Young Engineers II: Makers

Name _____ Date _____

Young Engineers II: Makers · Printables pack

This pack has everything to print for the year: the safety pages, Engineer’s Notebook pages, the nine lab sheets with parts lists, rough costs, supervision levels and blank data tables, and every unit test, the midterm and the final, with answer keys at the back.

Supervision levels

- 🟢 Adult nearby: in the house, checks in at the start and end.
- 🔵 Adult present: in the room or at the field the whole time.
- 🔴 Adult hands-on: the adult does the marked steps.

Scripture for each unit (KJV)

1. **Luke 14:28**: “For which of you, intending to build a tower, sitteth not down first, and counteth the cost, whether he have sufficient to finish it?”
2. **Psalm 19:1**: “The heavens declare the glory of God; and the firmament sheweth his handywork.”
3. **Proverbs 24:16**: “For a just man falleth seven times, and riseth up again:”
4. **Psalm 8:3**: “When I consider thy heavens, the work of thy fingers, the moon and the stars, which thou hast ordained;”
5. **Psalm 19:3**: “There is no speech nor language, where their voice is not heard.”
6. **Exodus 31:3**: “And I have filled him with the spirit of God, in wisdom, and in understanding, and in knowledge, and in all manner of workmanship,”
7. **Proverbs 22:29**: “Seest thou a man diligent in his business? he shall stand before kings; he shall not stand before mean men.”
8. **Job 28:10**: “He cutteth out rivers among the rocks; and his eye seeth every precious thing.”
9. **Genesis 2:15**: “And the LORD God took the man, and put him into the garden of Eden to dress it and to keep it.”

Safety Pages

Name _____ Date _____

Young Engineers II: Makers · Read together before the first lab; post in your work area

Read this page with your student before the first lab. Every lab in the course is marked with one of three supervision levels:

- 🟢 Adult nearby: in the house, checks in at the start and end.
- 🔵 Adult present: in the room or at the field the whole time.
- 🔴 Adult hands-on: the adult does the marked steps.

General shop rules

- Safety glasses on for every build and test, for everyone nearby too.
- Tie back long hair; no loose sleeves or dangling cords near tools or spinning parts.
- Ask before using any sharp or power tool; an adult does all cutting with craft knives for grades 3–5.
- Keep a first-aid kit and a fire extinguisher (or a bucket of sand) where you build.

Rockets

- Follow the NAR Model Rocket Safety Code for every motor-powered flight. Only certified, commercially made motors, never altered; never make propellant.
- An adult buys, stores and installs every motor and igniter, and holds the launch key. Grades 3–5 fly only air-powered (stomp) rockets.
- Ceiling for this track: up to F/G-class model rocket motors, flown by the adult as the flier of record and within the motor's labeling and state law. High-power rocketry is out of scope.
- Misfire: remove the safety key or disconnect the battery and wait 60 seconds. Stand back at least 15 ft for D and smaller motors and 30 ft for larger ones. Wind no more than 20 mph; no dry grass at the pad.
- Water rockets: only undamaged bottles, a pressure limit set by the adult, eye protection, nobody over the rocket.

Batteries

- Grades 3–5 use AA, AAA, C and D cells only. Keep button cells and magnets away from small children because swallowing them is a medical emergency.
- LiPo/Li-ion: balance charger on the right setting, fire-safe surface or LiPo bag, never unattended, never a swollen, dented or hot pack; store at storage voltage; recycle at a drop-off (EPA: Used Lithium-Ion Batteries).
- Fuse every battery near its positive terminal. Never short the terminals.

Electrical

- Students work only on low-voltage DC: 12 V solar, and at most 36 V nominal for the high-school EV.
- No student work on 120 V household wiring or on inverter AC output. Use inverter outlets only through plug-in devices. Never back-feed a house circuit.
- An adult makes all LiFePO4/Li-ion battery terminal connections in Grades 9–12 labs.

Vehicles

- The electric soapbox runs on a closed private course only, never streets or sidewalks. Helmet, gloves and closed shoes; mechanical brakes that work with power off; a kill switch and main fuse tested every session; top speed limited to about 15 mph.

Vacuum, magnets, digging and radio

- Vacuum: thick-wall plastic only, never glass; eye protection; no more than −80 kPa gauge.
- Neodymium magnets pinch and shatter; keep them away from pacemakers, phones and cards.
- Digging: tabletop or sandbox scale only. Never dig a pit or tunnel a person could enter.
- Radio: listening needs no license; transmitting on ham bands requires an FCC license. Keep all antennas far from power lines.

Labs, Supervision and Rough Costs

Name _____ Date _____

Young Engineers II: Makers · Plan purchases for the year

Lesson	Lab	Supervision	Cost
Unit 1 · 1.4	Egg-Lander Tower Challenge	🟢 Adult nearby	about $10
Unit 2 · 2.4	Two-Liter Water Rocket Fill Test	🔵 Adult present	about $40
Unit 3 · 3.4	Parachute Deployment Trials	🔵 Adult present	about $6
Unit 4 · 4.4	Satellite Pass Log	🟢 Adult nearby	about $3
Unit 5 · 5.4	SDR Receive Station	🟢 Adult nearby	about $40
Unit 6 · 6.4	Coil Motor Power Test	🟢 Adult nearby	about $33
Unit 7 · 7.4	RC Car Gearing and Tire Trials	🔵 Adult present	about $126
Unit 8 · 8.4	Tunnel Bore and Maglev Glide	🔵 Adult present	about $51
Unit 9 · 9.4	Solar USB Charger Build	🔵 Adult present	about $42

Rough total for the year: about $351 per family, less if you reuse parts or borrow tools (a multimeter, for example, serves Units 6–9). Optional kits are listed on each unit page. School Launch is independent and free.

Engineer’s Notebook Page

Name _____ Date _____

Young Engineers II: Makers · Copy as many as you need

Test Log

Name _____ Date _____

Young Engineers II: Makers · Any experiment

Trial	Variable changed	Setting	Result	Units	Notes

Lab Sheet 1.4: Egg-Lander Tower Challenge

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🟢 Adult nearby: in the house, checks in at the start and end.

Constraints: budget $10 of “store” parts (price list below), 45 minutes of build time, and the tower must stand by itself for 30 seconds.

