful. He revived old methods of hand dyeing and block printing. To make *Strawberry Thief*, the cloth was dyed blue in indigo vats and then printed with wooden blocks carrying a bleaching paste and other dyes, a process that could take days for each length. It became one of his firm’s best-loved patterns and is still printed today.

Look closely

- Find the repeat. Where does the pattern begin to copy itself, and in which directions does it mirror?
- Count the colors. How few colors did Morris use to make a design this rich?
- Find the thrushes and the strawberries. How does Morris turn a garden nuisance into a delight?

Talk about it

1. Why is this pattern recognizable from even a small scrap? What could a logo learn from that?
2. Morris's fabrics cost more than machine-printed ones. Why would buyers pay more, and what had to be true about the quality for that to be fair?

HANDS-ON: MY MAKER'S MARK, LABEL AND PACKAGE

Design a logo, write an honest label, and package one finished product for sale. Test your label against Deuteronomy 25 in the Primary source box.

You will need

- Plain paper, tracing paper and a black fine-tip pen
- Cardstock or kraft tags, and twine, ribbon or sleeves
- Optional: a soft white eraser and a craft knife (with a parent) to carve a stamp, and an ink pad
- One finished product from your batch
- A ruler and calculator

Steps

1. Choose a shop name. With a parent, do a quick online search to be sure no similar seller already uses it.
2. Sketch at least six logo ideas in black ink, each in a one-inch square. Choose the best two and redraw them at three inches. Pick one and refine it.
3. Make the logo usable: trace it, reduce it on a copier or by hand, or carve it into an eraser stamp (a parent supervises the knife).
4. Write your label: shop name and town, product name, size or quantity, materials (with fiber content for textiles), care instructions and the words "Handmade by ..." only if true. Read it aloud and remove anything that is not strictly accurate.
5. Design packaging that protects, displays and informs. Price each packaging part and add the total to your cost sheet.
6. Package one product completely. Photograph it or draw it, and file the design, label text and packaging cost in your Maker's File.

Check your work

- My logo is clear at one inch in one color.
- Every statement on my label is true and checkable.
- I added packaging cost to my unit cost.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, explain how you designed your logo, label and packaging, what the law and Deuteronomy 25 require of a label,

- and why a logo cannot make a good name by itself. A parent dates and keeps the page.
2. Paste or stamp your final logo at one inch, two inches and three inches.
 3. Draw a small repeat pattern in the style of Morris using one motif from your product.

Did you know? English silver often carries several marks: the maker's initials, the town or assay office mark, a quality mark (the lion passant for sterling, used from 1544) and a letter for the year. Collectors can often tell exactly who made a spoon and in what year from a row of tiny stamps.

Primary source. *Deuteronomy 25:13-16, King James Version (1611).*

13 Thou shalt not have in thy bag divers weights, a great and a small.
14 Thou shalt not have in thine house divers measures, a great and a small.
15 But thou shalt have a perfect and just weight, a perfect and just measure shalt thou have: that thy days may be lengthened in the land which the LORD thy God giveth thee.
16 For all that do such things, and all that do unrighteously, are an abomination unto the LORD thy God.

Go deeper. The Victoria and Albert Museum's online pages on William Morris and *Strawberry Thief*, including how indigo discharge printing works. Federal Trade Commission, "Threading Your Way Through the Labeling Requirements Under the Textile and Wool Acts" (free online). The William Morris Gallery, London, website. Second video topic: "Carving a rubber stamp for a logo."

Goes deeper in. Art, "Design, Pattern and William Morris," and Small Business & Economics, "Brands, Trust and Honest Advertising" (coming soon).

For families. Sources: Federal Trade Commission guidance on the Textile Fiber Products Identification Act and the Care Labeling Rule (rules and exemptions change; check the current guide before selling textiles); Goldsmiths' Company history of hallmarking (statute of 1300; lion passant from 1544); Victoria and Albert Museum notes on *Strawberry Thief* (designed 1883, printed at Merton Abbey). The stop gives no legal advice; a parent should confirm what applies to the family's products and state. Packaging prices are illustrative. Picture: William Morris, *Strawberry Thief*, furnishing fabric, designed 1883.

PRACTICE

1. **EASY** Name the three jobs of packaging.
2. **EASY** Where does the word "hallmark" come from?
3. **MEDIUM** A student labels a scarf "100% wool" when the yarn is 70% wool and 30% acrylic. Which verse in the Primary source box does this break, and how should the label read?
4. **MEDIUM** List four tests a good small-business logo should pass.

