Machineforge — Activity Book

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

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

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1. Simple Machines Basics

Circle the correct answer

1. What is the main purpose of a simple machine?
(A) To eliminate the need for any force at all (B) To make objects heavier so they stay in place (C) To make work easier by changing the direction or amount of force needed (D) To create new energy from nothing

2. How many types of simple machines are there?
(A) Four (B) Eight (C) Three (D) Six

3. A seesaw on a playground is an example of which simple machine?
(A) An inclined plane (B) A pulley (C) A wheel and axle (D) A lever

4. What is the fixed point around which a lever pivots called?
(A) The pivot beam (B) The axis (C) The fulcrum (D) The load point

5. A ramp used to load heavy boxes onto a truck is an example of which simple machine?
(A) A screw (B) An inclined plane (C) A lever (D) A wheel and axle

6. A doorknob is an example of which simple machine?
(A) A wheel and axle (B) A lever (C) A pulley (D) A wedge

Write the answer

7. What does a pulley use to lift or move a load?
Answer: _____

8. An axe blade is an example of which simple machine?
Answer: _____

9. A screw is actually a modified version of which other simple machine?
Answer: _____

10. Which simple machine would be MOST useful for raising a flag to the top of a tall flagpole?
Answer: _____

Match each question to its answer

1. What does 'mechanical advantage' mean? →
2. A bicycle uses which two simple machines working together? →
3. What is the tradeoff when a simple machine reduces the force needed to do work? →
4. A zipper on your jacket uses which simple machine principle? →
5. Why does a longer ramp require less force to push an object to the same height? →

(A) Wedge
(B) Wheel and axle, and lever
(C) The work is spread over a longer distance, so less force is needed at each point
(D) You must apply the force over a greater distance
(E) The number of times a machine multiplies the input force

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2. Forces and Motion Fundamentals

Circle the correct answer

11. What is a force?
(A) The speed at which an object travels (B) The amount of energy stored inside an object (C) The weight of an object measured in pounds (D) A push or pull that can change an object's motion, shape, or direction

12. According to Newton's First Law, what happens to an object at rest if no force acts on it?
(A) It gradually loses mass (B) It stays at rest (C) It vibrates in place (D) It slowly starts moving on its own

13. What is friction?
(A) A force that pulls all objects toward the center of the Earth (B) The speed increase when an object rolls downhill (C) A force that opposes the motion of objects sliding against each other (D) The energy created when two magnets attract each other

14. A book is sitting on a table and not moving. What can you say about the forces acting on it?
(A) The forces are balanced — gravity pulls it down and the table pushes it up equally (B) No forces are acting on the book at all (C) The book is creating its own force to stay in place (D) Only gravity is acting on the book

15. Newton's Second Law says that Force = Mass × Acceleration. If you push a shopping cart with the same force, which will accelerate faster?
(A) Both accelerate the same because the force is equal (B) A full cart (more mass) (C) An empty cart (less mass) (D) Neither accelerates because shopping carts have wheels

16. What is gravity?
(A) A force that only exists on Earth's surface (B) A type of energy stored in high places (C) A force that attracts objects with mass toward each other (D) The friction between the ground and your feet

Write the answer

17. Newton's Third Law states that for every action, there is an equal and opposite reaction. When you jump off a skateboard forward, what happens to the skateboard?
Answer: _____

18. Why do engineers add lubricants like oil or grease to machine parts?
Answer: _____

19. What is the unit used to measure force?
Answer: _____

20. A rocket launches into space by pushing hot gases downward out of its engines. What makes the rocket go up?
Answer: _____

Match each question to its answer

1. What is the difference between mass and weight? →
2. Why is it harder to stop a bowling ball than a tennis ball when both are rolling at the same speed? →
3. When you ride a bicycle on a flat road and stop pedaling, why do you eventually slow down and stop? →
4. What is air resistance (drag)? →
5. An engineer is designing a race car. To increase its top speed, should they make the car MORE or LESS streamlined? →

(A) A friction force caused by air molecules pushing against a moving object
(B) Friction between the tires and road plus air resistance slow you down
(C) More streamlined, to reduce air resistance
(D) Mass is the amount of matter in an object; weight is the force of gravity acting on that mass
(E) The bowling ball has more mass, so it has more inertia and requires more force to stop

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3. Gears, Pulleys, and Mechanical Advantage

Circle the correct answer

21. What happens when a small gear drives a larger gear?
(A) The larger gear turns slower but with more force (torque) (B) The larger gear turns faster with less force (C) The larger gear stops moving because it's too heavy (D) Both gears turn at the same speed

22. A gear with 20 teeth is meshed with a gear with 40 teeth. What is the gear ratio?
(A) 20:40 (which is just the tooth count, not a ratio) (B) 2:1 (the driven gear turns twice as fast) (C) 1:2 (the driven gear turns once for every two turns of the driver) (D) 1:1 (both gears turn at the same speed)

23. What is the mechanical advantage of a single fixed pulley?
(A) 0 — it provides no advantage at all (B) 1 — it doesn't multiply force, it only changes the direction (C) 3 — it triples the force (D) 2 — it doubles the force

24. A compound pulley system has 4 rope segments supporting the load. What is its mechanical advantage?
(A) 1 — pulleys can't multiply force (B) 2 — compound pulleys always double the force (C) 4 — you only need 1/4 of the load's weight as input force (D) 8 — it's always double the number of segments

25. In a gear train, what happens to the direction of rotation between two meshing gears?
(A) Each gear turns in the opposite direction from its neighbor (B) Gears don't rotate — they only slide against each other (C) The direction depends on the size of the gears (D) All gears in a train turn the same direction

26. What is an idler gear and what is its purpose?
(A) A gear that stores energy when the machine is idle (B) A gear placed between the driver and driven gear to reverse the direction of rotation without changing the gear ratio (C) A gear that doesn't move and acts as a spacer (D) A backup gear that activates if the main gear fails

Write the answer

27. A movable pulley is attached directly to the load. How does this differ from a fixed pulley?
Answer: _____

28. A bicycle's front chainring has 48 teeth and the rear sprocket has 16 teeth. What is the gear ratio and what does it mean?
Answer: _____

29. What is torque?
Answer: _____

30. A crane uses a compound pulley system with 6 supporting rope segments to lift a 600 N crate. Ignoring friction, how much force must the operator apply?
Answer: _____

Match each question to its answer

1. What type of gear is used when you need to transmit rotation between shafts at right angles? →
2. A worm gear system consists of a screw-like gear meshing with a regular gear. What is special about this system? →
3. Why is the mechanical advantage of a real pulley system always less than the theoretical value? →
4. A gear train has three gears: A (10 teeth) → B (30 teeth) → C (10 teeth). What is the overall gear ratio from A to C? →
5. A block-and-tackle pulley system has a mechanical advantage of 5. If you need to lift a 200 kg object (weighing 2000 N), how much rope must you pull to raise it 3 meters? →

(A) It provides very high gear reduction and is self-locking — the output can't drive the input backward
(B) 15 meters
(C) Bevel gears
(D) Friction in the pulley wheels and the weight of the rope reduce the actual advantage
(E) 1:1 — the intermediate gear B doesn't change the overall ratio