Parts list

Part	Rough cost	Have it?
Straws (pack of 50)	$2	
Masking tape (1 roll)	$3	
Index cards (100)	$2	
Raw eggs (6)	$2	
Plastic bags and string for the lander	$1	
Estimated total	**about $10**	

Steps

1. Write the problem, constraints and criteria in your notebook.
2. Sketch two different tower ideas and one lander; choose one with reasons.
3. Build. Track what you “buy” on the cost sheet.
4. Test: measure the height three times; load the egg; time 30 seconds.
5. Drop the lander from the top; record survived or cracked.
6. Improve one thing and test again.
7. Share: show your best design and your data to the family.

Data

Trial	Height (cm)	Cost ($)	Height ÷ cost	Egg OK?	What changed

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Tower ≥ 50 cm for 30 s ☐ Cost sheet adds up ☐ At least two iterations recorded ☐ One variable changed per iteration

Lab Sheet 2.4: Two-Liter Water Rocket Fill Test

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🔵 Adult present: in the room or at the field the whole time.

Find the water fill (in mL) that gives the highest flight, changing one variable at a time.

Parts list

Part	Rough cost	Have it?
Two 2-liter soda bottles (one for the body, one for the nose)	on hand	
Corrugated plastic or file folder for fins	$3	
Duct tape	$4	
Bike pump with gauge	on hand	
DIY PVC launcher parts	$25	
Measuring cup (mL)	$2	
Safety glasses for everyone	$6	
Estimated total	**about $40**	

Steps

1. Build: fins on the bottle near the nozzle, a nose cone on the base.
2. Check stability with the swing test.
3. Fill 300 mL. Set up the launcher in an open field, pointing straight up.
4. Everyone except the launcher stands at least 10 m back. Pump to the agreed pressure (no more than the bottle's limit; 60 psi is plenty).
5. Countdown, launch, and estimate height with the angle method (or time the flight).
6. Repeat with 500, 700 and 900 mL. Graph height against fill.
7. Improve the design and fly again at the best fill.

Data

Fill (mL)	Pressure (psi)	Flight time (s)	Height (m)	Notes

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Never exceed the pressure your adult sets ☐ Never use a scratched, dented or hot-filled bottle ☐ Stand behind the pump line ☐ Graph made

Lab Sheet 3.4: Parachute Deployment Trials

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🔵 Adult present: in the room or at the field the whole time.

Goal: five flights in a row with the parachute opening and the rocket reusable.

Parts list

Part	Rough cost	Have it?
Plastic trash bag or ripstop nylon for the canopy	$2	
Kite string or thread	$2	
Loose-fitting nose cone (a cut bottle top)	on hand	
Small binder clips for a swivel	$2	
Stopwatch	on hand	
Estimated total	**about $6**	

Steps

1. Cut a 40–60 cm hexagon canopy and attach six equal shroud lines.
2. Pack the chute loosely under a nose cone that slides off when the rocket tips over at apogee.
3. Drop test from a safe height (an adult on a ladder or a deck) to time descent.
4. Fly at your best fill from Unit 2. Record whether it opened and the descent time.
5. Change one thing (fold, line length, nose fit) and fly again.

Data

Flight	Opened? (Y/N)	Descent time (s)	Damage	Change made

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Chute opened 5 of 5 ☐ Descent time recorded ☐ Rocket flew again without repair

Lab Sheet 4.4: Satellite Pass Log

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🟢 Adult nearby: in the house, checks in at the start and end.

Predict three passes, observe at least two, and compare predicted and observed times.

Parts list

Part	Rough cost	Have it?
NASA Spot the Station alerts or a free planetarium app	on hand	
Compass (or phone compass)	on hand	
Clipboard, notebook and a red flashlight	$3	
Fist-width angle gauge (your hand at arm's length is about 10°)	on hand	
Estimated total	**about $3**	

Steps

1. Look up the next ISS passes: start time, where it appears, highest elevation, where it disappears.
2. Go outside 5 minutes early, face the starting direction, and let your eyes adjust.
3. Record the time you first see it, its highest elevation (in fists) and the time it vanishes.
4. Compute the error between predicted and observed times in seconds.
5. Bonus: watch for a "train" of new Starlink satellites shortly after a launch.

Data

Date	Predicted start	Observed start	Max elevation (°)	Error (s)

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Two passes observed ☐ Times recorded to the second ☐ Error computed

Lab Sheet 5.4: SDR Receive Station

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🟢 Adult nearby: in the house, checks in at the start and end.

Build a V-dipole from your wavelength math, then log what you receive.

Parts list

Part	Rough cost	Have it?
RTL-SDR USB dongle with telescoping dipole kit	$40	
Free SDR software on a laptop	on hand	
Tape measure	on hand	
Wooden dowel or cutting board for the antenna mount	on hand	
Estimated total	**about $40**	

Steps

1. Compute the half-length of a dipole for your target frequency.
2. Set the antenna arms to that length in a 120° V shape, outside or at a window.
3. Tune to NOAA weather radio (162.4–162.55 MHz) to confirm the setup.
4. Look up the next pass of a weather satellite that is transmitting, record the pass and run the decoder.
5. Log signal strength with the antenna horizontal and vertical.

Data

Time	Frequency (MHz)	Signal	Antenna setup	What you heard or saw

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Antenna length computed and measured ☐ At least three signals logged ☐ Receive only: no transmitting

Lab Sheet 6.4: Coil Motor Power Test

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🟢 Adult nearby: in the house, checks in at the start and end.

Build, run and measure a simple DC motor.

Parts list

Part	Rough cost	Have it?
Magnet wire, 22–26 gauge (about 3 m)	$5	
Two large paper clips	on hand	
Strong ceramic or neodymium magnet	$3	
D-cell and holder	$4	
Sandpaper	$1	
Multimeter	$20	
Estimated total	**about $33**	

Steps

1. Wind 10–20 turns around a marker; leave two straight leads.
2. Sand the insulation fully off one lead, and only half off the other (one side). This is your commutator.
3. Bend the clips into cradles taped to the battery ends; set the magnet under the coil.
4. Give the coil a flick. Measure volts across the battery and current in series.
5. Compute power. Change one variable and repeat.

Data

Trial	Turns	Volts (V)	Current (A)	Power (W)	Spins? notes

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Motor spins on its own ☐ V and I recorded ☐ P = V × I computed for each trial

Lab Sheet 7.4: RC Car Gearing and Tire Trials

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🔵 Adult present: in the room or at the field the whole time.

Find the setup that covers 20 m fastest, and the one that runs longest on a charge.