5. **CHALLENGE** Packaging per card: sleeve \$0.09, backing board \$0.04, sticker \$0.05. Cards cost \$1.10 each before packaging and sell for \$4. (a) What is the new unit cost? (b) By what percent did packaging raise the cost? (c) What is the new profit margin?
6. **CHALLENGE** A friend says, "If the package looks expensive enough, people will pay more no matter what's inside." Using Proverbs 22:1, Deuteronomy 25 and the story of Morris & Co., write a reasoned reply.

Make it a game • Name That Mark. A parent cuts out or sketches a dozen logos and maker's marks from packages, books and tools (with the names hidden). Players race to identify each one and then judge it by the logo tests: one idea, works in one color, readable small, distinctive. Finish by having each player draw their own logo from memory in ten seconds. If others can recognize it, it passes.

Scripture. "A good name is rather to be chosen than great riches, and loving favour rather than silver and gold." (Proverbs 22:1, KJV)

A logo is a small picture of a name. Solomon says a good name is worth more than riches, and a good name is not designed but earned by honest work and fair dealing over time.

Practice: answers

1. Protect, display and inform.
2. From Goldsmiths' Hall in London, where silver and gold were tested and stamped to show they met the legal standard.
3. Deuteronomy 25:13-15 (divers weights and measures; a "perfect and just measure"). The label should read "70% wool, 30% acrylic."
4. Any four: one clear idea; works in one color or black and white; readable at about one inch; no more than two lettering styles; original, not copied; name not already used by a similar seller.
5. (a) \$0.18 packaging; \$1.28. (b) $\$0.18 \div \$1.10 \approx 16.4$ percent. (c) Profit $\$4.00 - \$1.28 = \$2.72$; margin $\$2.72 \div \$4.00 = 68$ percent (down from 72.5 percent).
6. A strong answer grants that packaging can raise a first sale but argues it cannot sustain a business or honor God if it misleads: a package that suggests more value than the product has is a kind of false measure (Deuteronomy 25). Proverbs 22:1 values a good name above riches, and a name is earned by work and honesty. Morris & Co. could charge more because the quality behind its recognizable designs was real; the design pointed to the substance rather than hiding its lack.

4.7 A CRAFT-FAIR TABLE OR A FAMILY “SHOP”

OBJECTIVES

- Plan and set up a selling table: layout, levels, signs, prices, cash float and a sales tally.
- Serve customers courteously and honestly, and measure results with traffic, stop rate, conversion and average sale.
- Explain Adam Smith’s point that trade works by offering others what is to their advantage, and how Christian love of neighbor goes further.

Warm-up. Think of the best shop or market stall you have ever visited. Write down three things that made you want to stop and three things the seller did (or did not do) that made you comfortable buying. Now think of one place you walked past without stopping. Why?

Video slot. Video coming. How to set up a craft-fair booth: display levels, signage, pricing and handling cash. Search approved channels (U.S. Small Business Administration, a 4-H or Junior Achievement channel, a university extension small-business channel); preview first.

KEY TERMS

display

The arrangement of products on a table or shelf so that buyers can see, reach and understand them.

cash float

The money, in small bills and coins, that a seller starts the day with in order to make change. It is not profit and is subtracted at the end.

tally sheet

A simple record of each sale made during the day: item, quantity, price and how it was paid.

conversion rate

The share of people who buy out of those who stopped (or who passed): $\text{buyers} \div \text{visitors}$, as a percent.

average sale

$\text{Total sales} \div \text{number of buyers}$. It shows whether people buy one item or several.

sales tax

A tax many U.S. states and towns place on retail sales, collected by the seller from the buyer and paid to the state. Rules differ by state, and some require a permit even for a one-day fair.

CORE IDEAS

A craft fair is a small market in the old sense: a place where makers and buyers meet face to face. Your table has about three seconds to catch the eye of someone walking past, about thirty seconds to tell them what you sell, and a few minutes to make a sale. Everything in this stop is about using those moments well, and honestly. If your family cannot attend a fair, the same skills work for a “shop day” at home for neighbors and friends, a church bazaar, or a table at a family gathering.

Start with the **display**. Use height: a flat table hides everything, so raise some products on boxes or crates draped with cloth, so that items rise toward the back like seats in a theater. Show a few of each item neatly, not everything you own; keep the extra stock under the table and restock as you sell. Group items by kind and price. Put a sign with your shop name and logo at eye level where it can be read from ten feet away, and put a clear price on every item or every group. Many shoppers will not ask a price; they simply walk on. Leave one sample that people may pick up and handle, because buyers want to feel a notebook’s paper or a bag’s cloth before they pay.