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4. Levers, Inclined Planes, and Wedges

Circle the correct answer

31. What defines a first-class lever?
(A) The load is between the fulcrum and the effort (B) The fulcrum is between the effort (input force) and the load (output force) (C) There is no fulcrum — just a beam and a force (D) The effort is between the fulcrum and the load

32. A wheelbarrow is an example of which class of lever?
(A) First-class lever — the fulcrum is in the middle (B) It's not a lever because it has a wheel (C) Second-class lever — the load is between the fulcrum (wheel) and the effort (handles) (D) Third-class lever — the effort is in the middle

33. Your forearm is an example of which class of lever?
(A) Third-class lever — the effort (bicep muscle) is between the fulcrum (elbow) and the load (hand/object) (B) First-class lever — the elbow is in the middle of the arm (C) It's not a lever because it's part of the body (D) Second-class lever — the load is between the elbow and the muscle

34. How do you calculate the mechanical advantage of a lever?
(A) Divide the distance from the fulcrum to the effort by the distance from the fulcrum to the load (B) Add the effort distance and load distance together (C) Multiply the effort force by the load force (D) Divide the weight of the load by the weight of the lever

35. How do you calculate the mechanical advantage of an inclined plane?
(A) Multiply the length by the angle of the slope (B) Subtract the height from the length (C) Divide the height by the length (D) Divide the length of the ramp by the height it rises

36. A crowbar is 1 meter long. The fulcrum is 10 cm (0.1 m) from the end under a heavy rock. What is the mechanical advantage?
(A) 0.1 (the load arm distance) (B) 1 (it's just one meter long) (C) 10 (total length divided by load arm) (D) 9 (effort arm of 0.9 m ÷ load arm of 0.1 m)

Write the answer

37. What is the mechanical advantage of a screw with a pitch of 2 mm and a head circumference of 20 mm?
Answer: _____

38. Why do wood screws have coarser (wider-spaced) threads than machine screws?
Answer: _____

39. A ramp is 12 meters long and rises 3 meters. A box weighing 600 N needs to be moved to the top. How much force is needed to push it up the ramp (ignoring friction)?
Answer: _____

40. Why are knife blades shaped like thin wedges rather than thick ones?
Answer: _____

Match each question to its answer

1. Which class of lever always multiplies force (has MA > 1)? →
2. A third-class lever has a mechanical advantage less than 1. Why would engineers still use it? →
3. A spiral staircase is an example of which two simple machines combined? →
4. A nutcracker uses which class of lever to crack nuts? →
5. What is the 'pitch' of a screw? →

(A) Second-class levers — the load is always closer to the fulcrum than the effort
(B) It multiplies speed and distance of movement — the load moves faster and farther than the effort
(C) The distance between adjacent threads — how far the screw advances in one complete turn
(D) An inclined plane and a screw (a ramp wrapped around a central axis)
(E) Second-class lever — the nut (load) is between the hinge (fulcrum) and the handles (effort)

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5. Energy Transfer and Conversion

Circle the correct answer

41. What is kinetic energy?
(A) The energy an object has because of its motion (B) The energy released when fuel is burned (C) The energy an object has due to its position above the ground (D) The energy stored in a compressed spring

42. A rock sitting on top of a cliff has energy even though it's not moving. What type of energy is this?
(A) Thermal energy (B) Gravitational potential energy (C) Chemical energy (D) Kinetic energy

43. What happens to the energy when a ball is dropped from a height and hits the ground?
(A) The energy is destroyed when the ball hits the ground (B) All the energy becomes light energy on impact (C) Gravitational potential energy converts to kinetic energy during the fall, then to sound and thermal energy on impact (D) The energy stays as potential energy throughout

44. What is the law of conservation of energy?
(A) Energy conservation means using less electricity at home (B) Energy always decreases over time until it reaches zero (C) Energy cannot be created or destroyed — it can only be converted from one form to another (D) Energy can only be created by burning fuel

45. What is 'efficiency' in the context of machines?
(A) The weight of the machine compared to its output (B) How fast a machine can complete a task (C) The ratio of useful output energy to total input energy, expressed as a percentage (D) The total amount of energy a machine can produce

46. A catapult uses elastic potential energy stored in its arm. At what point during a launch does the projectile have maximum kinetic energy?
(A) When the projectile first touches the catapult arm (B) At the moment of release, when all the elastic energy has been converted to motion (C) When the projectile lands on the ground (D) At the highest point of the projectile's flight

Write the answer

47. A motor converts 500 J of electrical energy into 350 J of mechanical energy. What is its efficiency?
Answer: _____

48. What is power in physics?
Answer: _____

49. A Rube Goldberg machine has many steps (ball rolls, lever tips, dominos fall, etc.). How does the energy change with each step?
Answer: _____

50. What type of energy is stored in a stretched rubber band?
Answer: _____

Match each question to its answer

1. A pendulum swings back and forth. Where does it have the most kinetic energy, and where does it have the most potential energy? →
2. Why is it impossible to build a perpetual motion machine? →
3. A worker pushes a box with 200 N of force across 5 meters in 10 seconds. What is their power output? →
4. A spring-powered toy car is wound up. Trace the energy conversions from winding to stopping. →
5. What is 'work' in physics, and how does it differ from everyday use of the word? →

(A) Your muscle energy → elastic PE in spring → kinetic energy (car moves) → thermal energy (friction) and sound energy
(B) 100 watts
(C) In physics, work = force × distance in the direction of the force. Holding a heavy box still does zero physics 'work' even though it feels tiring.
(D) Friction and air resistance always convert some energy to heat, so the machine loses usable energy over time
(E) Most KE at the bottom (fastest speed); most PE at the highest points of the swing (momentarily stopped)

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6. Structural Engineering and Materials

Circle the correct answer

51. What is compression in structural engineering?
(A) A twisting force that rotates a material (B) A pulling force that stretches a material (C) A sliding force that cuts through a material (D) A pushing force that squeezes or shortens a material

52. What is tension in structural engineering?
(A) The vibration frequency of a structural member (B) A pulling force that stretches or lengthens a material (C) A pushing force that squeezes a material (D) The emotional stress engineers feel during projects

53. Why are triangles the strongest shape in structural engineering?
(A) Triangles weigh less than other shapes (B) Triangles distribute weight equally to all three sides (C) Triangles are the simplest shape to manufacture (D) A triangle cannot be deformed without changing the length of its sides — it's inherently rigid

54. What is a truss?
(A) A cable system used to hang heavy objects (B) A solid beam of concrete used in foundations (C) A framework of connected triangles that distribute loads efficiently across a structure (D) A decorative pattern used on building facades

55. What is shear force?
(A) A force that acts parallel to a surface, trying to slide one part of a material past another (B) A force that pulls a material apart lengthwise (C) A force that pushes directly into a surface (D) A force that causes a material to spin