Parts list

Part	Rough cost	Have it?
Hobby RC car kit	$90	
Spare pinion gear	$6	
Measuring tape and cones	$5	
Stopwatch	on hand	
LiPo bag and balance charger (if LiPo)	$25	
Estimated total	**about $126**	

Steps

1. Mark a 20 m straight course on pavement or a gym floor.
2. Baseline: three timed runs; compute average speed.
3. Change one variable (pinion, tires or added mass) and do three more runs.
4. Run a full-charge endurance test laps-to-empty for your best setup; note pack temperature.
5. Write a one-paragraph conclusion backed by your data.

Data

Setup	Run 1 (s)	Run 2 (s)	Run 3 (s)	Avg speed (m/s)

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Only one variable changed per test ☐ Averages computed ☐ Pack never overheated (warm, not hot)

Lab Sheet 8.4: Tunnel Bore and Maglev Glide

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🔵 Adult present: in the room or at the field the whole time.

Two short builds: a model TBM run, and a levitation track with timed glides.

Parts list

Part	Rough cost	Have it?
Plastic tub of damp sand and clay	$3	
Hand auger or 1-inch spade bit turned by hand	$10	
Paper towel tubes (lining)	on hand	
Ceramic block magnets (about 40)	$30	
Foam board, wood strips and hot glue	$8	
Stopwatch and ruler	on hand	
Estimated total	**about $51**	

Steps

1. Part A: pack the tub, bore 20 cm, and push in lining after every 5 cm. Weigh the muck and compute the tunnel volume.
2. Part B: glue two rows of magnets (same pole up) to a board with side rails.
3. Glue magnets (same pole down) under a foam sled so it floats.
4. Give the sled a gentle push and time 1 m of glide; repeat three times.
5. Add mass to the sled until it touches; compute the force each magnet pair supports.

Data

Test	Mass on sled (g)	Gap (mm)	Glide time for 1 m (s)	Notes

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Muck volume computed ☐ Sled floats with a measured gap ☐ Three timed glides

Lab Sheet 9.4: Solar USB Charger Build

Name _____ Date _____

Young Engineers II: Makers · Build-and-test lab

Supervision: 🔵 Adult present: in the room or at the field the whole time.

Measure panel output every hour, then charge a phone or power bank.

Parts list

Part	Rough cost	Have it?
10–20 W 12 V solar panel	$25	
12 V to USB buck converter module with fuse	$8	
Inline fuse holder and 2 A fuse	$4	
Wire, crimp connectors	$5	
Multimeter	on hand	
Estimated total	**about $42**	

Steps

1. Measure the panel's open-circuit volts and short-circuit amps in full sun (meter on the right range; an adult checks the setup).
2. Wire panel → fuse → USB module. Check polarity twice.
3. Every hour from 9 to 3, record volts and amps into a load; compute watts.
4. Charge a power bank and record how long it takes.
5. Make a poster: system diagram, data graph, cost and what you would improve.

Data

Time	Volts (V)	Amps (A)	Watts (W)	Sky

Design cycle. Ask · Imagine · Plan · Build · Test · Improve · Share

Problem and constraints:

My prediction:

What I will change next time and why:

Check

☐ Fuse installed ☐ Hourly data and graph ☐ Cost per watt computed ☐ Presentation given

Unit 1 Test: Thinking Like an Engineer

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A 100 W solar panel costs $146.88. What is the cost per watt? Round to the nearest cent.

2. The simulator predicted 193 m. The altimeter read 180 m. What is the percent error? Round to 0.1%.

3. The simulator predicted 44 m. The altimeter read 48 m. What is the percent error? Round to 0.1%.

4. The simulator predicted 170 m. The altimeter read 171 m. What is the percent error? Round to 0.1%.

5. A 100 W solar panel costs $176.94. What is the cost per watt? Round to the nearest cent.

6. The simulator predicted 89 m. The altimeter read 100 m. What is the percent error? Round to 0.1%.

7. The simulator predicted 86 m. The altimeter read 78 m. What is the percent error? Round to 0.1%.

8. The simulator predicted 82 m. The altimeter read 76 m. What is the percent error? Round to 0.1%.

Unit 2 Test: How Rockets Fly

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A model rocket has a mass of 1.94 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

2. A real tunnel is 12.0 m across. Your model is built at 1:10 scale. How wide is the model in centimeters? Round to 0.1 cm.

3. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.

4. A B motor delivers a total impulse of 5.0 N·s over a burn of 0.6 s. What is its average thrust? Round to 0.1 N.

5. A model rocket has a mass of 0.54 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

6. A real tunnel is 12.0 m across. Your model is built at 1:24 scale. How wide is the model in centimeters? Round to 0.1 cm.

7. A D motor delivers a total impulse of 17.0 N·s over a burn of 1.6 s. What is its average thrust? Round to 0.1 N.

8. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.

Unit 3 Test: Reusable Rockets and Landing

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A 100 W solar panel costs $131.64. What is the cost per watt? Round to the nearest cent.

2. An RC car covers 90 m in 11.1 s. What is its average speed? Round to 0.1 m/s.

3. A model rocket has a mass of 1.6 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

4. An RC car covers 279 m in 7.9 s. What is its average speed? Round to 0.1 m/s.

5. A 30 W solar panel costs $29.57. What is the cost per watt? Round to the nearest cent.

6. An RC car covers 235 m in 12.3 s. What is its average speed? Round to 0.1 m/s.

7. A model rocket has a mass of 0.34 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

8. An RC car covers 170 m in 2.5 s. What is its average speed? Round to 0.1 m/s.

Unit 4 Test: Satellites and Orbits

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. An RC car covers 133 m in 8.6 s. What is its average speed? Round to 0.1 m/s.

2. A radio signal has a frequency of 147.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

3. A 5 W light runs for 2 hours. How many watt-hours of energy does it use?

4. The simulator predicted 88 m. The altimeter read 78 m. What is the percent error? Round to 0.1%.

5. An RC car covers 273 m in 17.3 s. What is its average speed? Round to 0.1 m/s.

6. A radio signal has a frequency of 1575.42 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

7. A 18 W light runs for 6 hours. How many watt-hours of energy does it use?

8. The simulator predicted 66 m. The altimeter read 70 m. What is the percent error? Round to 0.1%.

Unit 5 Test: Radio and Communication

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A radio signal has a frequency of 7.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

2. A radio signal has a frequency of 50.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

3. A radio signal has a frequency of 7.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

4. A radio signal has a frequency of 50.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

5. A radio signal has a frequency of 437.8 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

6. A radio signal has a frequency of 50.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

7. A radio signal has a frequency of 28.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

8. A radio signal has a frequency of 433.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

Unit 6 Test: Electric Motors and Batteries

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A motor draws 0.7 A from a 1.4 V supply. What is its effective resistance? Round to 0.1 Ω.

