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length of six identical table-tennis balls placed between two wooden
blocks. What is the diameter of one ball?",
      "options": {
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      "key_concepts": "Direct measurement using a ruler, understanding that identical spheres in contact have their centers separated by one diameter, basic division",
      "common_mistakes": "Students might incorrectly use the wooden block measurements (38 to 65 cm) instead of the ball measurements, or might confuse radius with diameter"
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      "Step 2: Calculate total length:  $62 - 32 = 30$  cm",
      "Step 3: Divide by number of balls:  $30 \text{ cm} \div 6 \text{ balls} = 5$  cm per ball",
      "Step 4: Since balls are touching, this length represents the diameter of one ball"
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        "B": "1 and 4",
        "C": "2 and 3",
        "D": "3 and 4"
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    "difficulty": "medium",
    "correct_answer": "B",
    "explanation": "The horizontal line graph shows a constant
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at constant distance (statement 1) or a moving train at constant
speed (statement 4).",
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    "confidence": 0.9,
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indicating y remains constant over time ( $dy/dt = 0$ ). Let's analyze
each statement: Statement 1 – If the train is stationary and y
represents distance from last station, then distance remains
constant ( $\backslash u2713$ ). Statement 2 – If the train is moving and y
represents distance from last station, the distance would change
over time, creating a sloped line, not horizontal ( $\backslash u2717$ ).
Statement 3 – If the train is stationary, its speed is zero, so y
would be zero constantly, which could match the graph if the
horizontal line is at  $y=0$  ( $\backslash u2713$ ). Statement 4 – If the train is
moving at constant speed, y remains constant over time, matching the
horizontal line ( $\backslash u2713$ ). However, looking more carefully at the
graph, the horizontal line appears to be above zero. If y
represented speed and the train were stationary, y should be zero.
Since the line is above zero, statement 3 is less likely. Therefore,
statements 1 and 4 are the most consistent with the graph.",
        "key_concepts": "Graph interpretation, kinematics, constant
quantities, position vs time, velocity vs time",
        "common_mistakes": "Students often confuse position-time and
velocity-time graphs. They may not realize that a horizontal line on
a graph means the quantity is constant, or they may not consider
what physical situation would produce such a graph."
    },
    "calculation_steps": [
        "Step 1: Identify that the graph shows y is constant over
time (horizontal line)",
        "Step 2: Analyze each statement for consistency with
constant y",

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"Step 3: Statement 1: Stationary train, constant distance  
 \u2192 y constant \u2713",  
 "Step 4: Statement 2: Moving train, changing distance \u2192  
 y not constant \u2717",  
 "Step 5: Statement 3: Stationary train, speed = 0 \u2192  
 only if horizontal line at y=0",  
 "Step 6: Statement 4: Moving train, constant speed \u2192 y  
 constant \u2713",  
 "Step 7: Since horizontal line appears above zero,  
 statements 1 and 4 are most valid"

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  Mars has a mass of 200 kg. The acceleration of free fall on Mars is  

  3.7 m/s\u00b2. What is the weight of the vehicle on Mars?",
  "options": {
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  "difficulty": "easy",
  "correct_answer": "C",
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  "confidence": 0.9,
  "has_images": true,
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  "detailed_explanation": {
    "reasoning": "Weight is the gravitational force acting on an  

    object and is calculated using  $W = mg$ , where m is mass and g is
  
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gravitational acceleration. On Mars, the gravitational acceleration is different from Earth's ( $9.8 \text{ m/s}^2$ ), being only  $3.7 \text{ m/s}^2$ . The mass of the vehicle remains constant at  $200 \text{ kg}$  regardless of location, but its weight changes depending on the gravitational field strength of the celestial body.",

"key\_concepts": "Weight vs mass distinction, gravitational force, Newton's second law ( $F = ma$ ), planetary gravity variations",

"common\_mistakes": "Confusing mass with weight, using Earth's gravity ( $9.8 \text{ m/s}^2$ ) instead of Mars' gravity ( $3.7 \text{ m/s}^2$ ), or forgetting to multiply mass by gravitational acceleration"

},  
"calculation\_steps": [  
"Step 1: Identify given values - mass ( $m$ ) =  $200 \text{ kg}$ , Mars gravity ( $g$ ) =  $3.7 \text{ m/s}^2$ ",  
"Step 2: Apply weight formula -  $W = mg$ ",  
"Step 3: Calculate result -  $W = 200 \text{ kg} \times 3.7 \text{ m/s}^2$   
=  $740 \text{ N}$ "

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"B": "Mass is a scientific word that means the same as weight.",  
"C": "Mass is measured in newtons.",  
"D": "The mass of an astronaut is the same on the Moon as on the Earth."