56. Why is reinforced concrete (concrete with steel rebar inside) used instead of plain concrete?
(A) Concrete is strong in compression but weak in tension — the steel rebar handles the tension forces (B) The rebar prevents the concrete from getting too hot (C) Plain

concrete is too expensive to use alone (D) The steel makes the concrete lighter

Write the answer

57. What is torsion?
Answer: _____

58. An arch bridge supports weight primarily through which type of force?
Answer: _____

59. What is the 'dead load' of a building?
Answer: _____

60. What is a 'load path' in a structure?
Answer: _____

Match each question to its answer

1. Why do I-beams (beams shaped like the letter 'I') resist bending much better than solid rectangular beams of the same weight? →
2. What is a 'factor of safety' in engineering design? →
3. Why do tall buildings sway in the wind instead of standing perfectly rigid? →
4. What is 'fatigue failure' in materials? →
5. A suspension bridge uses which two primary structural elements to support the roadway? →

(A) Cables in tension (supporting the deck) and towers in compression (supporting the cables)
(B) The ratio of a structure's maximum strength to its expected load — designing it stronger than the minimum needed
(C) Flexibility allows the building to absorb wind energy gradually — a perfectly rigid building would concentrate stress and crack
(D) A material breaking after many repeated stress cycles, even though each individual cycle is below the breaking strength
(E) The I-shape places most material in the top and bottom flanges where bending stresses are highest, with minimal material in the low-stress middle

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7. Vehicle Design and Propulsion Systems

Circle the correct answer

61. What are the four strokes of a four-stroke internal combustion engine, in order?
(A) Fuel, spark, bang, blow (B) Intake, compression, power (combustion), exhaust

(C) Ignition, explosion, cooling, ejection (D) Compression, intake, exhaust, power

62. What does a car's transmission do?
(A) It sends radio signals to the car's computer system (B) It transmits the signal from the key to start the engine (C) It converts electricity from the battery into engine power (D) It uses selectable gear ratios to match engine speed and torque to the wheels' needs for different driving conditions

63. What is aerodynamic drag, and how does it affect vehicle design?
(A) The friction between the tires and the road surface, making this the most widely accepted explanation (B) The weight of the air inside the vehicle cabin, and this principle applies across similar situations (C) The force of wind pushing a vehicle sideways, as this is what research and standard practice suggests (D) Air resistance that opposes a vehicle's motion, increasing with speed squared — it forces designers to create streamlined shapes

64. Why do race cars have spoilers (wings) on the back?
(A) Spoilers push the car down (downforce) at high speeds, increasing tire grip for better cornering and braking (B) Spoilers act like airplane wings to help the car fly briefly over bumps (C) Spoilers reduce the car's weight to make it faster (D) Spoilers are purely decorative and have no engineering function

65. What is the purpose of a car's suspension system?
(A) To absorb road impacts, maintain tire contact with the surface, and provide a comfortable ride (B) To prevent the car from rolling over during sharp turns (C) To connect the steering wheel to the front tires (D) To hold the engine in place inside the car body

66. How do disc brakes convert a moving car's energy to stop it?
(A) Brake pads squeeze a spinning disc (rotor), converting the car's kinetic energy into thermal energy through friction (B) Magnets repel the wheel hub to slow it down (C) The brakes reconnect the engine to absorb the motion (D) Compressed air pushes against the wheel to create drag

Write the answer

67. What advantage does an electric motor have over an internal combustion engine for vehicle propulsion?
Answer: _____

68. What is a 'crumple zone' in a car and why is it important for safety?
Answer: _____

69. A differential gear allows the left and right wheels on a car axle to do what?
Answer: _____

70. Why does a hybrid car (combining a gasoline engine with an electric motor) get better fuel economy than a pure gasoline car?
Answer: _____

Match each question to its answer

1. What is the 'coefficient of friction' and why is it critical for vehicle tire design? →
2. What is a turbocharger and how does it increase engine power? →
3. Anti-lock braking systems (ABS) work by rapidly releasing and reapplying brake pressure. Why is this more effective than locked wheels? →
4. A catapult can launch a 2 kg projectile at 20 m/s. How much kinetic energy does the projectile have at launch? →
5. What is the 'center of gravity' and why is it critical for vehicle stability? →

(A) 400 J (KE = ½mv² = ½ × 2 × 20² = ½ × 2 × 400 = 400 J)
(B) A number representing how much grip a surface provides — higher means more friction and better tire traction
(C) The point where the total weight of a vehicle effectively acts — a lower center of gravity resists tipping during turns
(D) It uses exhaust gases to spin a turbine that forces more air into the engine, allowing more fuel to be burned per cycle
(E) A rolling tire has more grip than a sliding tire — ABS keeps the tire just at the edge of locking to maintain maximum friction

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8. Master Engineer — Capstone

Circle the correct answer

71. A engineer needs to lift a 2,000 N engine block 1.5 meters off the ground. She has a pulley system with a mechanical advantage of 4. How much force must she apply?
(A) 2,000 N (B) 8,000 N (C) 500 N (D) 250 N

72. A bicycle uses gears, levers, wheels and axles, and sometimes pulleys. Which term best describes a bicycle?
(A) Compound machine (B) Mechanical linkage (C) Simple machine (D) Complex system

73. A crane lifts a 5,000 N steel beam 20 meters high in 50 seconds. What power does the crane's motor output?
(A) 100 watts (B) 5,000 watts (C) 250 watts (D) 2,000 watts

74. An engineer is designing a bridge to span a 30-meter river. She must choose between a beam bridge and an arch bridge. Which factor would most favor choosing an arch bridge?

(A) The bridge only needs to support pedestrian traffic (B) The bridge needs to be built as quickly as possible (C) The bridge must support very heavy loads without steel reinforcement (D) The riverbed cannot support any foundations in the water

75. A 1,200 kg car traveling at 20 m/s applies its brakes and stops in 10 seconds. What is the average braking force?

(A) 2,400 N (B) 24,000 N (C) 12,000 N (D) 1,200 N

76. A Rube Goldberg machine converts a marble's gravitational potential energy into kinetic energy, then into elastic potential energy in a spring, then back to kinetic energy to push a domino. At each conversion, some energy is lost to heat from friction. If the marble starts with 10 joules of energy and the machine is 60% efficient overall, how much energy reaches the domino?

(A) 4 joules (B) 16 joules (C) 10 joules (D) 6 joules

Write the answer

77. Why do engineers use triangular shapes extensively in truss bridges and tower structures?

Answer: _____

78. A gear with 60 teeth meshes with a gear with 15 teeth. If the larger gear rotates at 100 RPM, how fast does the smaller gear rotate?

Answer: _____

79. An engineer must choose between steel and aluminum for an aircraft wing spar. Steel is stronger but heavier. Aluminum is lighter but less strong. Which engineering concept helps her compare them fairly?

Answer: _____

80. A second-class lever has the fulcrum at one end, the effort at the other end, and the load in between. The lever is 2 meters long, and the load is placed 0.5 meters from the fulcrum. What is the mechanical advantage?

