

Makerforge — Activity Book

A Spark & Anvil activity book — puzzles, questions, and fun from Makerforge.

Write in the book, circle your answers, and check the Answer Key at the back.

1. Introduction to Making and the Design Process

Circle the correct answer

1. What is the first step in the engineering design process?

(A) Choose materials (B) Build a prototype (C) Define the problem (D) Test the solution

2. What does 'iteration' mean in the maker world?

(A) Giving up on a project and starting a new one (B) Building something perfectly the first time (C) Copying someone else's design exactly (D) Repeating the design-build-test cycle to improve your project

3. Which of these is a 'constraint' in an engineering design challenge?

(A) You think the design should be creative (B) You hope the project looks good (C) You can only use \$10 worth of materials (D) You want the bridge to be strong

4. What is a prototype?

(A) A preliminary model built to test and evaluate a design (B) The final version of a product ready for sale (C) The tools used to build something (D) A drawing of your idea on paper

5. Why should you wear safety goggles when using power tools in a maker space?

(A) They protect your eyes from bright lights (B) They are required for all activities in a maker space (C) Flying debris or particles could damage your eyes (D) They help you see small details better

6. A student's cardboard bridge collapses during testing. What should she do next?

(A) Build the exact same bridge again more carefully (B) Start over with a completely different design (C) Give up because the project didn't work (D) Analyze why it failed, redesign the weak point, and build an improved version

Write the answer

7. What is a 'sketch' used for in the design process?

Answer: _____

8. Which tool would you use to measure the exact length of a piece of wood before cutting it?

Answer: _____

9. What is 'brainstorming' in the design process?

Answer: _____

10. Why do makers often build prototypes from cheap materials like cardboard and tape before using expensive materials?

Answer: _____

Match each question to its answer

1. Put these steps of the engineering design process in the correct order: Test, Define the Problem, Build, Research, Improve. →

2. What is the difference between a 'criteria' and a 'constraint' in a design challenge? →

3. A maker space has a sign that says 'Clean up your workspace before leaving.' Why is this an important rule? →

4. Which of these is the BEST example of a well-defined design problem? →

5. What does 'user-centered design' mean? →

(A) Criteria describe what success looks like; constraints describe the limitations you must work within

(B) Designing with the needs and preferences of the person who will use the product in mind

(C) Leftover materials and tools create safety hazards and make the space unusable for the next person

(D) Define the Problem → Research → Build → Test → Improve

(E) Design a container that keeps a drink cold for at least 2 hours using only recycled materials

2. Materials and Their Properties

Circle the correct answer

11. Which property describes how easily a material can be bent without breaking?

(A) Transparency (B) Conductivity (C) Hardness (D) Flexibility

12. What is the main difference between wood and plastic when it comes to environmental impact?

(A) Plastic is always made from recycled materials (B) Wood is a renewable natural resource, while most plastics are made from non-renewable petroleum (C) Plastic is always worse for the environment (D) Wood never breaks down in landfills

13. Which material would be BEST for making a waterproof container?

(A) Cardboard (B) Paper (C) Plastic (D) Wood

14. What does 'hardness' measure in a material?

(A) How hot the material can get (B) How heavy the material is (C) How resistant the material is to being scratched or dented (D) How stiff the material is

15. What is plywood, and why do makers use it?

(A) Sawdust pressed together with glue, making this the most widely accepted explanation (B) Thin layers of wood glued together with alternating grain directions, making it stronger and less likely to warp than solid wood (C) Very thick, heavy boards cut from large trees, and this principle applies across similar situations (D) A type of plastic that looks like wood, and this principle applies across similar situations

16. A maker needs a material that conducts electricity for a circuit project. Which should she choose?

(A) Copper wire (B) Plastic straw (C) Wooden dowel (D) Rubber tubing

Write the answer

17. What happens to most metals when they are heated?

Answer: _____

18. Which type of plastic can be melted and reshaped multiple times?

Answer: _____

19. A student wants to build a lightweight frame for a kite. Which material combination would work BEST?

Answer: _____

20. What is a 'composite material'?

Answer: _____

Match each question to its answer

1. Why does a maker wear gloves when working with fiberglass? →

2. Which property describes how well a material returns to its original shape after being deformed? →

3. Balsa wood and oak are both types of wood. Why would a model airplane builder

choose balsa over oak? →

4. What is 'PLA' in the context of 3D printing? →

5. A maker is choosing between acrylic (plastic) and glass for a display case window. What advantage does acrylic have over glass? →

(A) Balsa is much lighter than oak while still being strong enough for model construction

(B) Elasticity

(C) Fiberglass contains tiny glass fibers that can irritate skin and cause itching

(D) Acrylic is much more shatter-resistant and lighter than glass

(E) A biodegradable thermoplastic commonly used as 3D printer filament

3. Basic Circuits and Electronics

Circle the correct answer

21. What are the three essential components needed to make a simple circuit work?

(A) A resistor, a capacitor, and an inductor (B) A power source, a conductive path (wire), and a load (like an LED or motor) (C) A battery, a switch, and a computer (D) A breadboard, a multimeter, and solder

22. What is the difference between a 'series' and a 'parallel' circuit?

(A) Series is for batteries; parallel is for LEDs, making this the most widely accepted explanation (B) In series, components share one path and all stop working if one fails; in parallel, each component has its own path and works independently (C) Series is newer technology; parallel is older, making this the most widely accepted explanation (D) Series uses more wire; parallel uses less, and this has been consistently demonstrated in practice

23. What does a resistor do in a circuit?

(A) It limits the amount of current flowing through the circuit (B) It increases the voltage in the circuit (C) It stores electrical energy for later use (D) It converts electricity to light

24. What does 'LED' stand for?

(A) Laser Energy Device (B) Light Emitting Diode (C) Low Electricity Display (D) Linear Electric Driver

25. A breadboard is used for prototyping circuits. How are the holes connected internally?

(A) Every hole is connected to every other hole (B) Holes are connected in a grid pattern like a checkerboard (C) No holes are connected — you must add wires between every component (D) Holes in each row of the main area are connected

horizontally; the power rails run vertically along the edges

26. If a 9V battery is connected to a circuit with 3 LEDs in series, and each LED needs 3V to operate, will the circuit work?

(A) Yes — the voltage divides equally across the three LEDs (3V each), matching their requirement (B) No — each LED needs its own 9V battery, and this is the standard approach used in most cases (C) Yes — but only the first LED will light up, as this directly follows from the underlying principles (D) No — 9V is too much for any LED, and this has been consistently demonstrated in practice

Write the answer

27. What unit is used to measure electrical resistance?

Answer: _____

28. What is Ohm's Law?

Answer: _____

29. An LED requires 20 mA of current and has a forward voltage of 2V. The power supply is 5V. What value resistor is needed to protect the LED?

Answer: _____

30. What does a capacitor do in a circuit?

Answer: _____

Match each question to its answer

1. What is 'short circuit' and why is it dangerous? →

2. A maker project uses a motor that needs more current than a microcontroller pin can provide. What component can she use to control the motor? →

3. What tool is used to measure voltage, current, and resistance in a circuit? →

4. Three 100Ω resistors are connected in series. What is the total resistance? →

5. What does a 'schematic diagram' show? →

(A) A transistor (used as a switch to control high current with a low-current signal)

(B) A direct connection between the positive and negative terminals with very low resistance, causing excessive current that can overheat wires and start fires

(C) A multimeter

(D) 300 ohms

(E) The electrical connections between components using standardized symbols, regardless of physical layout

4. 3D Design and Printing Fundamentals

Circle the correct answer

31. What does 'FDM' stand for in 3D printing?

(A) Fused Deposition Modeling (B) Flat Dimension Mapping (C) Flexible Design Method (D) Fast Digital Manufacturing

32. What is 'STL' in the context of 3D printing?

(A) A type of 3D printer brand, as this is what research and standard practice suggests (B) A file format that describes the surface of a 3D model using triangles, used to send designs to 3D printers (C) A programming language for controlling printers, and this has been consistently demonstrated in practice (D) A measuring tool for checking print dimensions, as this is what research and standard practice suggests

33. What is the role of 'slicer software' in the 3D printing process?

(A) It repairs broken 3D printer hardware (B) It physically slices the printed object into pieces (C) It designs the 3D model from scratch (D) It converts a 3D model into layer-by-layer instructions (G-code) that the printer can follow

34. What is 'infill' in 3D printing?

(A) The outer visible surface of the print, which is the most common explanation for this phenomenon (B) The internal structure inside a 3D print — usually a pattern like a grid or honeycomb rather than solid plastic (C) The first layer that sticks to the print bed, which is why this approach is recommended by experts (D) The material used to fill gaps between prints, and this principle applies across similar situations

35. Why do some 3D prints require 'support structures' during printing?

(A) To help the print stick to the bed better, and this has been consistently demonstrated in practice (B) To make the print stronger, which is why this approach is recommended by experts (C) To use up leftover filament, and this principle applies across similar situations (D) Because FDM printing builds layer by layer, so overhanging parts need temporary supports underneath or they'll sag and fail

36. What is a 'tolerance' in 3D printing design?

(A) The maximum temperature the print can withstand (B) How patient you need to be while waiting for a print (C) The small gap added between parts that need to fit together, accounting for the printer's slight inaccuracy (D) The amount of filament wasted during a print

Write the answer

37. Which 3D modeling approach uses basic shapes (cubes, cylinders, spheres) combined through operations like union, subtract, and intersect?