},  
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"marks":  $1$ ,  
"subject": "physics",  
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"correct\_answer": "D",  
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  "key_concepts": "Mass vs weight distinction, gravitational force, intrinsic vs extrinsic properties, units of measurement",
  "common_mistakes": "Students often confuse mass and weight, thinking they're the same thing, or believing that mass changes with location like weight does"
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},
"calculation_steps": [
  "Step 1: No calculations needed – this is a conceptual question",
  "Step 2: Apply understanding that mass = amount of matter (constant)",
  "Step 3: Weight = mg, so weight varies with gravity, but mass stays constant"
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"options": {
  "A": "increase in reading after immersion of the solid"
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(measuring cylinder) and mass (balance)",
  "B": "increase in reading after immersion of the solid
(measuring cylinder) and weight (balance)",
  "C": "reading after immersion of the solid (measuring
cylinder) and mass (balance)",
  "D": "reading after immersion of the solid (measuring
cylinder) and weight (balance)"
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"subject": "physics",
"difficulty": "medium",
"correct_answer": "A",
"explanation": "To calculate density, we need the volume of
the solid (increase in liquid level when immersed) and its mass
(measured by the balance).",
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"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "To determine density using the formula density
= mass/volume, we need: 1) The mass of the solid from the balance 2)
The volume of the solid, which is found by measuring how much the
liquid level rises when the solid is immersed (displacement method).
The increase in reading gives the volume of the solid, while the
balance measures mass (not weight). The absolute reading after
immersion would include the original liquid volume plus the solid's
volume, which is not what we want.",
  "key_concepts": "Density calculation, displacement method
for volume measurement, difference between mass and weight,
measuring cylinder volume readings",
  "common_mistakes": "Students often confuse mass with weight,
or use the total reading instead of the increase in reading when
finding volume by displacement"
},
"calculation_steps": [
  "Step 1: Measure mass of solid using balance",
  "Step 2: Record initial liquid level in measuring cylinder",
  "Step 3: Immerse solid and record new liquid level",
  "Step 4: Calculate volume = increase in reading = new level
- initial level",
  "Step 5: Calculate density = mass/volume"
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"needs_review": false,
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centre. The rod is not attached to the pivot. Forces are then
applied to the rod in four different ways, as shown. The weight of
the rod can be ignored. Which diagram shows the rod in
equilibrium?",
  "options": {
    "A": "Rod with 100N downward forces at both ends, pivot at
center",
    "B": "Rod with 100N upward forces at both ends, pivot at
center",
    "C": "Rod with 100N upward force at left end and 100N
downward force at right end, pivot at center",
    "D": "Rod with 100N upward force at left end and 100N
downward forces at center and right end, pivot at center"
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  "difficulty": "medium",
  "correct_answer": "A",
  "explanation": "Option A shows equilibrium because the equal
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the pivot, resulting in zero net torque and zero net force.",
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  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "For a rod to be in equilibrium, two conditions
must be met: (1) The sum of all forces must be zero, and (2) The sum
of all torques about any point must be zero. Let's analyze each
option: \n\nOption A: Two 100N downward forces at equal distances
from the center create torques of equal magnitude but opposite
direction (one clockwise, one counterclockwise), so net torque = 0.
The net downward force is 200N, but this is balanced by an upward
reaction force from the pivot.\n\nOption B: Two 100N upward forces
would lift the rod off the pivot, so this cannot represent
equilibrium on the pivot.\n\nOption C: The 100N upward force on the
left creates a counterclockwise torque, while the 100N downward
force on the right creates a clockwise torque. These are equal and
opposite, so net torque = 0. However, the net upward force (100N up
- 100N down = 0) means no normal force from pivot, but the rod would

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tend to slide horizontally.\n\nOption D: The forces don't balance properly and create unequal torques about the center.",

"key\_concepts": "Rotational equilibrium, torque, moment arms, pivot forces, static equilibrium conditions",

"common\_mistakes": "Students often forget that the pivot can provide a reaction force, or they don't properly consider both force equilibrium and torque equilibrium simultaneously. Another mistake is not recognizing that equal and opposite forces at equal distances from a pivot create zero net torque."