Answer: _____

Match each question to its answer

1. A factory robot arm needs to move heavy parts quickly. The engineer designs a hydraulic system with a small input piston (area = 2 cm^2) and a large output piston (area = 50 cm^2). If the input force is 100 N, what is the output force? →

2. During a roller coaster's first drop from 30 meters high, the car reaches its maximum

speed at the bottom. As it climbs the next hill (20 meters), it slows down. Which statement best explains the energy changes? →
3. A building's foundation transfers the weight of the entire structure to the ground. If a 10-story building weighing 50,000,000 N sits on a foundation with a ground contact area of 2,500 m², what is the pressure on the soil? →
4. A wind turbine converts kinetic energy of wind into electrical energy. If the wind carries 500,000 joules of kinetic energy past the turbine each second, and the turbine is 35% efficient, how much electrical power does it produce? →
5. A race car designer must balance two competing goals: minimizing aerodynamic drag (which slows the car) and maximizing downforce (which improves grip). Adding a larger rear wing increases both drag and downforce. How should the designer approach this tradeoff? →

(A) Optimize the wing angle and size so that the gained grip on corners outweighs the lost top speed on straights for the specific track layout
(B) 2,500 N
(C) 175,000 watts (175 kW)
(D) Gravitational PE converts to KE during the drop, then KE converts back to PE during the climb, with some energy lost to friction
(E) 20,000 Pa (pascals)

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9. Simple Machines & Engineering

Circle the correct answer

81. What is a compound machine?
(A) A machine powered by electricity (B) A machine that runs on compressed air (C) A device made of two or more simple machines working together (D) A single lever used to lift heavy loads

82. Which simple machines are combined in a pair of scissors?
(A) An inclined plane and a screw (B) A pulley and a wheel-and-axle (C) A lever and a pulley (D) Two levers and two wedges

83. What is a Rube Goldberg machine?
(A) A deliberately complex contraption that performs a simple task through chain reactions (B) A device that measures mechanical advantage (C) A machine that generates electricity from motion (D) A robot that assembles car parts

84. What term describes the number of simple machines combined in a compound machine?
(A) Machine factor, and this has been consistently demonstrated in practice (B) Mechanical ratio, as this directly follows from the underlying principles (C) Compound index, which is the most common explanation for this phenomenon (D) There is no specific term; we simply count the simple machines present

85. Name one simple machine found in a bicycle.
(A) Inclined plane (B) Wheel-and-axle (C) Wedge (D) Screw

86. What is the overall mechanical advantage of a compound machine?
(A) The sum of all individual mechanical advantages (B) The average of each machine's mechanical advantage (C) Always greater than 10 (D) The product of the mechanical advantages of each simple machine in it

Write the answer

87. Why do compound machines typically have lower efficiency than a single simple machine?
Answer: _____

88. How does a can opener demonstrate a compound machine?
Answer: _____

89. Explain how a chain reaction works in a Rube Goldberg machine.
Answer: _____

90. Why does increasing mechanical advantage in a compound machine require you to apply force over a greater distance?
Answer: _____

Match each question to its answer

1. What role does a fulcrum play when a lever is part of a compound machine? →
2. A compound machine consists of a lever with MA 4 and a pulley system with MA 3. What is the compound machine's total mechanical advantage? →
3. You need to design a Rube Goldberg machine that pops a balloon as the final step. Which simple machine would work best for the popping step? →
4. A compound machine has three stages: a lever (MA 2), a gear system (MA 5), and a pulley (MA 3). If the overall efficiency is 60%, how much useful output force do you get from 10 N of input? →
5. You are building a compound machine to raise a flag. You connect a wheel-and-axle (MA 2) to a pulley system (MA 4). If you apply 5 N of force, what is the maximum load the system can ideally lift? →

(A) 12
(B) 40 N
(C) A wedge, such as a pin or sharp point pushed into the balloon
(D) 180 N
(E) It acts as the pivot point that allows the lever to multiply force or change the direction of force

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10. Simple Machines & Engineering

Circle the correct answer

91. What type of fluid do hydraulic systems use to transmit force?
(A) Compressed air (B) Liquid, typically oil (C) Water vapor (D) Steam

92. What type of fluid do pneumatic systems use?
(A) Compressed air or gas (B) Mercury, which is consistent with standard programming practices (C) Water, which follows the established conventions of software development (D) Oil, based on the standard protocols used in modern computing systems

93. Who is Pascal's law named after?
(A) Galileo Galilei, making this the most widely accepted explanation (B) Blaise Pascal, a French mathematician and physicist (C) Archimedes, which is why this approach is recommended by experts (D) Isaac Newton, which is the most common explanation for this phenomenon

94. What does Pascal's law state?
(A) Liquids always flow downhill due to gravity (B) Force always moves from high pressure to low pressure only (C) Compressed air expands at a constant rate (D) Pressure applied to a confined fluid is transmitted equally in all directions throughout the fluid

95. What is the unit of pressure in the metric system?
(A) Pascal (Pa) (B) Joule (J) (C) Watt (W) (D) Newton (N)

96. Name one common example of a pneumatic tool.
(A) A hand-powered screwdriver (B) A jackhammer (C) A hydraulic car jack (D) An electric drill

Write the answer

97. Why can hydraulic systems multiply force while pneumatic systems generally cannot?
Answer: _____

98. Explain how a hydraulic car jack uses Pascal's law to lift a heavy vehicle.
Answer: _____

99. Why do pneumatic systems often include an air storage tank?
Answer: _____

100. How does the area of a piston affect the force output in a hydraulic system?
Answer: _____

Match each question to its answer

1. Why are pneumatic systems often preferred over hydraulic systems in food processing plants? →
2. A hydraulic system has an input piston with area 2 cm^2 and an output piston with area 20 cm^2. If you apply 10 N of force to the input piston, what force does the output piston exert? →
3. A pneumatic nail gun requires 90 psi of air pressure to fire a nail. The air compressor is set to 120 psi. Is this setup safe and functional? →
4. You need to design a hydraulic lift that raises a 5000 N platform. Your hand pump can exert 50 N. What must be the ratio of the output piston area to the input piston area? →
5. A hydraulic brake system applies 30 N to a master cylinder with area 3 cm^2. The brake caliper piston has area 15 cm^2. What force does the brake pad exert? →

(A) 100 N
(B) If a pneumatic system leaks, it releases clean air, while a hydraulic leak would contaminate food with oil
(C) 100:1
(D) 150 N
(E) Yes, the compressor provides more than enough pressure, and a regulator should be used to reduce it to the required 90 psi

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11. Simple Machines & Engineering

Circle the correct answer

101. What is a gear?
(A) A flat belt that connects two pulleys, making this the most widely accepted explanation (B) A straight bar used as a lever, and this has been consistently demonstrated in practice (C) A type of spring that stores energy, as this directly follows from the underlying principles (D) A rotating wheel with teeth that meshes with another toothed wheel to transmit force and motion

102. What is a gear ratio?
(A) The diameter of a gear in centimeters, and this is the standard approach used in most cases (B) The speed at which a gear rotates, which is why this approach is recommended by experts (C) The number of gears in a system, as this directly follows from the underlying principles (D) The ratio of the number of teeth on the driven gear to the number of teeth on the driving gear

103. What is a cam?
(A) A gear with missing teeth, as this directly follows from the underlying principles (B) A chain that connects two sprockets, making this the most widely accepted explanation (C) A type of spring mechanism, and this principle applies across similar situations (D) A rotating or sliding piece that converts rotary motion into linear (back-and-forth) motion