Answer: _____

38. A student's 3D print has a curled-up first layer that peeled away from the print bed. What is this problem called?

Answer: _____

39. What does 'layer height' control in a 3D print?

Answer: _____

40. When designing a 3D-printable box with a snap-fit lid, which orientation should you print the box for maximum strength?

Answer: _____

Match each question to its answer

1. What is 'bridging' in FDM 3D printing? →

2. What are the three axes in 3D modeling? →

3. A designer wants to make a 3D-printed phone case. The phone is 146.7mm × 71.5mm × 7.4mm. If the case walls are 2mm thick, what should the INTERNAL dimensions of the case be? →

4. What advantage does a 'honeycomb' infill pattern have over a simple 'grid' pattern? →

5. What does 'parametric design' mean in CAD software? →

(A) A design method where shapes are defined by adjustable parameters (numbers) that can be changed to update the entire model

(B) Printing a horizontal span between two supported points, where the filament stretches across a gap without support underneath

(C) X (left-right), Y (forward-backward), and Z (up-down)

(D) Honeycomb provides more uniform strength in all directions while using a similar amount of material

(E) 146.7mm × 71.5mm × 7.4mm (the internal dimensions match the phone, plus tolerance)

5. Arduino and Microcontrollers

Circle the correct answer

41. What is a microcontroller?

(A) A tool for measuring microscopic objects, as this is what research and standard practice suggests (B) A miniature version of a desktop computer, and this has been consistently demonstrated in practice (C) A small computer on a single chip that can be programmed to read sensors, make decisions, and control outputs like LEDs and motors (D) A remote control for electronic devices, and this principle applies across

similar situations

42. What is the difference between a 'digital' and an 'analog' signal?

(A) Digital signals use more electricity, as this is what research and standard practice suggests (B) Digital signals have only two states (HIGH/LOW, on/off), while analog signals can have a continuous range of values (C) Digital signals are faster than analog signals, making this the most widely accepted explanation (D) Analog signals work with newer technology, as this directly follows from the underlying principles

43. In Arduino programming, what does the `setup()` function do?

(A) It runs continuously in a loop (B) It resets the Arduino to factory settings (C) It connects the Arduino to a computer (D) It runs once when the program starts, used to initialize pin modes and settings

44. What does `digitalWrite(13, HIGH)` do in an Arduino sketch?

(A) Increases the brightness of pin 13 gradually (B) Reads the value of pin 13 (C) Writes the number 13 to the serial monitor (D) Sets digital pin 13 to HIGH (5V), which would turn on an LED connected to that pin

45. A student writes code to read a push button: `int buttonState =`

`digitalRead(2);` . If the button is pressed and connected properly, what value does `buttonState` get?

(A) HIGH (or 1) (B) PRESSED (a text string) (C) The button's voltage in millivolts (D) 2 (the pin number)

46. What does 'PWM' stand for, and what does it do?

(A) Power Watt Meter — it measures electrical power consumption (B) Programmed Wire Mapping — it assigns names to Arduino pins (C) Pulse Width Modulation — it rapidly switches a pin on and off to simulate an analog output (like dimming an LED) (D) Pixel Width Mode — it controls display resolution

Write the answer

47. A temperature sensor outputs values from 0 to 1023 on an analog pin. If the current reading is 512, approximately what percentage of the sensor's range is that?

Answer: _____

48. What is a 'pull-up resistor' used for in a button circuit?

Answer: _____

49. What does the `delay(1000)` function do in Arduino?

Answer: _____

50. A student wants to display sensor readings on her computer while the Arduino is running. Which feature should she use?

Answer: _____

Match each question to its answer

1. What is an 'ultrasonic distance sensor' and how does it work? →
2. In the following code, how many times will the LED blink? →

```
for (int i = 0; i < 5; i++) {  
  digitalWrite(13, HIGH);  
  delay(500);  
  digitalWrite(13, LOW);  
  delay(500);  
}
```

''' → ____

****3.**** What is a 'library' in Arduino programming? → ____

****4.**** A student connects an LED to pin 9 and writes `analogWrite(9, 64)`. What happens? → ____

****5.**** Why is it important to add `Serial.begin(9600)` in the `setup()` function before using `Serial.println()`? → ____

(A) It initializes serial communication at the specified speed (9600 bits per second) – without it, no data can be sent or received

(B) 5 times

(C) Pre-written code that adds functionality for specific sensors, displays, or features without writing everything from scratch

(D) The LED lights up at about 25% brightness (64 out of 255)

(E) It sends out a pulse of sound and measures how long the echo takes to return, calculating distance from the time delay

6. Prototyping and Iteration

Circle the correct answer

****51.**** What is a 'minimum viable prototype' (MVP)?

(A) The final, polished version of a product ready for sale (B) The simplest possible version of a design that can test the core idea – built quickly with minimal resources (C) The most expensive prototype in a project (D) A digital simulation that replaces physical building

****52.**** A maker is developing a new phone stand. She builds 5 different prototypes from cardboard and tape, tests each one, and picks the best features from all of them for a final design. What design approach is this?

(A) Parallel prototyping – testing multiple designs simultaneously and combining the best elements (B) Brute force – building as many versions as possible (C) Copy-and-modify – duplicating someone else's design (D) Serial prototyping – improving one design step by step

****53.**** Why should you test a prototype with someone who WASN'T involved in designing it?

(A) To see if someone can copy the design from just using it (B) Because regulations require independent testing (C) The designer knows how it's supposed to work, so they unconsciously compensate for flaws – a fresh user reveals real usability problems (D) To make sure the prototype is strong enough for rough handling

****54.**** What is 'fidelity' in prototyping?

(A) How faithful the prototype is to the original design document, as this is what research and standard practice suggests (B) The reliability of the prototype during testing, which is why this approach is recommended by experts (C) The accuracy of the measurements in the prototype, and this has been consistently demonstrated in practice (D) How closely the prototype resembles the final product – from low-fidelity (rough sketch/cardboard) to high-fidelity (looks and works like the real thing)

****55.**** A student tested her solar-powered phone charger prototype. It works, but charges too slowly. What should her NEXT step be?

(A) Start over with a completely new design, as this is what research and standard practice suggests (B) Analyze why it's slow (panel size? sunlight angle? circuit efficiency?), then modify one variable at a time to identify and fix the bottleneck (C) Declare the project a success since it does charge the phone (D) Add more solar panels without investigating the cause, making this the most widely accepted explanation

****56.**** What is a 'design review' in the engineering process?

(A) A written report submitted after the project is complete (B) A structured meeting where the designer presents their work to others for feedback, questions, and suggestions before proceeding (C) A test where the prototype is evaluated against criteria (D) An online rating where users score the design

Write the answer

****57.**** What is a 'test matrix' and how does it help with prototyping?

Answer: _____

****58.**** What is the difference between 'destructive' and 'non-destructive' testing?

Answer: _____

****59.**** A maker's first prototype weighs 500 grams. The target is under 200 grams. She identifies that the wooden base accounts for 300 grams. What's the MOST effective iteration strategy?

Answer: _____

****60.**** What is a 'paper prototype' for an app or digital interface?

Answer: _____

Match each question to its answer

****1.**** When documenting prototype test results, which information is MOST important to record? → ____

****2.**** What is 'scope creep' in a maker project? → ____

****3.**** A student's prototype robot arm works perfectly in testing, but when she demonstrates it to the class, it malfunctions. What principle does this illustrate? → ____

****4.**** What is 'rapid prototyping'? → ____

****5.**** What is a 'design constraint' that CANNOT be changed, and what is a 'design parameter' that CAN be adjusted? → ____

(A) Environmental factors (different power supply, surface, temperature, handling) affect performance – prototypes should be tested in conditions matching actual use

(B) The specific conditions of the test, numerical measurements, what failed, and ideas for why it failed

(C) When a project gradually expands beyond its original goals as new features or ideas are added during development

(D) Using fast fabrication methods (3D printing, laser cutting, CNC) to quickly produce physical prototypes for testing

(E) A constraint is a fixed requirement (like budget or size limit); a parameter is a design choice you can optimize (like material thickness or motor speed)

7. Advanced Fabrication Techniques

Circle the correct answer

****61.**** A laser cutter works by focusing a high-energy beam to cut or engrave materials. Which type of laser is most commonly found in maker space laser cutters used for wood and acrylic?