Next, money. Start with a **cash float** so you can make change: for whole-dollar prices, \$40 in ten \$1 bills, four \$5 bills and one \$10 bill is plenty for a small table. Keep it in a closed box that never leaves an adult’s or your direct care. Many fairs now expect card payments; a parent may use a phone card reader, but these charge a fee of roughly 3 percent of each sale, which you must count as a cost. Keep a **tally sheet** and mark every sale as it happens: item, number, price, cash or card. This record becomes your books in Stop D8. At the end, count the money, subtract the float, and check that the cash matches the tally.

Then, people. Greet each person who stops with a smile and a simple word (“Good morning! These are hand-bound notebooks; the paper is acid-free.”) and then let them look. Do not pounce, and never pressure. Answer questions truthfully, including about flaws and seconds. Adam Smith described the heart of trade in 1776, in the excerpt in the Primary source box: a seller succeeds by showing others “that it is for their own advantage to do for him what he requires of them.” We “never talk to them of our own necessities, but of their advantages.” So tell the buyer what the item will do for them, not that you need the money for a new bike. Say thank you to everyone, whether they buy or not.

Measure the day. Suppose 300 people walk past your table, 60 stop to look, and 15 buy, spending \$135 in all. Your stop rate is $60 \div 300 = 20$ percent. Your **conversion rate** is $15 \div 60 = 25$ percent of those who stopped, or 5 percent of all who passed. Your **average sale** is $\$135 \div 15 = \9 . Each number points to a different improvement: a low stop rate suggests a better sign or display; low conversion suggests a price, quality or conversation problem; a low average sale suggests offering a bundle (“3 cards for \$10”) or a small add-on item.

There are rules and safety matters a parent must handle. Many states require sellers to collect **sales tax**, and some fair organizers ask every seller for a state permit; a parent should check before the event. A young seller should never staff a table alone, never leave the money box, and never go off with a buyer. Online selling is a different matter: most

marketplaces require an adult account-holder, and shipping, returns and privacy add complications. Before any real sale, a parent signs off on the plan in this stop's project.

Here is the honest complexity. Smith's famous sentence about the butcher and the baker is often misread as praise of selfishness. It is not. Smith also wrote *The Theory of Moral Sentiments* (1759) on sympathy and virtue. His point was that trade lets strangers serve one another by each offering what the other wants. A Christian goes further. The buyer is your neighbor, made in God's image, to be served honestly and kindly whether they buy or not. "Seest thou a man diligent in his business? he shall stand before kings" (Proverbs 22:29). Diligence at a table means careful preparation, honest dealing and real courtesy, the same whether the customer is a stranger or a king.

PICTURE STUDY



A Goldsmith in His Shop, Petrus Christus, 1449 · Oil on oak panel · The Metropolitan Museum of Art, New York (Robert Lehman Collection)
Wikimedia Commons · CC0

Petrus Christus worked in Bruges, a great trading city of Flanders, and painted this panel in 1449. It shows a goldsmith's shop open to the street, with his goods displayed on shelves and a couple, perhaps buying a wedding ring, at the counter. The painting was once thought to show Saint Eligius, the patron saint of goldsmiths, and it may have been made for the goldsmiths' guild of Bruges.

Look closely

- Find the goldsmith's display. How has he arranged his goods so that buyers can see them?
- Find the balance. Why would a buyer want to see the ring weighed in front of them?

- Look into the convex mirror. Who is outside, and what does the mirror tell you about where the shop stands?

Talk about it

1. What does this shop do well that you could copy on a craft-fair table?
2. How does the painting show trust between seller and buyer?

Safety first. A parent or other trusted adult is at the table the whole time. Never handle the money box alone in public, never leave it unattended, and never go anywhere with a customer. Online selling, if any, happens only through a parent's account. Check the fair's rules for table anchoring and walkways so nothing can tip or trip a visitor.

HANDS-ON: PLAN, SET UP AND RUN YOUR TABLE

Plan a real or practice table, set it up, and run it for at least one session: a fair, a church bazaar, a family shop day or a practice run for relatives. Use Smith's excerpt in the Primary source box to write your greeting.

You will need

- Your products, price list (Stop D4), labels and packaging (Stop D6)
- A table, a cloth, and boxes or crates for height
- Your shop sign and logo
- A cash box with a float, a pencil and a tally sheet
- Bags or paper for wrapping purchases

Steps

1. Draw a table plan from above: where each product goes, where the sign, price list, sample, cash box and seller will be.
2. Write a three-sentence greeting and a one-sentence description of each product that speaks of the buyer's advantage, not your needs.
3. Make a tally sheet with columns: time, item, quantity, price, cash or card, running total.
4. Count and record your cash float.
5. **Parent sign-off before any real sale:** a parent reviews the plan, the prices, the location, any permit or sales-tax question, the money handling and who will be at the table, then signs and dates the plan.
6. Set up, run the table, and record every sale. If you can, have a helper count how many people pass and how many stop in a sample half hour.
7. Afterward, count the cash, subtract the float, and check it against the tally. Calculate the stop rate, conversion rate and average sale. Write three things to change next time.