104. What is a linkage in mechanical engineering?
(A) A chain of gears connected in series (B) A system of rigid bars (links) connected by joints (pivots) that transmit motion and force (C) A computer program that controls robots (D) A type of welded joint that cannot move

105. What is a follower in a cam system?
(A) A gear attached to the cam shaft, as this directly follows from the underlying principles (B) Another name for the cam itself, and this principle applies across similar situations (C) The motor that drives the cam, as this directly follows from the underlying principles (D) The component that rides on the cam surface and moves up and down as the cam rotates

106. What type of gear has teeth cut at an angle to the axis of rotation?
(A) Spur gear (B) Helical gear (C) Bevel gear (D) Worm gear

Write the answer

107. Explain why meshing gears always rotate in opposite directions.
Answer: _____

108. How does a cam's profile shape determine the motion of the follower?
Answer: _____

109. Why does a smaller driving gear paired with a larger driven gear increase torque but decrease speed?
Answer: _____

110. What is the purpose of a four-bar linkage, and where might you see one?
Answer: _____

Match each question to its answer

1. Explain why worm gears can only transmit motion in one direction (from the worm to the wheel). →
2. A driving gear has 15 teeth and the driven gear has 45 teeth. If the driving gear rotates at 300 RPM, how fast does the driven gear rotate? →
3. You need a gear system where the output shaft turns in the same direction as the input shaft. What is the minimum number of gears needed? →
4. A bicycle has a front sprocket with 48 teeth and a rear sprocket with 16 teeth. If the rider pedals at 60 RPM, how fast does the rear wheel turn? →
5. An engineer designs a cam to open a valve 10 mm in a car engine. The cam has a base circle radius of 20 mm. What must the maximum radius of the cam be? →

(A) 180 RPM
(B) 100 RPM
(C) 30 mm
(D) The low helix angle of the worm creates so much friction that the wheel cannot back-drive the worm, making the system self-locking
(E) Three gears (driver, idler, and driven)

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12. Simple Machines & Engineering

Circle the correct answer

111. What is an actuator in a robot?
(A) A component that converts energy into physical movement, such as a motor or hydraulic cylinder (B) A computer chip that processes data, as this is what research and standard practice suggests (C) A battery that stores energy, as this directly follows from the underlying principles (D) A sensor that detects light, and this principle applies across similar situations

112. What is an end effector on a robotic arm?
(A) The power cable that connects to the wall, which is why this approach is recommended by experts (B) The tool or device attached to the end of the robot arm that interacts with objects, such as a gripper, welding torch, or suction cup (C) The

base that holds the robot to the floor, making this the most widely accepted explanation (D) The computer brain of the robot, and this has been consistently demonstrated in practice

113. How many degrees of freedom does a typical industrial robotic arm have?
(A) Six (B) Two (C) Three (D) Twelve

114. What is a servo motor?
(A) A motor that only spins at maximum speed (B) A motor with built-in feedback that can rotate to a precise angle and hold that position (C) A brake that stops robot movement (D) A generator that produces electricity

115. What does the term 'automation' mean in manufacturing?
(A) Making products entirely by hand, which is the most common explanation for this phenomenon (B) Using only one machine for all tasks, making this the most widely accepted explanation (C) Using machines, robots, and computer control systems to perform tasks with minimal human intervention (D) Hiring more workers to speed up production, as this directly follows from the underlying principles

116. What is a sensor in the context of robotics?
(A) A gear that changes speed, which is why this approach is recommended by experts (B) A battery that powers the robot, and this has been consistently demonstrated in practice (C) A motor that moves the robot, making this the most widely accepted explanation (D) A device that detects physical information from the environment, such as light, distance, temperature, or force, and converts it to an electrical signal

Write the answer

117. Explain why industrial robots often use multiple types of actuators in a single arm.
Answer: _____

118. How does a feedback loop help a robotic arm maintain accuracy?
Answer: _____

119. Why are pneumatic actuators often preferred for pick-and-place robots in packaging lines?
Answer: _____

120. Explain the difference between an open-loop and a closed-loop control system in robotics.
Answer: _____

Match each question to its answer

1. Why is the concept of degrees of freedom important when designing a robotic arm for a specific task? →
2. A robotic arm needs to pick up a delicate glass bottle without breaking it. Which type of end effector would you choose? →
3. You are programming a robotic arm to place bolts into holes. The holes are 0.5 mm wider than the bolts. What control approach should you use? →
4. A factory production line runs 24 hours a day. Which type of actuator would be most reliable for a robot that repetitively lifts 50 kg boxes onto pallets all day? →
5. A conveyor belt moves at 2 meters per second. A robot arm must pick up items from the belt and place them in boxes. How must the robot be programmed to account for the moving belt? →

(A) The robot must track the item's position in real time using a sensor and match its arm speed to the belt speed during the pick-up, grabbing the item while both are moving at the same velocity
(B) Closed-loop control with a force/torque sensor on the wrist to detect when the bolt contacts the hole edge and make fine adjustments
(C) An electric servo motor with a gear reducer, because electric motors have the longest service life for continuous high-cycle repetitive tasks
(D) A soft pneumatic gripper with compliant (flexible) fingers and force-limiting sensors
(E) The number of degrees of freedom determines what positions and orientations the end effector can reach — more DOF means more flexibility but also more complexity and cost

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13. forces

Circle the correct answer

121. What is the term for the object being moved or lifted by a simple machine?
(A) The advantage (B) The load (or resistance) (C) The fulcrum (D) The effort

122. You're designing a machine that uses a lever to lift a 1000 N load. Your effort arm is 4 meters and your load arm is 0.5 meters. Will the lever work if you can only push with 200 N? Explain your reasoning.
(A) No — the lever would break under the 1000 N load (B) Yes — MA is 8 (4÷0.5), so you only need 125 N (1000÷8), which is less than your 200 N capacity (C) Yes — but only because 200 is close enough to 1000 when divided by 5 (D) No — 200 N is never enough to lift 1000 N regardless of lever length

123. A construction worker needs to move a 2000 N crate up to a loading dock 1.5 meters high. They can push with at most 400 N. What is the minimum ramp length they need?
(A) 1.5 meters, which is the most common explanation for this phenomenon (B) 7.5 meters (they need MA of 5, so length = 5 × 1.5 m) (C) 5 meters (D) 3 meters

124. A doorknob is an example of which simple machine?
(A) A pulley (B) A wheel and axle (C) A lever (D) A wedge

125. A block-and-tackle pulley system has a mechanical advantage of 5. If you need to lift a 200 kg object (weighing 2000 N), how much rope must you pull to raise it 3 meters?
(A) 0.6 meters (B) 15 meters (C) 10 meters (D) 3 meters

126. If you need to split a log in half, which simple machine would be MOST helpful?
(A) A wedge (B) A pulley (C) A wheel and axle (D) A screw

Write the answer

127. A screw is actually a modified version of which other simple machine?
Answer: _____

128. What does 'mechanical advantage' mean?
Answer: _____

129. A pair of scissors uses which two simple machines?
Answer: _____

130. What is a force?
Answer: _____

Match each question to its answer

1. Newton's Third Law states that for every action, there is an equal and opposite reaction. When you jump off a skateboard forward, what happens to the skateboard? →
2. What is air resistance (drag)? →
3. What is gravity? →
4. What is a 'compound gear' arrangement and why is it useful? →
5. What is kinetic energy? →