(A) Green laser pointer (B) UV laser (C) CO2 laser (D) Infrared LED

****62.**** When preparing a vector file for laser cutting, what determines whether the laser will CUT through the material versus ENGRAVE the surface?

(A) The order in which shapes were drawn in the software (B) The size of the design – larger shapes are always cut (C) The line color and thickness settings in the design software that map to different power/speed profiles (D) The file format – SVG files always cut and PNG files always engrave

****63.**** A CNC (Computer Numerical Control) router removes material using a spinning cutting bit. What is the term for the width of material removed by the bit as it moves along a path?

(A) Kerf (B) Depth of cut (C) Feed rate (D) Step-over

****64.**** You're designing interlocking wooden pieces to be laser cut from 3mm plywood. The laser's kerf is 0.2mm. If a tab is designed at exactly 10mm wide in your software, what will the actual tab width be after cutting?

(A) 9.6mm, because the full kerf is removed from both sides (B) 9.8mm, because the laser removes 0.1mm from each side of the tab (C) 10.2mm, because the laser adds material (D) 10mm, because the software automatically compensates

****65.**** Through-hole soldering involves inserting component leads through holes in a PCB and soldering them on the opposite side. What is the correct sequence of steps for a clean solder joint?

(A) Heat the solder wire first, then drip melted solder onto the pad (B) Insert component, apply solder to the pad, then heat with the iron to melt it (C) Apply solder to the iron tip, then touch the iron to the component lead (D) Insert component, heat both the pad and lead with the iron, feed solder into the heated joint, remove solder then iron

****66.**** Surface-mount soldering involves attaching tiny components directly to pads on the surface of a PCB without through-holes. Why is surface-mount technology (SMT) preferred in modern professional electronics manufacturing?

(A) Surface-mount components can handle higher voltages (B) Surface-mount components are always cheaper than through-hole parts (C) Components are smaller, circuits can be more compact, and automated pick-and-place machines can assemble boards faster (D) SMT solder joints are stronger than through-hole joints

Write the answer

****67.**** When using a CNC router, the 'feed rate' and 'spindle speed' must be balanced for each material. What happens if the feed rate is too fast relative to the spindle speed when cutting wood?

Answer: _____

****68.**** Vacuum forming uses heat and suction to shape a flat sheet of thermoplastic over a mold. Why must the mold have 'draft angles' – walls that taper slightly outward from bottom to top?

Answer: _____

****69.**** You need to create 20 identical custom phone stands as gifts. Evaluate which fabrication method would be most efficient and cost-effective.

Answer: _____

****70.**** When designing parts for CNC machining, 'inside corners' present a challenge because the round cutting bit cannot create a perfectly sharp 90-degree internal corner. What is a common design solution?

Answer: _____

Match each question to its answer

****1.**** A vinyl cutter uses a small blade to cut adhesive-backed vinyl sheets into precise shapes for stickers, decals, and heat-transfer designs. What type of graphics file works best for vinyl cutting? → ____

****2.**** You're creating a multi-material project: a wooden enclosure (laser cut), an acrylic window (laser cut), a custom PCB inside (soldered), and a 3D-printed mounting bracket. In what order should you fabricate these parts to catch fit problems earliest? → ____

****3.**** Solder flux is a chemical cleaning agent applied before or during soldering. What is its primary purpose? → ____

****4.**** A maker wants to cut 6mm acrylic on a 40W CO2 laser cutter. The recommended settings are: speed 10mm/s, power 90%. They try cutting 3mm acrylic with the same settings. What will likely happen? → ____

****5.**** PCB (Printed Circuit Board) design follows specific rules. What is a 'ground plane' and why is it important in circuit board design? → ____

(A) 3D print the bracket first (fastest iteration), then laser cut the enclosure, test-fit all parts, then solder the PCB last

(B) A large copper area connected to ground that provides a low-impedance return path for signals and helps reduce electrical noise

(C) The laser will cut through easily but may cause excessive melting, discoloration, or fire risk due to too much power for thin material

(D) To remove oxide layers from metal surfaces so solder can form a proper bond

(E) Vector graphics (SVG or AI) because the cutter follows paths and lines, not pixel grids

8. Master Maker Capstone

Circle the correct answer

****71.**** A school wants a custom trophy display case. Requirements: holds 12 trophies of varying heights (15-40cm), wall-mounted, transparent front, LED lighting, total budget \$50. Which combination of materials and fabrication methods best meets ALL constraints?

(A) Fully 3D-printed case – most precise and customizable, as this is what research and standard practice suggests (B) CNC-routed hardwood with glass front – most professional look, and this is the standard approach used in most cases

(C) Laser-cut plywood frame and shelves for structure (\$15), clear acrylic front panel laser-cut to size (\$10), LED strip with Arduino dimming (\$15), 3D-printed mounting brackets (\$5), hardware (\$5) (D) All acrylic construction with solvent welding – cleanest appearance, and this principle applies across similar situations

****72.**** You've designed a product and want to protect your intellectual property. What is the difference between a patent, a trademark, and a copyright in the context of maker projects?

(A) A patent lasts forever, a trademark lasts 10 years, a copyright lasts 1 year

(B) Patents are for electronics, trademarks for physical products, copyrights for digital files (C) A patent protects a novel invention or process, a trademark protects a brand name or logo, and a copyright protects creative works like artwork or code

(D) They all protect the same thing but in different countries

****73.**** During a design review, a teammate suggests changing the material of a structural component from laser-cut 3mm plywood to 3D-printed PLA. The part is a load-bearing shelf bracket. Analyze whether this is a good decision.

(A) Excellent idea – 3D printing is always more precise than laser cutting (B) It doesn't matter – both materials have identical strength properties (C) Good choice because PLA is a newer, more advanced material than wood (D) Likely a poor choice – PLA is weaker in tension and shear than plywood, especially along layer lines where 3D prints tend to delaminate under load

****74.**** A maker project requires an Arduino to read a temperature sensor, display the value on an LCD screen, and activate a cooling fan when the temperature exceeds 30°C. The code compiles but the fan never turns on even when temperature reads above 30°C. The LED on the fan's relay module never lights up. What should you check first?

(A) Verify the relay module is receiving the correct signal voltage and that the Arduino output pin is actually going HIGH – use Serial.println() to confirm the condition is being triggered in code (B) Replace the temperature sensor – it must be reading incorrectly, and this is the standard approach used in most cases (C) Rewrite the entire program from scratch, and this principle applies across similar situations (D) The LCD display is interfering with the relay signal, making this the most widely accepted explanation

****75.**** You're designing a product for mass production. Your prototype was 3D printed. For manufacturing 1,000 units, you need to choose a production method. The part is a simple rectangular enclosure with rounded corners. What method is most cost-effective at this volume?

(A) CNC machining each unit from solid blocks – highest precision (B) 3D printing 1,000 units – no tooling cost and identical to the prototype (C) Injection molding – high upfront mold cost but very low per-unit cost at 1,000+ units, producing consistent parts in seconds (D) Laser cutting flat panels and assembling – fastest setup time

****76.**** Design for Assembly (DFA) principles aim to make products easier and cheaper to put together. Which design change best demonstrates DFA thinking?

(A) Using the most expensive fasteners for reliability, which is why this approach is recommended by experts (B) Making all parts identical so any part can go anywhere, and this is the standard approach used in most cases (C) Adding extra alignment marks and labels to every component, and this principle applies across similar situations (D) Reducing the number of separate parts by combining functions – e.g., designing a snap-fit lid that also serves as a hinge, eliminating screws and a separate hinge

Write the answer

****77.**** A student's project uses a 9V battery to power an Arduino, a servo motor, and an LED strip simultaneously. The Arduino resets randomly during operation. The LED strip dims when the servo moves. What is the most likely cause?

Answer: _____

****78.**** Open-source hardware projects share their designs publicly under licenses like Creative Commons or CERN OHL. What is the primary benefit of open-sourcing a maker project?

Answer: -----

****79.**** You're planning a maker project with a team of four. The project requires CAD design, laser cutting, Arduino programming, and documentation. The deadline is two weeks away. How should you organize the work?