2. A motor draws 2.5 A from a 10.0 V supply. What is its effective resistance? Round to 0.1 Ω.

3. A LiPo pack is rated 1,500 mAh at 11.1 V. How many watt-hours does it store? Round to 0.1 Wh.

4. A 24 V pack supplies 5.3 A to a motor. How much power is delivered? Round to 0.1 W.

5. A motor draws 0.5 A from a 2.5 V supply. What is its effective resistance? Round to 0.1 Ω.

6. A motor draws 1.2 A from a 6.0 V supply. What is its effective resistance? Round to 0.1 Ω.

7. A LiPo pack is rated 3,000 mAh at 3.7 V. How many watt-hours does it store? Round to 0.1 Wh.

8. A 7.4 V pack supplies 6.4 A to a motor. How much power is delivered? Round to 0.1 W.

Unit 7 Test: Building an Electric Vehicle

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A 3.7 V pack supplies 7.8 A to a motor. How much power is delivered? Round to 0.1 W.

2. A motor spins at 9,000 rpm. Its 15-tooth pinion drives a 45-tooth gear. How fast does the big gear turn?

3. A battery stores 100 Wh. A 5 W fan runs on it. About how many hours will it run? Round to 0.1 h.

4. An RC car covers 97 m in 14.6 s. What is its average speed? Round to 0.1 m/s.

5. A 12 V pack supplies 1.6 A to a motor. How much power is delivered? Round to 0.1 W.

6. A motor spins at 12,000 rpm. Its 15-tooth pinion drives a 45-tooth gear. How fast does the big gear turn?

7. A battery stores 40 Wh. A 4 W fan runs on it. About how many hours will it run? Round to 0.1 h.

8. An RC car covers 111 m in 3.0 s. What is its average speed? Round to 0.1 m/s.

Unit 8 Test: Tunnels and Tube Travel

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A model tunnel is 4 cm across and 30 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.

2. A force of 722 N presses on an area of 0.05 m². What is the pressure in pascals (Pa)?

3. A force of 334 N presses on an area of 0.02 m². What is the pressure in pascals (Pa)?

4. A model tunnel is 10 cm across and 40 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.

5. A model tunnel is 8 cm across and 60 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.

6. A force of 713 N presses on an area of 0.25 m². What is the pressure in pascals (Pa)?

7. A force of 232 N presses on an area of 0.25 m². What is the pressure in pascals (Pa)?

8. A model tunnel is 12 cm across and 30 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.

Unit 9 Test: Solar Power and the Capstone

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A 20 W solar panel costs $16.67. What is the cost per watt? Round to the nearest cent.

2. A battery stores 40 Wh. A 20 W fan runs on it. About how many hours will it run? Round to 0.1 h.

3. A 10 W light runs for 0.5 hours. How many watt-hours of energy does it use?

4. A 18 W light runs for 6 hours. How many watt-hours of energy does it use?

5. A 30 W solar panel costs $27.97. What is the cost per watt? Round to the nearest cent.

6. A battery stores 120 Wh. A 20 W fan runs on it. About how many hours will it run? Round to 0.1 h.

7. A 18 W light runs for 6 hours. How many watt-hours of energy does it use?

8. A 5 W light runs for 4 hours. How many watt-hours of energy does it use?

Midterm Exam

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A 10 W solar panel costs $6.30. What is the cost per watt? Round to the nearest cent.

2. The simulator predicted 160 m. The altimeter read 141 m. What is the percent error? Round to 0.1%.

3. The simulator predicted 113 m. The altimeter read 125 m. What is the percent error? Round to 0.1%.

4. The simulator predicted 155 m. The altimeter read 174 m. What is the percent error? Round to 0.1%.

5. A model rocket has a mass of 0.58 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

6. A real tunnel is 12.0 m across. Your model is built at 1:20 scale. How wide is the model in centimeters? Round to 0.1 cm.

7. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.

8. A C motor delivers a total impulse of 10.0 N·s over a burn of 1.7 s. What is its average thrust? Round to 0.1 N.

9. A 50 W solar panel costs $115.78. What is the cost per watt? Round to the nearest cent.

10. An RC car covers 211 m in 15.5 s. What is its average speed? Round to 0.1 m/s.

11. A model rocket has a mass of 1.27 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

12. An RC car covers 135 m in 6.8 s. What is its average speed? Round to 0.1 m/s.

13. An RC car covers 118 m in 8.3 s. What is its average speed? Round to 0.1 m/s.

14. A radio signal has a frequency of 146.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

15. A 12 W light runs for 2 hours. How many watt-hours of energy does it use?

16. The simulator predicted 87 m. The altimeter read 86 m. What is the percent error? Round to 0.1%.

Final Exam

Name _____ Date _____

Young Engineers II: Makers · Show your work and units

1. A 10 W solar panel costs $11.82. What is the cost per watt? Round to the nearest cent.

2. The simulator predicted 124 m. The altimeter read 123 m. What is the percent error? Round to 0.1%.

3. The simulator predicted 120 m. The altimeter read 111 m. What is the percent error? Round to 0.1%.

4. The simulator predicted 75 m. The altimeter read 68 m. What is the percent error? Round to 0.1%.

5. A model rocket has a mass of 0.49 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

6. A real tunnel is 70.0 m across. Your model is built at 1:50 scale. How wide is the model in centimeters? Round to 0.1 cm.

7. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.

8. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.