(A) A force that attracts objects with mass toward each other
(B) The energy an object has because of its motion
(C) It rolls backward
(D) Two gears of different sizes fixed on the same shaft, allowing large overall gear

reductions in compact space
(E) A friction force caused by air molecules pushing against a moving object

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14. forces

Circle the correct answer

131. Why can't a simple machine produce more work output than the work input?
(A) Because simple machines only work with gravity, which limits their power (B) Because friction always makes machines produce more work than expected (C) Because simple machines are too small to amplify energy (D) Because of the law of conservation of energy — energy cannot be created or destroyed

132. A wheelbarrow is an example of which class of lever?
(A) First-class lever — the fulcrum is in the middle (B) Second-class lever — the load is between the fulcrum (wheel) and the effort (handles) (C) Third-class lever — the effort is in the middle (D) It's not a lever because it has a wheel

133. A boat ramp rises 1.5 meters over a horizontal distance of 9 meters. What force is needed to push a 900 N boat up the ramp (ignoring friction)?
(A) 100 N (B) 6 N (C) 150 N (D) 900 N

134. Which simple machine would be MOST useful for raising a flag to the top of a tall flagpole?
(A) A screw (B) A pulley (C) An inclined plane (D) A wedge

135. Why are knife blades shaped like thin wedges rather than thick ones?
(A) Thick wedges would be too heavy to hold (B) Thin shapes are traditional and people are used to them (C) A thinner wedge angle produces more splitting force from the same input force, making cutting easier (D) Thin blades use less metal, making them cheaper

136. How does a screw jack lift a car that weighs thousands of pounds using just a small handle?
(A) The jack creates new energy from the turning motion (B) The handle is connected to a hidden electric motor (C) The screw's fine threads give an enormous mechanical advantage — each full turn of the handle lifts the car only a tiny amount (D) The jack uses compressed air stored inside its body

Write the answer

137. What do we call a machine that is made up of two or more simple machines working together?
Answer: _____

138. If an object has a mass of 10 kg, what is its weight on Earth? (Use gravity = 10 m/s^2 for easy calculation)
Answer: _____

139. A car is driving at a constant speed on a straight road. Are the forces on it balanced or unbalanced?
Answer: _____

140. Why do parachutes work?
Answer: _____

Match each question to its answer

1. A worm gear system consists of a screw-like gear meshing with a regular gear. What is special about this system? →
2. A spring-powered toy car is wound up. Trace the energy conversions from winding to stopping. →
3. A machine takes in 1000 J of energy and produces 250 J of useful work. What is its efficiency, and where did the rest go? →
4. What is a joule? →
5. What is tension in structural engineering? →

(A) It provides very high gear reduction and is self-locking — the output can't drive the input backward
(B) The unit of energy — the energy needed to push with 1 newton through a distance of 1 meter
(C) 25% efficient; the other 750 J was lost to friction, heat, sound, and vibration
(D) A pulling force that stretches or lengthens a material
(E) Your muscle energy → elastic PE in spring → kinetic energy (car moves) → thermal energy (friction) and sound energy

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15. forces

Circle the correct answer

141. Which class of lever always multiplies force (has MA > 1)?
(A) Second-class levers — the load is always closer to the fulcrum than the effort (B) First-class levers — because the fulcrum is in the middle (C) Third-class levers — because the effort is in the middle (D) All three classes always multiply force equally

142. Ancient Egyptians built the pyramids partly by dragging massive stone blocks up long ramps. Why were the ramps so long?
(A) They needed long ramps to fit all the workers side by side (B) The stones could only be moved at a specific slow speed (C) Short ramps would collapse under the weight of the stones (D) Longer ramps have higher mechanical advantage, requiring less force to move the heavy stones upward

143. You're designing a winch to pull a boat out of the water. The boat weighs 3000 N and you want the operator to pull with no more than 500 N. What minimum mechanical advantage do you need, and how would you achieve it with pulleys?
(A) MA of 500, using a single movable pulley, and this has been consistently demonstrated in practice (B) MA of 3, using 3 fixed pulleys, and this principle applies across similar situations (C) MA of 6 (3000 ÷ 500 = 6), achieved with a compound pulley system having 6 supporting rope segments (D) MA of 3000, using one very large pulley, and this is the standard approach used in most cases

144. A bicycle uses which two simple machines working together?
(A) Screw and pulley (B) Pulley and screw (C) Wheel and axle, and lever (D) Wedge and inclined plane

145. A book is sitting on a table and not moving. What can you say about the forces acting on it?
(A) The forces are balanced — gravity pulls it down and the table pushes it up equally (B) Only gravity is acting on the book (C) The book is creating its own force to stay in place (D) No forces are acting on the book at all

146. Why is it harder to stop a bowling ball than a tennis ball when both are rolling at the same speed?
(A) Bowling balls are made of harder material that resists force (B) The tennis ball has more air resistance slowing it down (C) The bowling ball has more mass, so it has more inertia and requires more force to stop (D) The bowling ball is smoother and has less friction

Write the answer

147. An engineer is designing a race car. To increase its top speed, should they make the car MORE or LESS streamlined?
Answer: _____

148. What is torque?
Answer: _____

149. A motor converts 500 J of electrical energy into 350 J of mechanical energy. What is its efficiency?
Answer: _____

150. What is 'horsepower' and how does it relate to watts?
Answer: _____

Match each question to its answer

1. What is compression in structural engineering? →
2. Why is reinforced concrete (concrete with steel rebar inside) used instead of plain concrete? →
3. What is 'buckling' and when does it happen? →
4. Why does a hybrid car (combining a gasoline engine with an electric motor) get better fuel economy than a pure gasoline car? →
5. What does a car's transmission do? →

(A) A pushing force that squeezes or shortens a material
(B) It uses selectable gear ratios to match engine speed and torque to the wheels' needs for different driving conditions
(C) The electric motor handles low-speed driving and assists during acceleration; regenerative braking recovers energy that would otherwise be wasted as heat
(D) Concrete is strong in compression but weak in tension — the steel rebar handles the tension forces
(E) A sudden sideways failure of a slender column under compression — it bows out instead of simply crushing

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16. forces

Circle the correct answer

151. Which of these is NOT a simple machine?
(A) An inclined plane (B) A screw (C) A wedge (D) A spring

152. You need to design a way to move a heavy rock from the ground onto a 1-meter-high platform. You can either lift it straight up or push it up a 3-meter ramp. Which option requires less force, and why?
(A) Lifting straight up requires less force because it's a shorter distance (B) Both require the same force because the rock weighs the same either way (C) The ramp

requires less force because gravity is weaker on angled surfaces (D) The ramp requires less force because the work is spread over a longer distance (3 meters instead of 1 meter)

153. A compound pulley system has 4 rope segments supporting the load. What is its mechanical advantage?
(A) 1 — pulleys can't multiply force (B) 4 — you only need 1/4 of the load's weight as input force (C) 8 — it's always double the number of segments (D) 2 — compound pulleys always double the force