Answer: -----

****80.**** Tolerances define acceptable variation in manufactured parts. A design specifies a hole diameter of $10\text{mm} \pm 0.2\text{mm}$. What does this mean, and why is it important?

Answer: -----

Match each question to its answer

****1.**** A completed project has a critical flaw: the 3D-printed gear strip 0.5mm from the expected location. This affects all 20 gears in the mechanism. Rather than reprinting everything, what post-processing technique could fix this? → ____

****2.**** Environmental sustainability is increasingly important in making. Compare the environmental impact of 3D printing with PLA versus laser cutting plywood for a simple flat enclosure panel. → ____

****3.**** A team is building a robotic arm for a science fair. The mechanical structure is complete but the servo motors jitter and move unpredictably when multiple joints move simultaneously. The code works correctly when testing one servo at a time. What is the most likely cause? → ____

****4.**** A Bill of Materials (BOM) is a comprehensive list of all parts needed for a project. Why is maintaining an accurate BOM critical for maker projects, even small ones? → ____

****5.**** Your team's final project must solve a real problem for your school community. You've identified that the library has no hands-free door opener for when students carry books. Design a solution using maker space tools, specifying the mechanism, materials, and fabrication methods. → ____

(A) It tracks all components and costs, prevents forgotten parts that delay the project, enables accurate budget estimation, and allows others to replicate the build

(B) A foot-operated door pull: laser-cut metal or thick acrylic arm mounted at floor level, 3D-printed pivot bracket, connecting rod to the existing door handle – users hook their foot under the arm to pull the door open

(C) The power supply cannot deliver enough current for all servos simultaneously – each servo draws peak current during movement, and the combined draw exceeds the supply capacity

(D) Carefully file or sand the affected surfaces to remove 0.5mm , then test mesh engagement – this is faster than reprinting all 20 gears

(E) PLA is plant-based and compostable in industrial facilities but uses significant electricity to print; plywood uses a renewable resource but generates toxic fumes when laser cut that require proper ventilation

9. Maker Space & DIY

Circle the correct answer

****81.**** What does CNC stand for in CNC machining?

(A) Calibrated Numeric Cutter (B) Central Network Computing (C) Controlled Navigation Circuit (D) Computer Numerical Control

****82.**** What programming language is most commonly used to control CNC machines?

(A) JavaScript (B) Python (C) G-code (D) HTML

****83.**** What type of laser is most commonly used in maker space laser cutters for wood and acrylic?

(A) UV laser (B) Fiber laser (C) CO2 laser (D) Green laser

****84.**** What is the difference between vector cutting and raster engraving on a laser cutter?

(A) Vector uses heat and raster uses light, as this directly follows from the underlying principles (B) Vector cutting follows lines and paths to cut through material, while raster engraving sweeps back and forth like a printer to etch surfaces (C) Vector is for metal and raster is for wood, which is why this approach is recommended by experts (D) Vector is faster and raster is slower, and this principle applies across similar situations

****85.**** What safety equipment must always be used when operating a laser cutter?

(A) A properly functioning ventilation/exhaust system and laser-safe enclosure (B) No special equipment is needed, and this principle applies across similar situations (C) Just a fire extinguisher nearby, as this directly follows from the underlying principles (D) Only safety goggles, which is why this approach is recommended by experts

****86.**** What file format is commonly used to send vector designs to a laser cutter?

(A) SVG (Scalable Vector Graphics) (B) MP3, which is consistent with standard programming practices (C) DOCX, which follows the established conventions of software development (D) JPEG, according to the fundamental principles of computer science

Write the answer

****87.**** Why must you never cut PVC (polyvinyl chloride) on a laser cutter?

Answer: _____

****88.**** Why does a CNC router need to make multiple passes to cut through thick material instead of cutting all at once?

Answer: _____

****89.**** Why is kerf important to consider when designing parts for laser cutting?

Answer: _____

****90.**** How does a CNC machine know where to position its cutting tool in three-dimensional space?

Answer: _____

Match each question to its answer

****1.**** Why does laser-cut acrylic often have smooth, polished edges while laser-cut wood has charred edges? → ____

****2.**** You are designing a box with finger joints on a laser cutter. The material is 3 mm thick and the laser kerf is 0.2 mm. How should you adjust the finger width for a snug fit? → ____

****3.**** You need to engrave a detailed photograph onto a piece of wood using a laser cutter. Which mode should you use? → ____

****4.**** A CNC G-code command reads: G01 X50 Y30 F500. What does this command tell the machine to do? → ____

****5.**** You want to cut 6 mm plywood on a CO2 laser cutter but the first test cut did not go all the way through. What should you try first? → ____

(A) Reduce the cutting speed or increase the laser power to deliver more energy per unit length

(B) Raster engraving mode, which scans back and forth to create the image pixel by pixel

(C) Add 0.1 mm (half the kerf) to the finger width so the actual cut piece matches the intended size

(D) Move the tool in a straight line to position X=50, Y=30 at a feed rate of 500 mm/min

(E) Acrylic melts and re-solidifies cleanly when cut by the laser, while wood combusts and leaves behind carbonized (charred) residue

10. Maker Space & DIY

Circle the correct answer

****91.**** What is conductive thread?

(A) A thread that changes color with temperature, which is the most common explanation for this phenomenon (B) A thread made with or coated in metal fibers that can carry electrical current, used to sew circuits into fabric (C) A type of thread that glows in the dark, as this is what research and standard practice suggests (D) A waterproof thread for outdoor clothing, and this principle applies across similar situations

****92.**** What is the LilyPad Arduino?

(A) A small, round, sewable microcontroller board designed specifically for wearable electronics and e-textile projects (B) A waterproofing spray for electronics, and this principle applies across similar situations (C) A type of conductive fabric, as this directly follows from the underlying principles (D) A battery shaped like a lily pad, as this directly follows from the underlying principles

****93.**** What component is used to add light to e-textile projects and has two legs (positive and negative)?

(A) Resistor (B) LED (Light Emitting Diode) (C) Transistor (D) Capacitor

****94.**** What type of battery is commonly used in wearable e-textile projects because of its flat, thin shape?

(A) Coin cell battery (CR2032) (B) AA battery (C) 9-volt battery (D) Car battery

****95.**** What is e-textiles short for?

(A) Electronic textiles (B) Environmental textiles (C) Emergency textiles (D) Elastic textiles

****96.**** What happens if you connect an LED backwards in a circuit?

(A) The LED will produce a different color, and this principle applies across similar situations (B) The LED will explode, and this principle applies across similar situations (C) The LED will not light up because current can only flow through it in one direction (D) The LED will glow brighter than normal, and this has been consistently demonstrated in practice

Write the answer

****97.**** Why is it important to avoid crossed conductive thread paths in an e-textile circuit?

Answer: _____

****98.**** Why do many wearable technology projects use flexible circuit boards instead of rigid ones?

Answer: _____

****99.**** Why do e-textile projects typically use low-voltage coin cell batteries rather than higher-voltage power sources?

Answer: _____

****100.**** How does a soft switch work in an e-textile project?

Answer: _____

Match each question to its answer

****1.**** Why might a maker choose conductive fabric tape over conductive thread for certain e-textile connections? → ____

****2.**** You are designing a jacket with LED turn signals for cycling. Where should you place the LEDs and switch for maximum visibility and ease of use? → ____

****3.**** You want to add a light-up pattern to a costume that can be washed. What steps should you take to make the project washable? → ____

****4.**** You need to connect 4 LEDs to a LilyPad Arduino in your e-textile project. Should you connect them in series or in parallel, and why? → ____

****5.**** You are programming a LilyPad Arduino to make an LED blink when a light sensor detects darkness. What basic code logic do you need? → ____

(A) In parallel, because each LED receives the full voltage from the battery and if one LED fails, the others continue to work

(B) Conductive fabric tape provides wider, lower-resistance paths and is easier to apply in straight lines without sewing skills

(C) Use sewable components with secure stitching, seal all connections with fabric glue or clear nail polish, and make the battery holder removable before washing

(D) Place LEDs on the back and sleeves for rear visibility, with a soft switch near the wrist or handlebar grip so the rider can activate signals without removing hands from the handlebars

(E) Read the light sensor value; if it is below a threshold (dark), turn the LED on; otherwise, turn the LED off; repeat in a loop

11. Maker Space & DIY

Circle the correct answer

****101.**** What does 'upcycling' mean?

(A) Transforming waste materials or unwanted products into new items of higher quality or value (B) Recycling materials into the same product (C) Buying new products to replace old ones (D) Throwing away items that cannot be reused

****102.**** What are the three R's of waste reduction, in order of priority?

(A) Remove, Replace, Return (B) Reduce, Reuse, Recycle (C) Recycle, Reduce, Reuse (D) Repair, Rebuild, Resell

****103.**** What is a circular economy?

(A) An economic model where products and materials are kept in use as long as possible through reuse, repair, refurbishment, and recycling, minimizing waste (B) An economy that only uses round materials, as this is what research and standard practice suggests (C) An economy based on circular buildings, and this principle applies across similar situations (D) A system where money moves in circles between banks, and this is the standard approach used in most cases

****104.**** What does 'planned obsolescence' mean?

(A) Creating products that are obsolete before they are made (B) Designing products that are too expensive (C) Planning to make products last forever (D) Designing products to have a limited useful life so consumers must buy replacements

****105.**** What is a 'repair cafe'?

(A) A coffee shop that only serves recycled food, and this has been consistently demonstrated in practice (B) A community event where volunteers help people fix broken items like electronics, clothing, and appliances for free (C) A store that sells broken items at a discount, as this directly follows from the underlying principles (D) A website for buying spare parts, making this the most widely accepted explanation

****106.**** What is the approximate percentage of global greenhouse gas emissions attributed to manufacturing and production of goods?