9. A 100 W solar panel costs $139.75. What is the cost per watt? Round to the nearest cent.

10. An RC car covers 240 m in 16.3 s. What is its average speed? Round to 0.1 m/s.

11. A model rocket has a mass of 1.46 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.

12. An RC car covers 125 m in 6.2 s. What is its average speed? Round to 0.1 m/s.

13. An RC car covers 136 m in 4.4 s. What is its average speed? Round to 0.1 m/s.

14. A radio signal has a frequency of 147.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

15. A 12 W light runs for 2 hours. How many watt-hours of energy does it use?

16. The simulator predicted 134 m. The altimeter read 125 m. What is the percent error? Round to 0.1%.

17. A radio signal has a frequency of 437.8 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

18. A radio signal has a frequency of 1575.42 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

19. A radio signal has a frequency of 146.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

20. A radio signal has a frequency of 433.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.

21. A current of 1.9 A flows through a 5 Ω resistor. What is the voltage across it?

22. A 6.0 V battery drives current through a 10 Ω load. What current flows? Round to 0.01 A.

23. A LiPo pack is rated 1,000 mAh at 11.1 V. How many watt-hours does it store? Round to 0.1 Wh.

24. A 24 V pack supplies 0.9 A to a motor. How much power is delivered? Round to 0.1 W.

Unit 1 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A 100 W solar panel costs $146.88. What is the cost per watt? Round to the nearest cent.
   $1.47 per watt
   1. Cost per watt = price ÷ watts
   2. 146.88 ÷ 100 = 1.4688 ≈ $1.47 per watt

2. The simulator predicted 193 m. The altimeter read 180 m. What is the percent error? Round to 0.1%.
   6.7 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |180 − 193| = 13
   3. 13 ÷ 193 × 100 = 6.74 ≈ 6.7%

3. The simulator predicted 44 m. The altimeter read 48 m. What is the percent error? Round to 0.1%.
   9.1 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |48 − 44| = 4
   3. 4 ÷ 44 × 100 = 9.09 ≈ 9.1%

4. The simulator predicted 170 m. The altimeter read 171 m. What is the percent error? Round to 0.1%.
   0.6 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |171 − 170| = 1
   3. 1 ÷ 170 × 100 = 0.59 ≈ 0.6%

5. A 100 W solar panel costs $176.94. What is the cost per watt? Round to the nearest cent.
   $1.77 per watt
   1. Cost per watt = price ÷ watts
   2. 176.94 ÷ 100 = 1.7694 ≈ $1.77 per watt

6. The simulator predicted 89 m. The altimeter read 100 m. What is the percent error? Round to 0.1%.
   12.4 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |100 − 89| = 11
   3. 11 ÷ 89 × 100 = 12.36 ≈ 12.4%

7. The simulator predicted 86 m. The altimeter read 78 m. What is the percent error? Round to 0.1%.
   9.3 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |78 − 86| = 8
   3. 8 ÷ 86 × 100 = 9.30 ≈ 9.3%

8. The simulator predicted 82 m. The altimeter read 76 m. What is the percent error? Round to 0.1%.
   7.3 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |76 − 82| = 6
   3. 6 ÷ 82 × 100 = 7.32 ≈ 7.3%

Unit 2 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A model rocket has a mass of 1.94 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
   19.01 N
   1. Weight W = m × g
   2. W = 1.94 × 9.8 = 19.012 ≈ 19.01 N

2. A real tunnel is 12.0 m across. Your model is built at 1:10 scale. How wide is the model in centimeters? Round to 0.1 cm.
   120.0 cm
   1. Model size = real size ÷ 10
   2. 12.0 ÷ 10 = 1.2000 m
   3. × 100 cm/m = 120.00 ≈ 120.0 cm

3. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.
   5.4 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 4.3 ÷ 0.8 = 5.37 ≈ 5.4 N

4. A B motor delivers a total impulse of 5.0 N·s over a burn of 0.6 s. What is its average thrust? Round to 0.1 N.
   8.3 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 5.0 ÷ 0.6 = 8.33 ≈ 8.3 N

5. A model rocket has a mass of 0.54 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
   5.29 N
   1. Weight W = m × g
   2. W = 0.54 × 9.8 = 5.292 ≈ 5.29 N

6. A real tunnel is 12.0 m across. Your model is built at 1:24 scale. How wide is the model in centimeters? Round to 0.1 cm.
   50.0 cm
   1. Model size = real size ÷ 24
   2. 12.0 ÷ 24 = 0.5000 m
   3. × 100 cm/m = 50.00 ≈ 50.0 cm

7. A D motor delivers a total impulse of 17.0 N·s over a burn of 1.6 s. What is its average thrust? Round to 0.1 N.
   10.6 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 17.0 ÷ 1.6 = 10.62 ≈ 10.6 N

8. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.
   5.4 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 4.3 ÷ 0.8 = 5.37 ≈ 5.4 N

Unit 3 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A 100 W solar panel costs $131.64. What is the cost per watt? Round to the nearest cent.
   $1.32 per watt
   1. Cost per watt = price ÷ watts
   2. 131.64 ÷ 100 = 1.3164 ≈ $1.32 per watt

2. An RC car covers 90 m in 11.1 s. What is its average speed? Round to 0.1 m/s.
   8.1 m/s
   1. v = d ÷ t
   2. v = 90 ÷ 11.1 = 8.108… ≈ 8.1 m/s

3. A model rocket has a mass of 1.6 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
   15.68 N
   1. Weight W = m × g
   2. W = 1.6 × 9.8 = 15.680 ≈ 15.68 N

4. An RC car covers 279 m in 7.9 s. What is its average speed? Round to 0.1 m/s.
   35.3 m/s
   1. v = d ÷ t
   2. v = 279 ÷ 7.9 = 35.316… ≈ 35.3 m/s

5. A 30 W solar panel costs $29.57. What is the cost per watt? Round to the nearest cent.
   $0.99 per watt
   1. Cost per watt = price ÷ watts
   2. 29.57 ÷ 30 = 0.9857 ≈ $0.99 per watt

6. An RC car covers 235 m in 12.3 s. What is its average speed? Round to 0.1 m/s.
   19.1 m/s
   1. v = d ÷ t
   2. v = 235 ÷ 12.3 = 19.106… ≈ 19.1 m/s

7. A model rocket has a mass of 0.34 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
   3.33 N
   1. Weight W = m × g
   2. W = 0.34 × 9.8 = 3.332 ≈ 3.33 N

8. An RC car covers 170 m in 2.5 s. What is its average speed? Round to 0.1 m/s.
   68.0 m/s
   1. v = d ÷ t
   2. v = 170 ÷ 2.5 = 68.000… ≈ 68.0 m/s

Unit 4 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. An RC car covers 133 m in 8.6 s. What is its average speed? Round to 0.1 m/s.
   15.5 m/s
   1. v = d ÷ t
   2. v = 133 ÷ 8.6 = 15.465… ≈ 15.5 m/s

2. A radio signal has a frequency of 147.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   2.04 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 147,000,000 = 2.0408 ≈ 2.04 m

3. A 5 W light runs for 2 hours. How many watt-hours of energy does it use?
   10.0 Wh
   1. Energy = power × time
   2. E = 5 × 2 = 10.0 Wh