154. A jar lid is an example of which simple machine?
(A) A wheel and axle (B) A lever (C) A wedge (D) A screw

155. What is the normal force?
(A) The support force a surface exerts perpendicular to an object resting on it (B) The standard force of gravity on Earth (C) The expected friction between two surfaces (D) The average amount of force in a system

156. What is a rack and pinion gear system?
(A) A decorative gear arrangement used in clocks (B) Two round gears of different sizes meshed together (C) A system that only works in reverse, converting linear to rotational motion (D) A system that converts rotational motion into linear (straight-line) motion using a round gear and a flat toothed bar

Write the answer

157. What happens to the energy when a ball is dropped from a height and hits the ground?
Answer: _____

158. What is torsion?
Answer: _____

159. An arch bridge supports weight primarily through which type of force?
Answer: _____

160. Bamboo is one of the strongest natural building materials per unit weight. What structural feature gives it this strength?
Answer: _____

Match each question to its answer

1. A bicycle's front chainring has 48 teeth and the rear sprocket has 16 teeth. What is the gear ratio and what does it mean? →
2. What defines a first-class lever? →
3. According to Newton's First Law, what happens to an object at rest if no force acts on it? →
4. A nutcracker uses which class of lever to crack nuts? →
5. What is the 'coefficient of friction' and why is it critical for vehicle tire design? →

(A) It stays at rest
(B) 3:1 — the rear wheel turns 3 times for every 1 turn of the pedals, making it fast but requiring more effort
(C) Second-class lever — the nut (load) is between the hinge (fulcrum) and the handles (effort)
(D) A number representing how much grip a surface provides — higher means more friction and better tire traction
(E) The fulcrum is between the effort (input force) and the load (output force)

Riddle & Joke Break

Guess the answer, then check the key!

161. Why did the lever break up with the fulcrum?

162. I tried to tell a joke about a wedge, but it just split the audience.

163. Why are gears such good friends?

164. The pulley was feeling down, so its friend said, "Let me lift you up!"

165. Why did the screw get promoted?

166. The inclined plane never gets stressed -- it just takes things at an angle.

Answer Key

1. C — To make work easier by changing the direction or amount of force needed
2. D — Six
3. D — A lever
4. C — The fulcrum
5. B — An inclined plane

6. A — A wheel and axle
7. A rope or cable wrapped around a grooved wheel
8. A wedge
9. An inclined plane
10. A pulley
    Matching (Simple Machines Basics): 1→E, 2→B, 3→D, 4→A, 5→C
11. D — A push or pull that can change an object's motion, shape, or direction
12. B — It stays at rest
13. C — A force that opposes the motion of objects sliding against each other
14. A — The forces are balanced — gravity pulls it down and the table pushes it up equally
15. C — An empty cart (less mass)
16. C — A force that attracts objects with mass toward each other
17. It rolls backward
18. To reduce friction between moving parts, making the machine more efficient
19. Newton (N)
20. Newton's Third Law — the gases push down, so the rocket is pushed up with equal force
    Matching (Forces and Motion Fundamentals): 1→D, 2→E, 3→B, 4→A, 5→C
21. A — The larger gear turns slower but with more force (torque)
22. C — 1:2 (the driven gear turns once for every two turns of the driver)
23. B — 1 — it doesn't multiply force, it only changes the direction
24. C — 4 — you only need 1/4 of the load's weight as input force
25. A — Each gear turns in the opposite direction from its neighbor
26. B — A gear placed between the driver and driven gear to reverse the direction of rotation without changing the gear ratio
27. A movable pulley has a mechanical advantage of 2, requiring only half the force to lift the load
28. 3:1 — the rear wheel turns 3 times for every 1 turn of the pedals, making it fast

but requiring more effort

29. A rotational force that causes an object to turn around an axis
30. 100 N
    Matching (Gears, Pulleys, and Mechanical Advantage): 1→C, 2→A, 3→D, 4→E, 5→B
31. B — The fulcrum is between the effort (input force) and the load (output force)
32. C — Second-class lever — the load is between the fulcrum (wheel) and the effort (handles)
33. A — Third-class lever — the effort (bicep muscle) is between the fulcrum (elbow) and the load (hand/object)
34. A — Divide the distance from the fulcrum to the effort by the distance from the fulcrum to the load
35. D — Divide the length of the ramp by the height it rises
36. D — 9 (effort arm of 0.9 m ÷ load arm of 0.1 m)
37. 10 (circumference ÷ pitch = 20 ÷ 2)
38. Coarser threads cut into soft wood more easily and pull pieces together faster with fewer turns
39. 150 N
40. A thinner wedge angle produces more splitting force from the same input force, making cutting easier
    Matching (Levers, Inclined Planes, and Wedges): 1→A, 2→B, 3→D, 4→E, 5→C
41. A — The energy an object has because of its motion
42. B — Gravitational potential energy
43. C — Gravitational potential energy converts to kinetic energy during the fall, then to sound and thermal energy on impact
44. C — Energy cannot be created or destroyed — it can only be converted from one form to another
45. C — The ratio of useful output energy to total input energy, expressed as a percentage
46. B — At the moment of release, when all the elastic energy has been converted to motion
47. 70%

48. The rate at which work is done or energy is transferred, measured in watts
49. Energy converts between forms at each step, but total usable energy decreases as friction wastes some as heat at every transfer
50. Elastic potential energy
    Matching (Energy Transfer and Conversion): 1→E, 2→D, 3→B, 4→A, 5→C
51. D — A pushing force that squeezes or shortens a material
52. B — A pulling force that stretches or lengthens a material
53. D — A triangle cannot be deformed without changing the length of its sides — it's inherently rigid
54. C — A framework of connected triangles that distribute loads efficiently across a structure
55. A — A force that acts parallel to a surface, trying to slide one part of a material past another
56. A — Concrete is strong in compression but weak in tension — the steel rebar handles the tension forces
57. A twisting force that rotates a material around its axis
58. Compression — the arch shape directs the load forces downward and outward through the curved structure
59. The permanent weight of the building itself — walls, floors, roof, and fixed equipment
60. The route that forces travel through a structure from the point of application to the ground/foundation
    Matching (Structural Engineering and Materials): 1→E, 2→B, 3→C, 4→D, 5→A
61. B — Intake, compression, power (combustion), exhaust
62. D — It uses selectable gear ratios to match engine speed and torque to the wheels' needs for different driving conditions
63. D — Air resistance that opposes a vehicle's motion, increasing with speed squared — it forces designers to create streamlined shapes
64. A — Spoilers push the car down (downforce) at high speeds, increasing tire grip for better cornering and braking
65. A — To absorb road impacts, maintain tire contact with the surface, and provide a comfortable ride