Check your work

- My plan is drawn and signed by a parent before any real sale.

- Every item had a visible price, and every sale is on my tally sheet.
- My cash, minus the float, matches my tally (or I explained the difference).

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, describe how you set up and ran your table, what your numbers showed, how you treated your customers, and what Adam Smith and Proverbs 22:29 taught you about selling. A parent dates and keeps the page.
2. Paste or redraw your table plan and mark what you would change.
3. File your tally sheet in your Maker's File for Stop D8.

Did you know? Many English towns still hold markets on the days granted in medieval royal charters; some have met on the same weekday for more than 700 years. A charter gave a town the right to hold a market and to keep order and fair measures in it.

Primary source. *Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations (1776), Book I, Chapter II. Text from Project Gutenberg, eBook #3300.*

But man has almost constant occasion for the help of his brethren, and it is in vain for him to expect it from their benevolence only. He will be more likely to prevail if he can interest their self-love in his favour, and shew them that it is for their own advantage to do for him what he requires of them. Whoever offers to another a bargain of any kind, proposes to do this. Give me that which I want, and you shall have this which you want, is the meaning of every such offer; and it is in this manner that we obtain from one another the far greater part of those good offices which we stand in need of. It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest. We address ourselves, not to their humanity, but to their self-love, and never talk to them of our own necessities, but of their advantages.

Go deeper. Daryl Bernstein, *Better Than a Lemonade Stand! Small Business Ideas for Kids* (1992), written by a teenager. The Metropolitan Museum of Art's online page for *A Goldsmith in His Shop* (1975.1.110), with a zoomable image of the mirror. Adam Smith, *The Wealth of Nations*, Book I, Chapter II, read in full with a parent (Project Gutenberg #3300). Second video topic: "Craft-fair booth before and after: improving a display."

Goes deeper in. Small Business & Economics, "Markets, Customers and Selling," and History, "Medieval Towns, Fairs and Guilds" (coming soon).

For families. Sources: Smith text from Project Gutenberg #3300; Metropolitan Museum of Art catalogue notes on Petrus Christus, *A Goldsmith in His Shop* (1449), including the older identification as Saint Eligius. Card-reader fees and sales-tax rules vary by company and state and change often; the stop gives a rough figure and no tax advice. The stop

requires a parent's signed approval before any real selling, adult presence at the table, and adult handling of any online account. The traffic figures are illustrative.

PRACTICE

1. **EASY** Why should a display use height rather than laying everything flat?
2. **EASY** What is a cash float, and why is it subtracted at the end of the day?
3. **MEDIUM** According to Smith, what should a seller talk about with a customer: his own necessities or the customer's advantages? Rewrite "Please buy one; I'm saving for a bike" in Smith's spirit.
4. **MEDIUM** A card reader charges about 3 percent. A \$12 sale is paid by card. How much does the seller keep? If 20 such sales are made, what is the total fee?
5. **CHALLENGE** At a fair, 400 people pass, 72 stop and 18 buy, with total sales of \$198. Find the stop rate, the conversion rate of those who stopped, the conversion rate of all who passed, and the average sale. Which number would a bundle offer most likely improve?
6. **CHALLENGE** Start: float of \$40. End of day: \$211 in the cash box. The tally shows \$180 in cash sales and \$36 in card sales. Does the cash balance? If not, by how much is it off, and what are two likely causes?

Make it a game • Market Day. Set up two or three practice tables at home with real or paper products and price tags. Each seller gets a \$20 play-money float; each shopper gets \$30 in play money and a secret "shopping list" card (for example, "a gift for a grandmother under \$10"). Shoppers visit, sellers greet and serve. After fifteen minutes, sellers count their boxes against their tally sheets. Points go to the most accurate count, the friendliest seller (voted by shoppers) and the shopper who best met their list.

Scripture. "Seest thou a man diligent in his business? he shall stand before kings; he shall not stand before mean men." (Proverbs 22:29, KJV)

"Mean" here means low or obscure. Diligence in ordinary business, done well and faithfully, is noticed and honored. A well-kept, honest table is a small school of diligence.