4. The simulator predicted 88 m. The altimeter read 78 m. What is the percent error? Round to 0.1%.
   11.4 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |78 − 88| = 10
   3. 10 ÷ 88 × 100 = 11.36 ≈ 11.4%

5. An RC car covers 273 m in 17.3 s. What is its average speed? Round to 0.1 m/s.
   15.8 m/s
   1. v = d ÷ t
   2. v = 273 ÷ 17.3 = 15.780… ≈ 15.8 m/s

6. A radio signal has a frequency of 1575.42 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   0.19 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 1,575,420,000 = 0.1904 ≈ 0.19 m

7. A 18 W light runs for 6 hours. How many watt-hours of energy does it use?
   108.0 Wh
   1. Energy = power × time
   2. E = 18 × 6 = 108.0 Wh

8. The simulator predicted 66 m. The altimeter read 70 m. What is the percent error? Round to 0.1%.
   6.1 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |70 − 66| = 4
   3. 4 ÷ 66 × 100 = 6.06 ≈ 6.1%

Unit 5 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A radio signal has a frequency of 7.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   42.86 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 7,000,000 = 42.8571 ≈ 42.86 m

2. A radio signal has a frequency of 50.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   6.00 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 50,000,000 = 6.0000 ≈ 6.00 m

3. A radio signal has a frequency of 7.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   42.86 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 7,000,000 = 42.8571 ≈ 42.86 m

4. A radio signal has a frequency of 50.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   6.00 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 50,000,000 = 6.0000 ≈ 6.00 m

5. A radio signal has a frequency of 437.8 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   0.69 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 437,800,000 = 0.6852 ≈ 0.69 m

6. A radio signal has a frequency of 50.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   6.00 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 50,000,000 = 6.0000 ≈ 6.00 m

7. A radio signal has a frequency of 28.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   10.71 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 28,000,000 = 10.7143 ≈ 10.71 m

8. A radio signal has a frequency of 433.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
   0.69 m
   1. λ = c ÷ f
   2. λ = 300,000,000 ÷ 433,000,000 = 0.6928 ≈ 0.69 m

Unit 6 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A motor draws 0.7 A from a 1.4 V supply. What is its effective resistance? Round to 0.1 Ω.
   2.0 Ω
   1. R = V ÷ I
   2. R = 1.4 ÷ 0.7 = 2.0 Ω

2. A motor draws 2.5 A from a 10.0 V supply. What is its effective resistance? Round to 0.1 Ω.
   4.0 Ω
   1. R = V ÷ I
   2. R = 10.0 ÷ 2.5 = 4.0 Ω

3. A LiPo pack is rated 1,500 mAh at 11.1 V. How many watt-hours does it store? Round to 0.1 Wh.
   16.6 Wh
   1. Change mAh to Ah: 1,500 ÷ 1,000 = 1.5 Ah
   2. Wh = Ah × V = 1.5 × 11.1 = 16.65 ≈ 16.6 Wh

4. A 24 V pack supplies 5.3 A to a motor. How much power is delivered? Round to 0.1 W.
   127.2 W
   1. P = V × I
   2. P = 24 × 5.3 = 127.20 ≈ 127.2 W

5. A motor draws 0.5 A from a 2.5 V supply. What is its effective resistance? Round to 0.1 Ω.
   5.0 Ω
   1. R = V ÷ I
   2. R = 2.5 ÷ 0.5 = 5.0 Ω

6. A motor draws 1.2 A from a 6.0 V supply. What is its effective resistance? Round to 0.1 Ω.
   5.0 Ω
   1. R = V ÷ I
   2. R = 6.0 ÷ 1.2 = 5.0 Ω

7. A LiPo pack is rated 3,000 mAh at 3.7 V. How many watt-hours does it store? Round to 0.1 Wh.
   11.1 Wh
   1. Change mAh to Ah: 3,000 ÷ 1,000 = 3.0 Ah
   2. Wh = Ah × V = 3.0 × 3.7 = 11.10 ≈ 11.1 Wh

8. A 7.4 V pack supplies 6.4 A to a motor. How much power is delivered? Round to 0.1 W.
   47.4 W
   1. P = V × I
   2. P = 7.4 × 6.4 = 47.36 ≈ 47.4 W

Unit 7 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A 3.7 V pack supplies 7.8 A to a motor. How much power is delivered? Round to 0.1 W.
   28.9 W
   1. P = V × I
   2. P = 3.7 × 7.8 = 28.86 ≈ 28.9 W

2. A motor spins at 9,000 rpm. Its 15-tooth pinion drives a 45-tooth gear. How fast does the big gear turn?
   3,000 rpm
   1. Gear ratio = 45 ÷ 15 = 3.00
   2. Output = 9,000 × 15 ÷ 45 = 3,000 rpm

3. A battery stores 100 Wh. A 5 W fan runs on it. About how many hours will it run? Round to 0.1 h.
   20.0 hours
   1. Time = energy ÷ power
   2. t = 100 ÷ 5 = 20.0 h

4. An RC car covers 97 m in 14.6 s. What is its average speed? Round to 0.1 m/s.
   6.6 m/s
   1. v = d ÷ t
   2. v = 97 ÷ 14.6 = 6.644… ≈ 6.6 m/s

5. A 12 V pack supplies 1.6 A to a motor. How much power is delivered? Round to 0.1 W.
   19.2 W
   1. P = V × I
   2. P = 12 × 1.6 = 19.20 ≈ 19.2 W

6. A motor spins at 12,000 rpm. Its 15-tooth pinion drives a 45-tooth gear. How fast does the big gear turn?
   4,000 rpm
   1. Gear ratio = 45 ÷ 15 = 3.00
   2. Output = 12,000 × 15 ÷ 45 = 4,000 rpm

7. A battery stores 40 Wh. A 4 W fan runs on it. About how many hours will it run? Round to 0.1 h.
   10.0 hours
   1. Time = energy ÷ power
   2. t = 40 ÷ 4 = 10.0 h

8. An RC car covers 111 m in 3.0 s. What is its average speed? Round to 0.1 m/s.
   37.0 m/s
   1. v = d ÷ t
   2. v = 111 ÷ 3.0 = 37.000… ≈ 37.0 m/s

Unit 8 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A model tunnel is 4 cm across and 30 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.
   377 cm³
   1. Radius r = 4 ÷ 2 = 2.0 cm
   2. V = π r² L = 3.14159 × 2.0² × 30
   3. V ≈ 377.0 ≈ 377 cm³