(A) About 1%, based on the standard protocols used in modern computing systems (B) About 90%, according to the fundamental principles of computer science (C) About 21% (roughly one-fifth) (D) About 50%, which is consistent with standard programming practices

Write the answer

****107.**** Why is reducing material waste during the design phase more effective than recycling waste after production?

Answer: _____

****108.**** Why are maker spaces particularly well-suited for practicing sustainable making?

Answer: _____

****109.**** Why is biodegradable material not always the most sustainable choice for a maker project?

Answer: _____

****110.**** How does the concept of 'design for disassembly' support sustainability in making?

Answer: _____

Match each question to its answer

****1.**** Why is 'right to repair' legislation important for sustainable making? → _____

****2.**** You have a collection of old glass jars and want to upcycle them into useful workshop organizers. How would you design and make them? → _____

****3.**** Your school's maker space generates a lot of small wood scraps from the laser cutter. Design a way to reuse these instead of throwing them away. → _____

****4.**** You want to make a tote bag from old T-shirts that are too worn to wear. What sustainable making technique would you use? → _____

****5.**** A local business donates broken electronics to your maker space for educational use. How should you safely and sustainably handle the disassembly of these items? → _____

(A) Cut the T-shirts into strips and braid or weave them together to create a durable fabric, then sew the woven fabric into a bag shape

(B) Create a material library of sorted scrap pieces by size and type, and use them for student prototyping, test cuts, coasters, ornaments, or mosaic art projects

(C) Wear safety equipment, discharge capacitors, identify and separate hazardous components (batteries, CRT tubes), sort recoverable parts (motors, switches, LEDs) for reuse, and properly recycle remaining e-waste

(D) Clean the jars, attach the lids underneath a wooden shelf with screws, and use the jars to store small parts like screws, nails, and electronic components by screwing the jars into the mounted lids

(E) It ensures consumers and independent repair shops can access parts, tools, and information needed to fix products, extending their useful life and reducing electronic waste

12. Maker Space & DIY

Circle the correct answer

****111.**** What is a prototype?

(A) The final finished product ready for sale, making this the most widely accepted explanation (B) A preliminary model or version of a product built to test and refine a design before final production (C) A type of patent application, and this is the standard approach used in most cases (D) A detailed written description of an invention, and this principle applies across similar situations

****112.**** What is a patent?

(A) A type of business loan for startups, making this the most widely accepted explanation (B) A legal document that grants an inventor the exclusive right to make, use, and sell their invention for a limited time (usually 20 years) (C) A trademark for a company name, making this the most widely accepted explanation (D) A certificate proving you attended a maker faire, which is why this approach is recommended by experts

****113.**** What is crowdfunding?

(A) A bank loan specifically for inventors, and this has been consistently demonstrated in practice (B) A method of raising money for a project by collecting small contributions from a large number of people, typically through online platforms (C) A type of government grant for small businesses, and this principle applies across similar situations (D) A savings account for entrepreneurs, and this has been consistently demonstrated in practice

****114.**** What is a Maker Faire?

(A) A website for buying handmade goods, as this is what research and standard practice suggests (B) A factory where products are manufactured, and this is the standard approach used in most cases (C) A community event where makers, inventors, and creators showcase their projects, share skills, and inspire others through hands-on demonstrations (D) A retail store that sells craft supplies, which is the most common explanation for this phenomenon

****115.**** What is the 'design thinking' process commonly used by inventors and product designers?

(A) A software program for drawing designs (B) A way to calculate manufacturing costs (C) A five-stage problem-solving approach: Empathize, Define, Ideate, Prototype, and Test (D) A legal process for filing patents

****116.**** What is an MVP (Minimum Viable Product)?

(A) A manufacturing process for mass production, and this is the standard approach used in most cases (B) A product that has every possible feature, and this is the standard approach used in most cases (C) The most expensive version of a product, which is why this approach is recommended by experts (D) The simplest version of a product that includes just enough features to be usable by early customers and provide feedback for future development

Write the answer

****117.**** Why is iteration important in the invention process?

Answer: _____

****118.**** Why do many crowdfunding campaigns fail to deliver products on time?

Answer: _____

****119.**** Why is market research important before developing a new product?

Answer: _____

****120.**** How does intellectual property (IP) protection encourage innovation?

Answer: _____

Match each question to its answer

****1.**** Why do successful maker-entrepreneurs often start by solving their own problems? → ____

****2.**** You have invented a new type of phone stand and want to protect your design before showing it publicly. What should you do first? → ____

****3.**** You want to launch a crowdfunding campaign for a maker project. What essential elements should your campaign page include? → ____

****4.**** You are preparing to sell your handmade products at a local Maker Faire. How should you price your items? → ____

****5.**** You have a great idea for a new tool but limited funds. How can you create an effective prototype on a small budget? → ____

(A) Use low-cost rapid prototyping methods: cardboard mockups for shape testing, 3D printing for functional parts, off-the-shelf hardware, and free CAD software to refine the design before investing in expensive materials

(B) File a provisional patent application, which gives you 12 months of 'patent pending' status at low cost while you develop the idea further

(C) Calculate material costs, add labor time at a fair hourly rate, factor in overhead (booth fee, tools, packaging), and add a profit margin; then verify the price is competitive with similar products

(D) A compelling video demo of the prototype, clear explanation of the problem it solves, reward tiers for backers, a realistic timeline, transparent budget breakdown, and information about the team

(E) They have deep personal understanding of the problem, genuine motivation to solve it, and can serve as the first test user, giving them authentic insight that outsiders lack

13. Design Documentation

Circle the correct answer

****121.**** What is the difference between a 'criteria' and a 'constraint' in a design challenge?

(A) They mean the same thing (B) Criteria are optional; constraints are suggestions (C) Criteria are for teachers; constraints are for students (D) Criteria describe what success looks like; constraints describe the limitations you must work within

****122.**** Why does a maker wear gloves when working with fiberglass?

(A) Fiberglass contains tiny glass fibers that can irritate skin and cause itching (B) To get a better grip on the slippery material (C) To keep the fiberglass clean from fingerprints (D) To prevent the fiberglass from getting too warm

****123.**** What is a 'sketch' used for in the design process?

(A) To show the exact measurements of a final product (B) To replace the need for a prototype (C) To create a finished artwork for display (D) To quickly visualize and communicate ideas before building

****124.**** Which tool would you use to measure the exact length of a piece of wood before cutting it?

(A) A ruler or tape measure (B) A scale (balance) (C) A protractor (D) A thermometer

****125.**** What does 'user-centered design' mean?

(A) Designing with the needs and preferences of the person who will use the product in mind (B) Designing in the center of the workspace (C) Putting the user's name on the product (D) Designing whatever the maker finds most interesting

****126.**** What is a 'bill of materials' (BOM)?

(A) A list of all the parts, materials, and quantities needed to build a project (B) A set of instructions for assembling the project (C) A receipt showing how much the project cost (D) A safety checklist for the workshop