Practice: answers

1. Raised items at the back are easier to see from a distance and from the aisle; a flat table hides items behind each other and looks less inviting.
2. The change money you start with. It is your own money, not income from sales, so it must be subtracted to find what you actually took in.
3. The customer's advantages. Example: "These notebooks lie flat when open and the paper takes ink without bleeding; they make a good gift for anyone who journals."
4. Fee \$0.36; the seller keeps \$11.64. On 20 sales the fee is $20 \times \$0.36 = \7.20 .
5. Stop rate $72 \div 400 = 18$ percent; conversion of stoppers $18 \div 72 = 25$ percent; of all passers $18 \div 400 = 4.5$ percent; average sale $\$198 \div 18 = \11 . A bundle (such as 3 for \$10) would most likely raise the average sale.
6. Expected cash = $\$40 + \$180 = \$220$. Actual \$211, so it is \$9 short. (Card sales are not in the box.) Likely causes: wrong change given, a sale tallied but paid by card instead of cash, a sale

tallied at the wrong price, or money taken out without a note. The seller should record the \$9 difference honestly rather than hide it.

4.8 KEEP THE BOOKS: SALES, COSTS AND PROFIT

OBJECTIVES

- Keep a simple ledger and turn it into a profit sheet: revenue, cost of goods sold, gross profit, expenses and net profit.
- Track inventory and explain why cash in the box is not the same as profit.
- Explain the history and purpose of bookkeeping from Pacioli and Franklin, and decide with a parent how profit will be given, saved and reinvested.

Warm-up. Look at your tally sheet from Stop D7 (or invent a small one). Without calculating anything, write down how much profit you think you made. Then list everything you spent money on for this trail, from paper to packaging to the table fee. Do you still believe your first guess?

Video slot. Video coming. Simple bookkeeping for a small business: ledgers, income statements, cost of goods sold and profit. Search approved channels (U.S. Small Business Administration, SCORE, Khan Academy, a university extension small-business channel); preview first.

KEY TERMS

ledger

A book or sheet recording every money transaction in date order: what came in, what went out and why.

revenue

All the money earned from sales before any costs are subtracted. Also called sales or gross income.

cost of goods sold (COGS)

The direct cost (materials and packaging) of the items actually sold, not of all the items made.

gross profit and net profit

Gross profit = revenue – cost of goods sold. Net profit = gross profit – all other expenses (fees, table rent, supplies).

inventory

Finished products (and materials) on hand and not yet sold. Inventory holds money you have spent but not yet earned back.

double-entry bookkeeping

A method of recording every transaction twice, as a debit in one account and a credit in another, so that the books check themselves. It was first described in print by Luca Pacioli in Venice in 1494.

CORE IDEAS

A maker who does not keep accounts does not really know whether the business is working. The cash box can be full while the business is losing money, or nearly empty while it is doing well. Benjamin Franklin gave a young tradesman this advice in 1748: “keep an exact account for some time both of your expenses and your income.” If you do, he promised, “you will discover how wonderfully small, trifling expenses mount up to large sums.” Read his words in the Primary source box. Bookkeeping is not about suspicion; it is about knowing the truth of your affairs.

Merchants have kept books for as long as there has been trade; clay tablets from ancient Mesopotamia record grain, oil and silver owed. The method most businesses still use grew up among the merchants of Italian cities such as Venice, Genoa and Florence in the later Middle Ages. In 1494 a Franciscan friar and mathematician, Luca Pacioli, published a mathematics textbook in Venice that included the first printed explanation of **double-entry bookkeeping**, in which every transaction is entered twice so that the books balance and errors show up. Pacioli advised merchants to begin their books in the name of God. You do not need double entry for a family table. A careful single **ledger** will do.

Your ledger has a line for every transaction, in date order: date, description, money in, money out and a running balance. Paper for \$8 is a line; the table fee is a line; each sale (or each day’s sales from your tally sheet) is a line. Keep every receipt in an envelope, numbered to match its ledger line. At the end of a selling event or a season, turn the ledger into a **profit sheet**, which accountants call an income statement.

Work an example. At a fair you sold 15 notebooks at \$10 and 10 bookmarks at \$4: **revenue** is $\$150 + \$40 = \$190$. Each notebook used \$0.89 of materials and packaging and each bookmark \$0.55, so the **cost of goods sold** is $15 \times \$0.89 + 10 \times \$0.55 = \$13.35 + \$5.50 = \$18.85$. Gross profit is $\$190.00 - \$18.85 = \$171.15$. Other expenses were the \$20 table fee and card fees of 3 percent on \$60 of card sales, \$1.80. **Net profit** is $\$171.15 - \$21.80 = \$149.35$. If making and selling took you 12 hours, you earned about $\$149.35 \div 12 \approx \12.45 an hour. That is the honest answer to “Was it worth it?”

Notice what the profit sheet leaves out. You may have made 25 notebooks and sold only 15. The 10 unsold notebooks are **inventory**: their materials were paid for, but they count as cost only when they sell. So you need an inventory count too: starting stock + items made – items sold = ending stock. If your count of ending stock does not match the shelf, something was lost, given away or miscounted, and the books should say so. Inventory is one reason cash and profit differ; buying tools or a big stock of materials for next time is another. A business can be profitable and still short of cash if too much money sits in unsold goods.