2. A force of 722 N presses on an area of 0.05 m². What is the pressure in pascals (Pa)?
   14,440 Pa
   1. P = F ÷ A
   2. P = 722 ÷ 0.05 = 14,440 Pa

3. A force of 334 N presses on an area of 0.02 m². What is the pressure in pascals (Pa)?
   16,700 Pa
   1. P = F ÷ A
   2. P = 334 ÷ 0.02 = 16,700 Pa

4. A model tunnel is 10 cm across and 40 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.
   3,142 cm³
   1. Radius r = 10 ÷ 2 = 5.0 cm
   2. V = π r² L = 3.14159 × 5.0² × 40
   3. V ≈ 3,141.6 ≈ 3,142 cm³

5. A model tunnel is 8 cm across and 60 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.
   3,016 cm³
   1. Radius r = 8 ÷ 2 = 4.0 cm
   2. V = π r² L = 3.14159 × 4.0² × 60
   3. V ≈ 3,015.9 ≈ 3,016 cm³

6. A force of 713 N presses on an area of 0.25 m². What is the pressure in pascals (Pa)?
   2,852 Pa
   1. P = F ÷ A
   2. P = 713 ÷ 0.25 = 2,852 Pa

7. A force of 232 N presses on an area of 0.25 m². What is the pressure in pascals (Pa)?
   928 Pa
   1. P = F ÷ A
   2. P = 232 ÷ 0.25 = 928 Pa

8. A model tunnel is 12 cm across and 30 cm long. How much soil (volume) was removed? Use π ≈ 3.14159. Round to the nearest cm³.
   3,393 cm³
   1. Radius r = 12 ÷ 2 = 6.0 cm
   2. V = π r² L = 3.14159 × 6.0² × 30
   3. V ≈ 3,392.9 ≈ 3,393 cm³

Unit 9 Test Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A 20 W solar panel costs $16.67. What is the cost per watt? Round to the nearest cent.
   $0.83 per watt
   1. Cost per watt = price ÷ watts
   2. 16.67 ÷ 20 = 0.8335 ≈ $0.83 per watt

2. A battery stores 40 Wh. A 20 W fan runs on it. About how many hours will it run? Round to 0.1 h.
   2.0 hours
   1. Time = energy ÷ power
   2. t = 40 ÷ 20 = 2.0 h

3. A 10 W light runs for 0.5 hours. How many watt-hours of energy does it use?
   5.0 Wh
   1. Energy = power × time
   2. E = 10 × 0.5 = 5.0 Wh

4. A 18 W light runs for 6 hours. How many watt-hours of energy does it use?
   108.0 Wh
   1. Energy = power × time
   2. E = 18 × 6 = 108.0 Wh

5. A 30 W solar panel costs $27.97. What is the cost per watt? Round to the nearest cent.
   $0.93 per watt
   1. Cost per watt = price ÷ watts
   2. 27.97 ÷ 30 = 0.9323 ≈ $0.93 per watt

6. A battery stores 120 Wh. A 20 W fan runs on it. About how many hours will it run? Round to 0.1 h.
   6.0 hours
   1. Time = energy ÷ power
   2. t = 120 ÷ 20 = 6.0 h

7. A 18 W light runs for 6 hours. How many watt-hours of energy does it use?
   108.0 Wh
   1. Energy = power × time
   2. E = 18 × 6 = 108.0 Wh

8. A 5 W light runs for 4 hours. How many watt-hours of energy does it use?
   20.0 Wh
   1. Energy = power × time
   2. E = 5 × 4 = 20.0 Wh

Midterm Exam Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A 10 W solar panel costs $6.30. What is the cost per watt? Round to the nearest cent.
   $0.63 per watt
   1. Cost per watt = price ÷ watts
   2. 6.30 ÷ 10 = 0.6300 ≈ $0.63 per watt

2. The simulator predicted 160 m. The altimeter read 141 m. What is the percent error? Round to 0.1%.
   11.9 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |141 − 160| = 19
   3. 19 ÷ 160 × 100 = 11.88 ≈ 11.9%

3. The simulator predicted 113 m. The altimeter read 125 m. What is the percent error? Round to 0.1%.
   10.6 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |125 − 113| = 12
   3. 12 ÷ 113 × 100 = 10.62 ≈ 10.6%

4. The simulator predicted 155 m. The altimeter read 174 m. What is the percent error? Round to 0.1%.
   12.3 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |174 − 155| = 19
   3. 19 ÷ 155 × 100 = 12.26 ≈ 12.3%

5. A model rocket has a mass of 0.58 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
   5.68 N
   1. Weight W = m × g
   2. W = 0.58 × 9.8 = 5.684 ≈ 5.68 N

6. A real tunnel is 12.0 m across. Your model is built at 1:20 scale. How wide is the model in centimeters? Round to 0.1 cm.
   60.0 cm
   1. Model size = real size ÷ 20
   2. 12.0 ÷ 20 = 0.6000 m
   3. × 100 cm/m = 60.00 ≈ 60.0 cm

7. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.
   5.4 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 4.3 ÷ 0.8 = 5.37 ≈ 5.4 N

8. A C motor delivers a total impulse of 10.0 N·s over a burn of 1.7 s. What is its average thrust? Round to 0.1 N.
   5.9 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 10.0 ÷ 1.7 = 5.88 ≈ 5.9 N

9. A 50 W solar panel costs $115.78. What is the cost per watt? Round to the nearest cent.
   $2.32 per watt
   1. Cost per watt = price ÷ watts
   2. 115.78 ÷ 50 = 2.3156 ≈ $2.32 per watt

10. An RC car covers 211 m in 15.5 s. What is its average speed? Round to 0.1 m/s.
    13.6 m/s
    1. v = d ÷ t
    2. v = 211 ÷ 15.5 = 13.613… ≈ 13.6 m/s

11. A model rocket has a mass of 1.27 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
    12.45 N
    1. Weight W = m × g
    2. W = 1.27 × 9.8 = 12.446 ≈ 12.45 N

12. An RC car covers 135 m in 6.8 s. What is its average speed? Round to 0.1 m/s.
    19.9 m/s
    1. v = d ÷ t
    2. v = 135 ÷ 6.8 = 19.853… ≈ 19.9 m/s

13. An RC car covers 118 m in 8.3 s. What is its average speed? Round to 0.1 m/s.
    14.2 m/s
    1. v = d ÷ t
    2. v = 118 ÷ 8.3 = 14.217… ≈ 14.2 m/s