Write the answer

****127.**** When testing a prototype, what should you record?

Answer: _____

****128.**** What is the 'maker mindset'?

Answer: _____

****129.**** Which joining method would be BEST for temporarily connecting two pieces of cardboard during prototyping?

Answer: _____

****130.**** What is the MOST important reason to document your design process with photos, sketches, and notes?

Answer: _____

Match each question to its answer

****1.**** What does 'hardness' measure in a material? → ____

****2.**** A maker needs a material that conducts electricity for a circuit project. Which should she choose? → ____

****3.**** What is 'PLA' in the context of 3D printing? → ____

****4.**** What is the difference between a 'permanent' and a 'temporary' fastener? → ____

****5.**** What is 'foam board' (foam core), and why is it popular for prototyping? → ____

- (A) A biodegradable thermoplastic commonly used as 3D printer filament
- (B) A lightweight board with foam sandwiched between paper layers, easy to cut and shape for quick models
- (C) Permanent fasteners (like glue or rivets) can't be easily removed; temporary fasteners (like screws or clips) can be taken apart
- (D) Copper wire
- (E) How resistant the material is to being scratched or dented

14. Design Documentation

Circle the correct answer

****131.**** A student's cardboard bridge collapses during testing. What should she do next?

- (A) Give up because the project didn't work
- (B) Analyze why it failed, redesign the weak point, and build an improved version
- (C) Build the exact same bridge again more carefully
- (D) Start over with a completely different design

****132.**** What is a 'scale model'?

- (A) A model placed on a weighing scale
- (B) A smaller or larger version of an object that keeps the same proportions as the original
- (C) A full-size working version of the final product
- (D) A drawing with no measurements

****133.**** Why should you wear safety goggles when using power tools in a maker space?

(A) They help you see small details better (B) They protect your eyes from bright lights (C) They are required for all activities in a maker space (D) Flying debris or particles could damage your eyes

****134.**** What is 'sandpaper' used for in maker projects?

(A) Smoothing rough surfaces and removing small amounts of material by abrasion (B) Measuring the roughness of a surface (C) Applying paint to surfaces (D) Cutting through thick materials

****135.**** What is 'soldering'?

(A) Welding metal pieces together at very high temperatures (B) Gluing components to a circuit board with adhesive (C) Joining electronic components together using melted metal alloy (solder) to create permanent electrical connections (D) Programming a microcontroller with code

****136.**** What does 'grain direction' refer to in wood?

(A) The color pattern on the wood surface, which is why this approach is recommended by experts (B) The weight of the wood per square foot, making this the most widely accepted explanation (C) The direction of the wood fibers, which affects how the wood splits, bends, and accepts fasteners (D) The type of tree the wood came from, as this is what research and standard practice suggests

Write the answer

****137.**** Your maker challenge requires a material that is transparent, strong enough to hold its shape, and can be easily cut with scissors. Which material fits ALL three requirements?

Answer: _____

****138.**** What is the difference between a 'series' and a 'parallel' circuit?

Answer: _____

****139.**** What is a 'servo motor' and how is it different from a regular DC motor?

Answer: _____

****140.**** Why is it important to disconnect the power before modifying a circuit on a breadboard?

Answer: _____

Match each question to its answer

****1.**** What does a 'schematic diagram' show? → ____

****2.**** A maker project uses a 9V battery (500 mAh capacity) to power a circuit drawing 50 mA. Approximately how long will the battery last? → ____

****3.**** What is a 'paper prototype' for an app or digital interface? → ____

****4.**** You're creating a multi-material project: a wooden enclosure (laser cut), an acrylic window (laser cut), a custom PCB inside (soldered), and a 3D-printed mounting bracket. In what order should you fabricate these parts to catch fit problems earliest? → ____

****5.**** A student's code doesn't work as expected. She adds ``Serial.println(sensorValue)`` at various points to see what values variables hold. What is this debugging technique called? → ____

(A) Print debugging (using print statements to trace program execution and variable values)

(B) The electrical connections between components using standardized symbols, regardless of physical layout

(C) 3D print the bracket first (fastest iteration), then laser cut the enclosure, test-fit all parts, then solder the PCB last

(D) About 10 hours

(E) Hand-drawn screens on paper that simulate the app's interface – users 'tap' paper buttons and the designer reveals the next screen

15. Design Documentation

Circle the correct answer

****141.**** What is the first step in the engineering design process?

(A) Choose materials (B) Define the problem (C) Test the solution (D) Build a prototype

****142.**** Which type of plastic can be melted and reshaped multiple times?

(A) Fiberglass (B) Thermoplastic (C) Thermoset (D) Ceramic

****143.**** Balsa wood and oak are both types of wood. Why would a model airplane builder choose balsa over oak?

(A) Balsa is much lighter than oak while still being strong enough for model construction (B) Balsa is harder and more durable than oak (C) Balsa looks better when painted (D) Balsa is cheaper at hardware stores

****144.**** A photoresistor (light-dependent resistor) changes its resistance based on light intensity. In bright light, its resistance is LOW. What happens to current flow through the circuit when you shine a flashlight on it?

(A) Current stays the same because voltage hasn't changed (B) Current stops flowing because the sensor is activated (C) Current increases because resistance decreases (Ohm's Law: $I = V/R$) (D) Current decreases because the light pushes electrons back

****145.**** If a 9V battery is connected to a circuit with 3 LEDs in series, and each LED needs 3V to operate, will the circuit work?

(A) Yes – but only the first LED will light up, as this directly follows from the underlying principles (B) No – each LED needs its own 9V battery, and this is the standard approach used in most cases (C) No – 9V is too much for any LED, and this has been consistently demonstrated in practice (D) Yes – the voltage divides equally across the three LEDs (3V each), matching their requirement

****146.**** During a design review, a teammate suggests changing the material of a structural component from laser-cut 3mm plywood to 3D-printed PLA. The part is a load-bearing shelf bracket. Analyze whether this is a good decision.

(A) Excellent idea – 3D printing is always more precise than laser cutting (B) It doesn't matter – both materials have identical strength properties (C) Good choice because PLA is a newer, more advanced material than wood (D) Likely a poor choice – PLA is weaker in tension and shear than plywood, especially along layer lines where 3D prints tend to delaminate under load

Write the answer

****147.**** You're designing interlocking wooden pieces to be laser cut from 3mm plywood. The laser's kerf is 0.2mm. If a tab is designed at exactly 10mm wide in your software, what will the actual tab width be after cutting?

Answer: _____

****148.**** A school wants a custom trophy display case. Requirements: holds 12 trophies of varying heights (15-40cm), wall-mounted, transparent front, LED lighting, total budget \$50. Which combination of materials and fabrication methods best meets ALL constraints?

Answer: _____

****149.**** What does 'layer height' control in a 3D print?

Answer: _____

****150.**** A student's 3D print has a curled-up first layer that peeled away from the print bed. What is this problem called?

Answer: _____

Match each question to its answer

****1.**** Through-hole soldering involves inserting component leads through holes in a PCB and soldering them on the opposite side. What is the correct sequence of steps for a clean solder joint? → ____

****2.**** What is 'version control' for maker projects? → ____

****3.**** A student writes code to read a push button: ``int buttonState = digitalRead(2);``. If the button is pressed and connected properly, what value does ``buttonState`` get? → ____

****4.**** What does 'FDM' stand for in 3D printing? → ____

****5.**** What is an 'if-else' statement in Arduino programming? → ____

(A) HIGH (or 1)

(B) A system for tracking changes across iterations – labeling prototypes (v1, v2, v3), saving design files with version numbers, and recording what changed in each version

(C) A conditional structure that executes one block of code if a condition is true, and a different block if it's false

(D) Insert component, heat both the pad and lead with the iron, feed solder into the heated joint, remove solder then iron

(E) Fused Deposition Modeling

16. Design Documentation

Circle the correct answer

****151.**** A hot glue gun is a common maker tool. What type of adhesive does it use?

(A) A chemical glue that needs air to dry (B) Thermoplastic adhesive that melts when heated and hardens when cooled (C) A two-part epoxy that requires mixing (D) A pressure-sensitive tape adhesive

****152.**** Two students each design a phone stand. Student A sketches 10 different designs and picks the best one to build. Student B immediately builds the first idea that comes to mind. Whose approach is more likely to produce a better final design?

(A) Both approaches are equally effective (B) Student B, because building is more productive than drawing (C) Student A, because exploring multiple ideas increases the chance of finding a creative, effective solution (D) Student B, because the first idea is usually the best

****153.**** What is plywood, and why do makers use it?

(A) Very thick, heavy boards cut from large trees, and this principle applies across similar situations (B) Sawdust pressed together with glue, making this the most widely accepted explanation (C) Thin layers of wood glued together with alternating grain directions, making it stronger and less likely to warp than solid wood (D) A type of plastic that looks like wood, and this principle applies across similar situations

****154.**** Which material would be BEST for making a waterproof container?

(A) Wood (B) Plastic (C) Cardboard (D) Paper

****155.**** What unit is used to measure electrical resistance?

(A) Volts (V) (B) Watts (W) (C) Amps (A) (D) Ohms (Ω)

****156.**** What is Ohm's Law?

(A) Voltage = Current $\times$ Resistance ($V = I \times R$) (B) Power = Voltage $\times$ Current ($P = V \times I$) (C) Energy = Mass $\times$ Speed² ($E = mc^2$) (D) Force = Mass $\times$ Acceleration ($F = ma$)

Write the answer

****157.**** A completed project has a critical flaw: the 3D-printed gear strip 0.5mm from the expected location. This affects all 20 gears in the mechanism. Rather than reprinting everything, what post-processing technique could fix this?