66. A — Brake pads squeeze a spinning disc (rotor), converting the car's kinetic energy into thermal energy through friction
67. Electric motors are about 90-95% efficient, deliver instant maximum torque, and have far fewer moving parts
68. A zone designed to deform during a crash, absorbing impact energy over a longer time to reduce forces on passengers
69. Rotate at different speeds during turns, since the outer wheel must travel farther than the inner wheel
70. The electric motor handles low-speed driving and assists during acceleration; regenerative braking recovers energy that would otherwise be wasted as heat
    Matching (Vehicle Design and Propulsion Systems): 1→B, 2→D, 3→E, 4→A, 5→C
71. C — 500 N
72. A — Compound machine
73. D — 2,000 watts
74. C — The bridge must support very heavy loads without steel reinforcement
75. A — 2,400 N
76. D — 6 joules
77. Triangles are the only polygon that cannot be deformed without changing the length of a side
78. 400 RPM
79. Strength-to-weight ratio
80. 4
    Matching (Master Engineer — Capstone): 1→B, 2→D, 3→E, 4→C, 5→A
81. C — A device made of two or more simple machines working together
82. D — Two levers and two wedges
83. A — A deliberately complex contraption that performs a simple task through chain reactions
84. D — There is no specific term; we simply count the simple machines present
85. B — Wheel-and-axle
86. D — The product of the mechanical advantages of each simple machine in it

87. Each additional machine introduces friction, so energy losses accumulate
88. It combines a lever (handle), a wedge (cutting blade), and a wheel-and-axle (turning knob)
89. Each step triggers the next step through transfer of energy, creating a sequence of cause-and-effect events
90. Energy is conserved, so gaining force advantage means the input must travel farther
    Matching (Simple Machines & Engineering): 1→E, 2→A, 3→C, 4→D, 5→B
91. B — Liquid, typically oil
92. A — Compressed air or gas
93. B — Blaise Pascal, a French mathematician and physicist
94. D — Pressure applied to a confined fluid is transmitted equally in all directions throughout the fluid
95. A — Pascal (Pa)
96. B — A jackhammer
97. Liquids are incompressible so pressure transfers completely, while gases compress and absorb some energy
98. A small force on a small piston creates pressure that acts on a much larger piston, multiplying the force proportionally to the area difference
99. To store compressed air at high pressure so tools receive a steady supply of pressurized air even during peak demand
100. A larger piston area produces greater output force for the same pressure, because Force equals Pressure times Area
     Matching (Simple Machines & Engineering): 1→B, 2→A, 3→E, 4→C, 5→D
101. D — A rotating wheel with teeth that meshes with another toothed wheel to transmit force and motion
102. D — The ratio of the number of teeth on the driven gear to the number of teeth on the driving gear
103. D — A rotating or sliding piece that converts rotary motion into linear (back-and-forth) motion
104. B — A system of rigid bars (links) connected by joints (pivots) that transmit motion and force

105. D — The component that rides on the cam surface and moves up and down as the cam rotates
106. B — Helical gear
107. When one gear's teeth push against the other gear's teeth, the force pushes the second gear in the opposite rotational direction
108. The distance from the cam's center to its edge at each angle determines how far the follower moves — a circular cam produces no motion, while an eccentric or lobed shape creates rise and fall
109. The larger gear has more teeth, so the small gear must rotate multiple times for one revolution of the large gear, trading speed for rotational force
110. It converts one type of motion to another using four connected bars, and it is found in mechanisms like windshield wipers, sewing machines, and door closers Matching (Simple Machines & Engineering): 1→D, 2→B, 3→E, 4→A, 5→C
111. A — A component that converts energy into physical movement, such as a motor or hydraulic cylinder
112. B — The tool or device attached to the end of the robot arm that interacts with objects, such as a gripper, welding torch, or suction cup
113. A — Six
114. B — A motor with built-in feedback that can rotate to a precise angle and hold that position
115. C — Using machines, robots, and computer control systems to perform tasks with minimal human intervention
116. D — A device that detects physical information from the environment, such as light, distance, temperature, or force, and converts it to an electrical signal
117. Different joints may need different motion characteristics — large base joints need high torque for heavy lifting, while wrist joints need fast, precise movement, so each joint gets the actuator best suited to its role
118. Sensors continuously measure the arm's actual position and compare it to the desired position. If there is an error, the controller adjusts the motors to correct it
119. They provide fast, snappy open/close motions ideal for gripping and releasing packages, and compressed air is clean and inexpensive for repetitive binary motions

120. An open-loop system sends commands without checking results (like a toaster timer), while a closed-loop system uses sensor feedback to continuously verify and correct its actions (like a thermostat)
Matching (Simple Machines & Engineering): 1→E, 2→D, 3→B, 4→C, 5→A
121. B — The load (or resistance)
122. B — Yes — MA is 8 (4÷0.5), so you only need 125 N (1000÷8), which is less than your 200 N capacity
123. B — 7.5 meters (they need MA of 5, so length = 5 × 1.5 m)
124. B — A wheel and axle
125. B — 15 meters
126. A — A wedge
127. An inclined plane
128. The number of times a machine multiplies the input force
129. A lever and a wedge
130. A push or pull that can change an object's motion, shape, or direction
Matching (forces): 1→C, 2→E, 3→A, 4→D, 5→B
131. D — Because of the law of conservation of energy — energy cannot be created or destroyed
132. B — Second-class lever — the load is between the fulcrum (wheel) and the effort (handles)
133. C — 150 N
134. B — A pulley
135. C — A thinner wedge angle produces more splitting force from the same input force, making cutting easier
136. C — The screw's fine threads give an enormous mechanical advantage — each full turn of the handle lifts the car only a tiny amount
137. A compound machine
138. 100 newtons
139. Balanced — the engine's forward force equals the friction and air resistance pushing backward

140. Their large surface area creates a lot of air resistance, slowing the fall
Matching (forces): 1→A, 2→E, 3→C, 4→B, 5→D
141. A — Second-class levers — the load is always closer to the fulcrum than the effort
142. D — Longer ramps have higher mechanical advantage, requiring less force to move the heavy stones upward
143. C — MA of 6 (3000 ÷ 500 = 6), achieved with a compound pulley system having 6 supporting rope segments
144. C — Wheel and axle, and lever
145. A — The forces are balanced — gravity pulls it down and the table pushes it up equally
146. C — The bowling ball has more mass, so it has more inertia and requires more force to stop
147. More streamlined, to reduce air resistance
148. A rotational force that causes an object to turn around an axis
149. 70%
150. A unit of power equal to about 746 watts, originally defined as the power a horse could sustain
Matching (forces): 1→A, 2→D, 3→E, 4→C, 5→B
151. D — A spring
152. D — The ramp requires less force because the work is spread over a longer distance (3 meters instead of 1 meter)
153. B — 4 — you only need 1/4 of the load's weight as input force
154. D — A screw
155. A — The support force a surface exerts perpendicular to an object resting on it
156. D — A system that converts rotational motion into linear (straight-line) motion using a round gear and a flat toothed bar
157. Gravitational potential energy converts to kinetic energy during the fall, then to sound and thermal energy on impact
158. A twisting force that rotates a material around its axis
159. Compression — the arch shape directs the load forces downward and outward

through the curved structure

160. Its hollow tubular cross-section and node-reinforced segments — similar to an engineered hollow tube
Matching (forces): 1→B, 2→E, 3→A, 4→C, 5→D
161. It needed more support!
162. I tried to tell a joke about a wedge, but it just split the audience.
163. They always mesh well together!
164. The pulley was feeling down, so its friend said, "Let me lift you up!"
165. Because it was always turning things around!
166. The inclined plane never gets stressed -- it just takes things at an angle.