There are also duties. A Christian maker decides with a parent, before the money arrives, how profit will be divided: a portion given (to church, to missions or to someone in need), a portion saved, a portion reinvested in materials, and perhaps a portion spent. Taxes are part of honest dealing too: “Render therefore unto Caesar the things which are Caesar’s” (Matthew 22:21). Under current U.S. Internal Revenue Service rules, a person of any age

with net self-employment earnings of \$400 or more in a year generally must file a tax return, so a parent should check whether a student's sales reach that level. Good books make all of this simple.

Here is the honest complexity. Your profit per hour may be lower than you hoped, perhaps lower than a simple job would pay. That is a real result, not a failure. It may mean raising prices, choosing a quicker product, selling in a larger market, or simply recognizing that some of the reward is in learning, in serving neighbors and in the joy of making. What matters is that you know. "Be thou diligent to know the state of thy flocks, and look well to thy herds" (Proverbs 27:23). A shepherd counts his sheep; a maker counts notebooks, dollars and hours, and gives thanks to God for whatever increase He gives.

PICTURE STUDY



The Merchant Georg Gisze, Hans Holbein the Younger, 1532 · Oil and tempera on oak panel ·
Gemäldegalerie, Staatliche Museen zu Berlin
Wikimedia Commons · Public domain

Georg Gisze was a merchant from Danzig (now Gdańsk) who worked in London at the Steelyard, the trading base of the Hanseatic League, a network of northern European merchant cities. Hans Holbein, the German painter who later became court painter to Henry VIII, painted him surrounded by the tools of his trade: letters from partners, pens and ink, seals for documents, scales for coins and a clock. A merchant's whole business lived in papers like these.

Look closely

- Find every tool of record-keeping in the picture: pens, ink, sealing tools, letters, a box for papers. How many can you count?

- Find the scales and the clock. What do they say about how a merchant thought about money and time?
- Look at the vase of flowers. Why might Holbein have added something so fragile to a room full of business?

Talk about it

1. If Gisze opened his account book, what kinds of entries would you expect to find?
2. Holbein painted a young man who is clearly successful. What signs in the picture suggest that success depended on careful, orderly work?

HANDS-ON: THE PROFIT SHEET AND TRAIL D REPORT

Turn your ledger and tally sheet into a profit sheet, count your inventory, and write a short report on your whole Trail D business. Use Franklin's advice in the Primary source box as your standard.

You will need

- Your Maker's File: cost sheet, price list, tally sheet, receipts
- A ledger page (or a simple spreadsheet)
- A calculator
- Your unsold stock, to count

Steps

1. Make a ledger with columns: date, description, receipt number, money in, money out, balance. Enter every purchase and every sale since Stop D2 in date order.
2. Count your inventory: items made, items sold, items given away or kept, items on hand. Make sure the numbers agree.
3. Write a profit sheet: revenue; cost of goods sold (materials and packaging of items sold only); gross profit; each other expense; net profit.
4. Calculate net profit margin ($\text{net profit} \div \text{revenue}$) and profit per hour ($\text{net profit} \div \text{total hours worked}$).
5. With a parent, decide and write down how the profit will be divided among giving, saving, reinvesting and spending, and carry it out.
6. Write a one-page report: what you made, how many you sold, what you earned, what you learned, and three decisions for your next season. Quote Franklin once.
7. Have a parent review the ledger, check the arithmetic and sign the report.

Check your work

- Every ledger line has a receipt or tally record behind it.
- My cost of goods sold counts only items actually sold.
- My profit sheet, inventory and cash agree, or I explain the difference honestly.

FIELD NOTEBOOK

1. **Narration (keep this page).** In one written paragraph, explain how you kept the books for your Trail D business, what your net profit and profit per hour were, why cash is not the same as profit, and what you decided to give, save and reinvest. Use Franklin or Proverbs 27:23. A parent dates and keeps the page.
2. Draw a bar chart with three bars: revenue, total costs and net profit.
3. Write a prayer of thanks for the skill, materials and customers God provided.

Did you know? Pacioli's 1494 book, *Summa de arithmetica, geometria, proportioni et proportionalita*, was one of the earliest mathematics books printed in Italian rather than Latin, so that merchants could read it. Its short section on bookkeeping was translated and copied across Europe, and the words "debit" and "credit" still used today come from the Latin *debere* (to owe) and *credere* (to trust).