Answer: _____

****158.**** When soldering, a 'cold solder joint' appears dull and grainy rather than shiny and smooth. Why is this a problem, and what causes it?

Answer: _____

****159.**** Which of these is a 'constraint' in an engineering design challenge?

Answer: _____

****160.**** A CNC (Computer Numerical Control) router removes material using a spinning cutting bit. What is the term for the width of material removed by the bit as it moves along a path?

Answer: _____

Match each question to its answer

****1.**** What is the 'map()' function used for in Arduino? → ____

****2.**** A laser cutter works by focusing a high-energy beam to cut or engrave materials. Which type of laser is most commonly found in maker space laser cutters used for wood and acrylic? → ____

****3.**** When working with mixed materials in a single project (wood, acrylic, metal, fabric), different adhesives are needed for different material combinations. Which adhesive type bonds the widest variety of materials? → ____

****4.**** What is a 'minimum viable prototype' (MVP)? → ____

****5.**** Which material property is MOST important when choosing material for a cooking pot handle? → ____

(A) It converts a number from one range to another – for example, converting a sensor value (0-1023) to a PWM value (0-255)

(B) Two-part epoxy, because it creates strong chemical bonds with most rigid materials including wood, metal, glass, and many plastics

(C) CO2 laser

(D) Low thermal conductivity (doesn't conduct heat well)

(E) The simplest possible version of a design that can test the core idea – built quickly with minimal resources

Riddle & Joke Break

Guess the answer, then check the key!

****161.**** Why did the 3D printer go to therapy?

****162.**** What did the circuit say to the battery?

****163.**** Why was the soldering iron always invited to parties?

****164.**** What did the LED say when it finally turned on?

****165.**** Why did the resistor break up with the capacitor?

****166.**** What do you call a 3D print that fails halfway through?

Answer Key

1. C – Define the problem
2. D – Repeating the design-build-test cycle to improve your project
3. C – You can only use \$10 worth of materials
4. A – A preliminary model built to test and evaluate a design
5. C – Flying debris or particles could damage your eyes
6. D – Analyze why it failed, redesign the weak point, and build an improved version
7. To quickly visualize and communicate ideas before building
8. A ruler or tape measure
9. Generating as many ideas as possible without judging them
10. To test the design quickly and cheaply before investing in expensive materials
- Matching (Introduction to Making and the Design Process): 1→D, 2→A, 3→C, 4→E, 5→B
11. D – Flexibility
12. B – Wood is a renewable natural resource, while most plastics are made from non-renewable petroleum
13. C – Plastic
14. C – How resistant the material is to being scratched or dented
15. B – Thin layers of wood glued together with alternating grain directions, making it stronger and less likely to warp than solid wood
16. A – Copper wire
17. They expand slightly and become easier to bend or shape
18. Thermoplastic
19. Thin wooden dowels for the frame and nylon fabric for the sail
20. A material made by combining two or more different materials to create something with better properties than either one alone
- Matching (Materials and Their Properties): 1→C, 2→B, 3→A, 4→E, 5→D
21. B – A power source, a conductive path (wire), and a load (like an LED or motor)
22. B – In series, components share one path and all stop working if one fails; in parallel, each component has its own path and works independently
23. A – It limits the amount of current flowing through the circuit
24. B – Light Emitting Diode
25. D – Holes in each row of the main area are connected horizontally; the power rails run vertically along the edges
26. A – Yes – the voltage divides equally across the three LEDs (3V each), matching their requirement
27. Ohms (Ω)
28. Voltage = Current $\times$ Resistance ($V = I \times R$)
29. 150 ohms
30. It stores electrical energy temporarily and can release it quickly

Matching (Basic Circuits and Electronics): 1→B, 2→A, 3→C, 4→D, 5→E

- 31. A – Fused Deposition Modeling
- 32. B – A file format that describes the surface of a 3D model using triangles, used to send designs to 3D printers
- 33. D – It converts a 3D model into layer-by-layer instructions (G-code) that the printer can follow
- 34. B – The internal structure inside a 3D print – usually a pattern like a grid or honeycomb rather than solid plastic
- 35. D – Because FDM printing builds layer by layer, so overhanging parts need temporary supports underneath or they'll sag and fail
- 36. C – The small gap added between parts that need to fit together, accounting for the printer's slight inaccuracy
- 37. Constructive Solid Geometry (CSG)
- 38. Warping
- 39. The thickness of each printed layer – smaller layers give smoother surfaces but take longer to print
- 40. Right-side up (open top facing up) so the walls are vertical and layers run horizontally around the sides

Matching (3D Design and Printing Fundamentals): 1→B, 2→C, 3→E, 4→D, 5→A

- 41. C – A small computer on a single chip that can be programmed to read sensors, make decisions, and control outputs like LEDs and motors
- 42. B – Digital signals have only two states (HIGH/LOW, on/off), while analog signals can have a continuous range of values
- 43. D – It runs once when the program starts, used to initialize pin modes and settings
- 44. D – Sets digital pin 13 to HIGH (5V), which would turn on an LED connected to that pin
- 45. A – HIGH (or 1)
- 46. C – Pulse Width Modulation – it rapidly switches a pin on and off to simulate an analog output (like dimming an LED)
- 47. About 50%
- 48. It keeps the input pin at a defined HIGH state when the button is not pressed, preventing unpredictable readings
- 49. Pauses the program for 1000 milliseconds (1 second)
- 50. Serial Monitor – it sends data from the Arduino to the computer over the USB cable

Matching (Arduino and Microcontrollers): 1→E, 2→B, 3→C, 4→D, 5→A

- 51. B – The simplest possible version of a design that can test the core idea – built quickly with minimal resources
- 52. A – Parallel prototyping – testing multiple designs simultaneously and combining the best elements
- 53. C – The designer knows how it's supposed to work, so they unconsciously compensate for flaws – a fresh user reveals real usability problems
- 54. D – How closely the prototype resembles the final product – from low-fidelity (rough sketch/cardboard) to high-fidelity (looks and works like the real thing)
- 55. B – Analyze why it's slow (panel size? sunlight angle? circuit efficiency?), then modify one variable at a time to identify and fix the bottleneck
- 56. B – A structured meeting where the designer presents their work to others for feedback, questions, and suggestions before proceeding

57. A table listing design criteria as rows and prototype versions as columns, with pass/fail or score for each test – showing which version performs best overall

58. Destructive testing breaks or damages the prototype to find its limits; non-destructive testing evaluates it without causing damage

59. Replace the wooden base with a lighter material (like foam board or thin plastic) since it's the biggest contributor to excess weight

60. Hand-drawn screens on paper that simulate the app's interface – users 'tap' paper buttons and the designer reveals the next screen

Matching (Prototyping and Iteration): 1→B, 2→C, 3→A, 4→D, 5→E

61. C – CO₂ laser

62. C – The line color and thickness settings in the design software that map to different power/speed profiles

63. A – Kerf

64. B – 9.8mm, because the laser removes 0.1mm from each side of the tab

65. D – Insert component, heat both the pad and lead with the iron, feed solder into the heated joint, remove solder then iron

66. C – Components are smaller, circuits can be more compact, and automated pick-and-place machines can assemble boards faster

67. The bit takes too large a bite per rotation, causing rough cuts, potential bit breakage, or the workpiece being pulled loose

68. So the formed plastic part can be lifted off the mold without getting stuck

69. 3D printing a mold, then vacuum forming all 20 from plastic sheet – fast replication once the mold is made

70. Add a small radius (fillet) to inside corners that matches or exceeds the bit diameter, or use dog-bone/T-bone relief cuts

Matching (Advanced Fabrication Techniques): 1→E, 2→A, 3→D, 4→C, 5→B

71. C – Laser-cut plywood frame and shelves for structure (\$15), clear acrylic front panel laser-cut to size (\$10), LED strip with Arduino dimming (\$15), 3D-printed mounting brackets (\$5), hardware (\$5)

72. C – A patent protects a novel invention or process, a trademark protects a brand name or logo, and a copyright protects creative works like artwork or code