14. A radio signal has a frequency of 146.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
    2.05 m
    1. λ = c ÷ f
    2. λ = 300,000,000 ÷ 146,000,000 = 2.0548 ≈ 2.05 m

15. A 12 W light runs for 2 hours. How many watt-hours of energy does it use?
    24.0 Wh
    1. Energy = power × time
    2. E = 12 × 2 = 24.0 Wh

16. The simulator predicted 87 m. The altimeter read 86 m. What is the percent error? Round to 0.1%.
    1.1 %
    1. Percent error = |measured − predicted| ÷ predicted × 100
    2. |86 − 87| = 1
    3. 1 ÷ 87 × 100 = 1.15 ≈ 1.1%

Final Exam Key

Name _____ Date _____

Young Engineers II: Makers · Answers with steps

1. A 10 W solar panel costs $11.82. What is the cost per watt? Round to the nearest cent.
   $1.18 per watt
   1. Cost per watt = price ÷ watts
   2. 11.82 ÷ 10 = 1.1820 ≈ $1.18 per watt

2. The simulator predicted 124 m. The altimeter read 123 m. What is the percent error? Round to 0.1%.
   0.8 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |123 − 124| = 1
   3. 1 ÷ 124 × 100 = 0.81 ≈ 0.8%

3. The simulator predicted 120 m. The altimeter read 111 m. What is the percent error? Round to 0.1%.
   7.5 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |111 − 120| = 9
   3. 9 ÷ 120 × 100 = 7.50 ≈ 7.5%

4. The simulator predicted 75 m. The altimeter read 68 m. What is the percent error? Round to 0.1%.
   9.3 %
   1. Percent error = |measured − predicted| ÷ predicted × 100
   2. |68 − 75| = 7
   3. 7 ÷ 75 × 100 = 9.33 ≈ 9.3%

5. A model rocket has a mass of 0.49 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
   4.80 N
   1. Weight W = m × g
   2. W = 0.49 × 9.8 = 4.802 ≈ 4.80 N

6. A real tunnel is 70.0 m across. Your model is built at 1:50 scale. How wide is the model in centimeters? Round to 0.1 cm.
   140.0 cm
   1. Model size = real size ÷ 50
   2. 70.0 ÷ 50 = 1.4000 m
   3. × 100 cm/m = 140.00 ≈ 140.0 cm

7. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.
   5.4 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 4.3 ÷ 0.8 = 5.37 ≈ 5.4 N

8. A B motor delivers a total impulse of 4.3 N·s over a burn of 0.8 s. What is its average thrust? Round to 0.1 N.
   5.4 N
   1. Average thrust = total impulse ÷ burn time
   2. F = 4.3 ÷ 0.8 = 5.37 ≈ 5.4 N

9. A 100 W solar panel costs $139.75. What is the cost per watt? Round to the nearest cent.
   $1.40 per watt
   1. Cost per watt = price ÷ watts
   2. 139.75 ÷ 100 = 1.3975 ≈ $1.40 per watt

10. An RC car covers 240 m in 16.3 s. What is its average speed? Round to 0.1 m/s.
    14.7 m/s
    1. v = d ÷ t
    2. v = 240 ÷ 16.3 = 14.724… ≈ 14.7 m/s

11. A model rocket has a mass of 1.46 kg. What is its weight in newtons? Use g = 9.8 m/s². Round to 0.01 N.
    14.31 N
    1. Weight W = m × g
    2. W = 1.46 × 9.8 = 14.308 ≈ 14.31 N

12. An RC car covers 125 m in 6.2 s. What is its average speed? Round to 0.1 m/s.
    20.2 m/s
    1. v = d ÷ t
    2. v = 125 ÷ 6.2 = 20.161… ≈ 20.2 m/s

13. An RC car covers 136 m in 4.4 s. What is its average speed? Round to 0.1 m/s.
    30.9 m/s
    1. v = d ÷ t
    2. v = 136 ÷ 4.4 = 30.909… ≈ 30.9 m/s

14. A radio signal has a frequency of 147.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
    2.04 m
    1. λ = c ÷ f
    2. λ = 300,000,000 ÷ 147,000,000 = 2.0408 ≈ 2.04 m

15. A 12 W light runs for 2 hours. How many watt-hours of energy does it use?
    24.0 Wh
    1. Energy = power × time
    2. E = 12 × 2 = 24.0 Wh

16. The simulator predicted 134 m. The altimeter read 125 m. What is the percent error? Round to 0.1%.
    6.7 %
    1. Percent error = |measured − predicted| ÷ predicted × 100
    2. |125 − 134| = 9
    3. 9 ÷ 134 × 100 = 6.72 ≈ 6.7%

17. A radio signal has a frequency of 437.8 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
    0.69 m
    1. λ = c ÷ f
    2. λ = 300,000,000 ÷ 437,800,000 = 0.6852 ≈ 0.69 m

18. A radio signal has a frequency of 1575.42 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
    0.19 m
    1. λ = c ÷ f
    2. λ = 300,000,000 ÷ 1,575,420,000 = 0.1904 ≈ 0.19 m

19. A radio signal has a frequency of 146.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
    2.05 m
    1. λ = c ÷ f
    2. λ = 300,000,000 ÷ 146,000,000 = 2.0548 ≈ 2.05 m

20. A radio signal has a frequency of 433.0 MHz. What is its wavelength? Use c = 300,000,000 m/s. Round to 0.01 m.
    0.69 m
    1. λ = c ÷ f
    2. λ = 300,000,000 ÷ 433,000,000 = 0.6928 ≈ 0.69 m

21. A current of 1.9 A flows through a 5 Ω resistor. What is the voltage across it?
    9.5 V
    1. Ohm’s law: V = I × R
    2. V = 1.9 × 5 = 9.5 V

22. A 6.0 V battery drives current through a 10 Ω load. What current flows? Round to 0.01 A.
    0.60 A
    1. I = V ÷ R
    2. I = 6.0 ÷ 10 = 0.60 A

23. A LiPo pack is rated 1,000 mAh at 11.1 V. How many watt-hours does it store? Round to 0.1 Wh.
    11.1 Wh
    1. Change mAh to Ah: 1,000 ÷ 1,000 = 1.0 Ah
    2. Wh = Ah × V = 1.0 × 11.1 = 11.10 ≈ 11.1 Wh

24. A 24 V pack supplies 0.9 A to a motor. How much power is delivered? Round to 0.1 W.
    21.6 W
    1. P = V × I
    2. P = 24 × 0.9 = 21.60 ≈ 21.6 W