Primary source. Benjamin Franklin, "Advice to a Young Tradesman" (1748), as printed in *Memoirs of Benjamin Franklin, vol. 2* (New York: Harper & Brothers, 1860). Text from Project Gutenberg, eBook #40236.

Beware of thinking all your own that you possess, and of living accordingly. It is a mistake that many people who have credit fall into. To prevent this, keep an exact account for some time both of your expenses and your income. If you take the pains at first to mention particulars, it will have this good effect: you will discover how wonderfully small, trifling expenses mount up to large sums, and will discern what might have been, and may, for the future, be saved, without occasioning any great inconvenience.

Go deeper. Jane Gleeson-White, *Double Entry: How the Merchants of Venice Created Modern Finance* (2011), a history of bookkeeping from Pacioli onward (for older students; parents preview). Khan Academy's free lessons on income statements. The Gemäldegalerie Berlin's collection page for *Georg Gisze*. Second video topic: "Setting up a simple ledger in a spreadsheet."

Goes deeper in. Small Business & Economics, "Keeping the Books: Profit, Loss and Stewardship," and Arithmetic, "Percent and Rates in Real Life" (coming soon).

For families. Sources: Franklin text from Project Gutenberg #40236; Pacioli's *Summa* (Venice, 1494) as the first printed account of double-entry bookkeeping; Internal Revenue Service guidance on self-employment tax (the \$400 filing threshold for net self-employment earnings applies regardless of age under current rules; thresholds and rules can change, so check the current IRS publications). The stop gives no tax advice. Numbers in the worked example follow the notebook example from Stops D3-D6. Picture: Holbein, *Der Kaufmann Georg Gisze*, Gemäldegalerie, Berlin.

PRACTICE

1. **EASY** What is the difference between revenue and net profit?
2. **EASY** What did Franklin say a person would discover by keeping “an exact account” of expenses and income?
3. **MEDIUM** You made 30 cards, sold 22, gave 2 as gifts and have 5 on the shelf. Does the inventory balance? If not, how many are missing?
4. **MEDIUM** Who published the first printed explanation of double-entry bookkeeping, where, and when?
5. **CHALLENGE** Sales: 18 pincushions at \$8 and 12 bags at \$14. COGS: \$1.40 per pincushion, \$3.10 per bag. Expenses: table \$25, card fees \$4.20, signs \$6. Hours worked: 20. Find revenue, COGS, gross profit, net profit, net profit margin and profit per hour.
6. **CHALLENGE** A student spent \$120 on materials for 40 bags, sold 15 bags for \$14 each, and paid a \$25 table fee. Counting cash, they say, “\$210 – \$120 – \$25 = \$65. I made only \$65.” Using cost of goods sold and inventory, show their actual net profit and explain the difference.

Make it a game · Balance the Books. A parent prepares an envelope of 12 to 15 slips: pretend receipts and sales (“Bought felt \$6.40,” “Sold 3 cards \$12,” “Table fee \$20”) with one slip deliberately missing from the set. Players race to build a ledger and profit sheet. The first player to find the net profit and to name what the missing slip must have been (by comparing with a given ending cash figure) wins.

Scripture. “Be thou diligent to know the state of thy flocks, and look well to thy herds.” (Proverbs 27:23, KJV)

In Solomon’s day a family’s wealth walked on four legs, so a wise owner counted the flock. Today a maker’s wealth is in materials, goods and accounts. Knowing their true state is diligence and stewardship, not greed.

Practice: answers

1. Revenue is all the money taken in from sales; net profit is what remains after the cost of goods sold and all other expenses are subtracted.
2. “How wonderfully small, trifling expenses mount up to large sums,” and what could be saved in the future without great inconvenience.
3. $22 + 2 + 5 = 29$, not 30, so one card is unaccounted for. Search, recount, and if it cannot be found, record it as lost.
4. Luca Pacioli, a Franciscan friar and mathematician, in Venice in 1494, in his *Summa de arithmetica*.
5. Revenue $\$144 + \$168 = \$312$. COGS $\$25.20 + \$37.20 = \$62.40$. Gross profit $\$249.60$. Expenses $\$35.20$. Net profit $\$214.40$. Margin $\$214.40 \div \$312 \approx 68.7$ percent. Profit per hour $\$214.40 \div 20 = \10.72 .
6. Materials per bag: $\$120 \div 40 = \3.00 . COGS for 15 sold: $\$45$. Revenue $\$210$. Gross profit $\$165$. Net profit $\$165 - \$25 = \$140$. The difference ($\140 vs. $\$65$ cash) is the $\$75$ of

materials sitting in the 25 unsold bags ($25 \times \$3$). That money is not lost; it is inventory, and it becomes profit only if the bags sell.