73. D – Likely a poor choice – PLA is weaker in tension and shear than plywood, especially along layer lines where 3D prints tend to delaminate under load

74. A – Verify the relay module is receiving the correct signal voltage and that the Arduino output pin is actually going HIGH – use Serial.println() to confirm the condition is being triggered in code

75. C – Injection molding – high upfront mold cost but very low per-unit cost at 1,000+ units, producing consistent parts in seconds

76. D – Reducing the number of separate parts by combining functions – e.g., designing a snap-fit lid that also serves as a hinge, eliminating screws and a separate hinge

77. Insufficient current from the 9V battery – when the servo draws high current during movement, voltage drops below the Arduino's minimum, causing resets

78. Other makers can study, improve, adapt, and build upon the design, accelerating innovation and allowing community-driven improvements

79. Assign roles based on skills but ensure dependencies are identified – CAD design must complete before laser cutting can begin, while programming and documentation can proceed in parallel

80. The hole can be between 9.8mm and 10.2mm and still be acceptable – this ensures parts from different machines or batches will fit together reliably

Matching (Master Maker Capstone): 1→D, 2→E, 3→C, 4→A, 5→B

81. D – Computer Numerical Control

82. C – G-code

83. C – CO2 laser

84. B – Vector cutting follows lines and paths to cut through material, while raster engraving sweeps back and forth like a printer to etch surfaces

85. A – A properly functioning ventilation/exhaust system and laser-safe enclosure

86. A – SVG (Scalable Vector Graphics)

87. PVC releases toxic chlorine gas and hydrochloric acid when burned, which is dangerous to breathe and corrodes the machine

88. Cutting too deep in one pass puts excessive force on the bit, which can break the tool, burn the material, or cause the workpiece to shift

89. The laser beam has a small width (kerf) that removes material, so parts will be slightly smaller than designed if kerf is not accounted for

90. It uses a coordinate system with X, Y, and Z axes, moving the tool to precise numerical positions specified in the G-code program

Matching (Maker Space & DIY): 1→E, 2→C, 3→B, 4→D, 5→A

91. B – A thread made with or coated in metal fibers that can carry electrical current, used to sew circuits into fabric

92. A – A small, round, sewable microcontroller board designed specifically for wearable electronics and e-textile projects

93. B – LED (Light Emitting Diode)

94. A – Coin cell battery (CR2032)

95. A – Electronic textiles

96. C – The LED will not light up because current can only flow through it in one direction

97. Crossed conductive threads create an unintended electrical connection (short circuit) that can cause components to malfunction or drain the battery

98. Flexible boards bend and conform to the body's curves, making them more comfortable and durable when integrated into clothing that moves

99. Low voltage (3V) is safe for direct skin contact, sufficient for LEDs and small sensors, and the batteries are lightweight and compact

100. Two pieces of conductive fabric or thread are separated by a gap; pressing them together completes the circuit, just like pushing a button

Matching (Maker Space & DIY): 1→B, 2→D, 3→C, 4→A, 5→E

101. A – Transforming waste materials or unwanted products into new items of higher quality or value

102. B – Reduce, Reuse, Recycle

103. A – An economic model where products and materials are kept in use as long as possible through reuse, repair, refurbishment, and recycling, minimizing waste

104. D – Designing products to have a limited useful life so consumers must buy replacements

105. B – A community event where volunteers help people fix broken items like electronics, clothing, and appliances for free

106. C – About 21% (roughly one-fifth)

107. Designing to minimize waste prevents the energy, water, and emissions used in manufacturing the excess material in the first place

108. Maker spaces provide shared tools and equipment, reducing individual ownership needs, and their community environment encourages material sharing, knowledge exchange, and collaborative repair

109. Biodegradable materials may require specific composting conditions, could have higher production impacts, or might degrade too quickly for the project's intended lifespan

110. Products designed for easy disassembly allow components to be separated for repair, reuse, or recycling at end of life, rather than going to landfill as mixed waste

Matching (Maker Space & DIY): 1→E, 2→D, 3→B, 4→A, 5→C

111. B – A preliminary model or version of a product built to test and refine a design before final production

112. B – A legal document that grants an inventor the exclusive right to make, use, and sell their invention for a limited time (usually 20 years)

113. B – A method of raising money for a project by collecting small contributions from a large number of people, typically through online platforms

114. C – A community event where makers, inventors, and creators showcase their projects, share skills, and inspire others through hands-on demonstrations

115. C – A five-stage problem-solving approach: Empathize, Define, Ideate, Prototype, and Test

116. D – The simplest version of a product that includes just enough features to be usable by early customers and provide feedback for future development

117. Each iteration incorporates feedback and testing results to improve the design, catching problems early and progressively refining the product before expensive final production

118. Creators often underestimate the complexity and cost of transitioning from a prototype to mass production, encountering unexpected manufacturing, tooling, supply chain, and quality control challenges

119. It reveals whether people actually need and would pay for the product, identifies competitors, and helps shape features and pricing before investing significant time and money

120. IP protection (patents, trademarks, copyrights) gives inventors a temporary monopoly on their creations, allowing them to profit from their investment in research and development, which incentivizes further innovation

Matching (Maker Space & DIY): 1→E, 2→B, 3→D, 4→C, 5→A

121. D – Criteria describe what success looks like; constraints describe the limitations you must work within

122. A – Fiberglass contains tiny glass fibers that can irritate skin and cause itching

123. D – To quickly visualize and communicate ideas before building

124. A – A ruler or tape measure

125. A – Designing with the needs and preferences of the person who will use the product in mind

126. A – A list of all the parts, materials, and quantities needed to build a project

127. What happened during the test, measurements taken, and what worked or didn't work

128. A belief that you can learn to build and create things through curiosity, experimentation, and persistence

129. Tape or binder clips

130. So you can learn from your process and share your knowledge with others

Matching (Design Documentation): 1→E, 2→D, 3→A, 4→C, 5→B

131. B – Analyze why it failed, redesign the weak point, and build an improved version

132. B – A smaller or larger version of an object that keeps the same proportions as the original

133. D – Flying debris or particles could damage your eyes

134. A – Smoothing rough surfaces and removing small amounts of material by abrasion

135. C – Joining electronic components together using melted metal alloy (solder) to create permanent electrical connections

136. C – The direction of the wood fibers, which affects how the wood splits, bends, and accepts fasteners

137. Clear acetate sheets (transparency film)

138. In series, components share one path and all stop working if one fails; in parallel, each component has its own path and works independently

139. A servo motor can rotate to a specific angle and hold that position, while a regular DC motor just spins continuously

140. Live circuits can be damaged by accidental short circuits when adding or removing components

Matching (Design Documentation): 1→B, 2→D, 3→E, 4→C, 5→A

141. B – Define the problem

142. B – Thermoplastic

143. A – Balsa is much lighter than oak while still being strong enough for model construction

144. C – Current increases because resistance decreases (Ohm's Law: $I = V/R$)

145. D – Yes – the voltage divides equally across the three LEDs (3V each), matching their requirement

146. D – Likely a poor choice – PLA is weaker in tension and shear than plywood, especially along layer lines where 3D prints tend to delaminate under load

147. 9.8mm, because the laser removes 0.1mm from each side of the tab

148. Laser-cut plywood frame and shelves for structure (\$15), clear acrylic front panel laser-cut to size (\$10), LED strip with Arduino dimming (\$15), 3D-printed mounting brackets (\$5), hardware (\$5)

149. The thickness of each printed layer – smaller layers give smoother surfaces but take longer to print

150. Warping

Matching (Design Documentation): 1→D, 2→B, 3→A, 4→E, 5→C

151. B – Thermoplastic adhesive that melts when heated and hardens when cooled

152. C – Student A, because exploring multiple ideas increases the chance of finding a creative, effective solution

153. C – Thin layers of wood glued together with alternating grain directions, making it stronger and less likely to warp than solid wood

154. B – Plastic

155. D – Ohms (Ω)

156. A – Voltage = Current $\times$ Resistance ($V = I \times R$)

157. Carefully file or sand the affected surfaces to remove 0.5mm, then test mesh engagement – this is faster than reprinting all 20 gears

158. The joint was not heated enough or was moved during cooling, creating a weak connection that may fail intermittently

159. You can only use \$10 worth of materials

160. Kerf

Matching (Design Documentation): 1→A, 2→C, 3→B, 4→E, 5→D

161. It had too many layers of issues!

162. "You really give me a charge!"

163. It knew how to make great connections!

164. "I'm de-lighted!"

165. There was too much resistance in the relationship!

166. A half-baked idea!

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