TRAIL 4 BADGE QUIZ

The badge quiz is optional. The student answers in writing, showing all arithmetic, and may use a calculator but not the stops. Eight right out of ten earns the full trail mark; partial credit is fair on multi-step problems where the method is right. Badges and the certificate are earned by doing the stops and keeping the Maker's File, not by scores.

Badge quiz 1 (Stops 1-5)

1. Who were Bezaleel and Aholiab, and what does Exodus 35:34 say God put in their hearts besides skill?
2. Name the four tests for a product idea (and the fifth beneath them), and explain Adam Smith's idea that the division of labour is limited by the extent of the market.
3. A pouch uses \$1.80 of materials (add 10 percent waste), takes 36 minutes at \$10 an hour, and carries \$0.70 of overhead. Find the full unit cost.
4. An item costs \$6 and sells for \$10. Find the markup as a percent of cost and the margin as a percent of price. With a \$24 table fee and \$1.50 of materials per item, how many must sell to cover the fee (materials only)?
5. You inspect 40 bookmarks and 3 fail. What is the defect rate? What should be done with an item whose flaw is only cosmetic, and with one whose flaw affects use?

Badge quiz 2 (Stops 6-8)

6. Name three things an honest product label should state, and the Bible passage this trail uses as the standard for honest labels.
7. 250 people pass your table, 50 stop and 10 buy, spending \$95. Find the stop rate, the conversion rate of those who stopped, and the average sale.
8. In Adam Smith's words, should a seller talk to customers "of our own necessities" or "of their advantages"? Does this mean Smith praised selfishness? Explain briefly.
9. Revenue \$260; cost of goods sold \$48; table fee \$30; card fees \$3. Find gross profit, net profit and net profit margin.
10. Why can a maker have \$50 less cash than profit at the end of a season? Give one cause and say who first printed an explanation of double-entry bookkeeping, and when.

TRAIL CERTIFICATE: MY MAKER'S FILE: A SMALL PRODUCT LINE WITH A PRICE LIST AND A PROFIT SHEET

Gather the Maker's File into one folder or bound section with a title page: shop name, logo, student's name and dates.

Include, in order: the product decision and decision matrix (D2), cost sheet (D3), price list with markup, margin and break-even (D4), specification and inspection report (D5), label, logo and packaging (D6), signed table plan and tally sheet (D7), and ledger, profit sheet and one-page report (D8).

Add one finished, labeled product (or a photograph of it) and the eight narration paragraphs. A parent reviews the file and signs the Trail D certificate.

- **Accuracy:** Costs, prices, rates and profit figures are correctly calculated, with the arithmetic shown, and the ledger agrees with receipts, tally and inventory.
- **Honesty:** Labels, prices, seconds and records are truthful; flaws and shortfalls are reported plainly; the work reflects Scripture's standard of just weights.
- **Craftsmanship:** The product meets its written specification, and labels, packaging and the logo are neat, clear and original.
- **Reasoning:** Narrations and the final report explain decisions with evidence, use the primary sources accurately, and draw sensible lessons for the next season.

Answer key

1. The craftsmen God called by name to make the tabernacle and its furnishings: Bezaleel of Judah and Aholiab of Dan. God put it in their hearts to teach.
2. Skill, demand, margin and time, plus safe and lawful. Smith argued that people can specialize in one trade only where there are enough buyers to exchange with; in a small market (like the Highlands) each family must do many kinds of work.
3. Materials \$1.98 + labor \$6.00 + overhead \$0.70 = \$8.68.
4. Markup $\$4 \div \$6 \approx 66.7$ percent; margin $\$4 \div \$10 = 40$ percent. Each item contributes \$8.50; $\$24 \div \$8.50 \approx 2.8$, so 3 items.
5. $3 \div 40 = 7.5$ percent. A cosmetic flaw: sell openly as a second at a lower price (or keep). A flaw affecting use or safety: repair and re-inspect, or do not sell.
6. Any three: maker or shop name, product name, size or quantity, materials (fiber content for textiles), care instructions. Deuteronomy 25:13-16 (no divers weights and measures; "a perfect and just weight").
7. Stop rate $50 \div 250 = 20$ percent; conversion $10 \div 50 = 20$ percent; average sale $\$95 \div 10 = \9.50 .
8. Of their advantages. No: Smith meant that trade lets strangers serve one another by offering what the other wants; he also wrote on sympathy and virtue in *The Theory of Moral Sentiments* (1759).
9. Gross profit \$212; net profit $\$212 - \$33 = \$179$; margin $\$179 \div \$260 \approx 68.8$ percent.
10. Money can be tied up in unsold inventory (materials paid for but not yet sold), or spent on tools or stock for next season. Luca Pacioli, in Venice, in 1494.