},

"calculation\_steps": [  
"Step 1: For each option, identify all forces and their distances from the pivot",  
"Step 2: Calculate torque for each force ( $\tau = F \cdot d$  with direction)",

"Step 3: Check if sum of torques = 0 and if force equilibrium is possible with pivot reaction",

"Step 4: Option A: Left torque =  $100\text{N} \cdot d$  (clockwise), Right torque =  $100\text{N} \cdot d$  (counterclockwise), Net torque = 0"

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"options": {

"A": " $Y \cdot (a + b)$ ",

"B": " $Y/(a + b)$ ",

"C": " $Y \cdot b$ ",

"D": " $Y/b$ "

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"image\_filename": "question\_07\_enhanced.png",

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"marks": 1,

"subject": "physics",

"difficulty": "easy",

"correct\_answer": "C",

"explanation": "The moment of force Y about the pivot is force

Y multiplied by its perpendicular distance from the pivot, which is distance b.",

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      "key_concepts": "Moment of a force (torque), lever arms, rotational equilibrium, perpendicular distance principle",
      "common_mistakes": "Students often confuse which distance to use - they might incorrectly use (a + b) thinking it's the total length, or use ratios like Y/(a+b) or Y/b, which would give incorrect units and values for moment calculations."
    },
    "calculation_steps": [
      "Step 1: Identify the pivot point (marked with triangle symbol)",
      "Step 2: Measure the perpendicular distance from force Y to the pivot = b",
      "Step 3: Apply moment formula: Moment = Force  $\times$  distance = Y  $\times$  b"
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    "options": {

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"A": "least energy in gravitational potential store of the mass: mass moving down, most energy in the elastic store of the spring: mass moving up",

"B": "least energy in gravitational potential store of the mass: mass moving down, most energy in the elastic store of the spring: lowest point",

"C": "least energy in gravitational potential store of the mass: lowest point, most energy in the elastic store of the spring: mass moving up",

"D": "least energy in gravitational potential store of the mass: lowest point, most energy in the elastic store of the spring: lowest point"

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"image\_filename": "question\_08\_enhanced.png",

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"marks": 1,

"subject": "physics",

"difficulty": "medium",

"correct\_answer": "D",

"explanation": "The mass has least gravitational potential energy at the lowest point (minimum height), and the spring has maximum elastic potential energy at the lowest point (maximum compression).",

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"confidence": 0.9,

"has\_images": true,

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"reasoning": "For gravitational potential energy:  $PE_{\text{grav}} = mgh$ , where  $h$  is height above a reference point. This is minimum when the mass is at its lowest position. For elastic potential energy:  $PE_{\text{elastic}} = \frac{1}{2}kx^2$ , where  $x$  is the displacement from natural length. In this oscillating system, the spring is most compressed (maximum  $x$ ) when the mass is at the lowest point, giving maximum elastic potential energy at this position.",

"key\_concepts": "Gravitational potential energy depends on height above reference level. Elastic potential energy depends on square of displacement from natural length. Energy conservation in simple harmonic motion – when gravitational PE is minimum, elastic PE is maximum.",

"common\_mistakes": "Students often confuse the positions where different energy types are maximum/minimum. They might think maximum compression occurs somewhere other than the lowest point, or forget that gravitational PE is simply determined by vertical height."

},

"calculation\_steps": [

"Step 1: Identify that gravitational  $PE = mgh$ , minimum when  $h$  is minimum (lowest point)",

"Step 2: Identify that elastic  $PE = \frac{1}{2}kx^2$ , maximum when compression  $x$  is maximum",

"Step 3: Recognize that maximum compression occurs at the lowest point of oscillation",

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    "Step 4: Apply energy conservation – total energy is
    constant, so when gravitational PE is minimum, other energies
    (elastic + kinetic) must sum to compensate"
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resources. Some of these resources are listed. \u2022 chemical
energy stored in biofuels \u2022 chemical energy stored in fossil
fuels \u2022 energy stored in tides \u2022 geothermal resources
\u2022 hydroelectric resources \u2022 light from the Sun \u2022
nuclear fuel. How many of the resources listed are classified as
renewable?",
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energy, geothermal energy, hydroelectric energy, and solar energy.
Fossil fuels and nuclear fuel are non-renewable.",
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  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "To determine renewable resources, I need to
identify which energy sources can be naturally replenished on human
timescales. Going through each resource: 1) Biofuels – renewable
(plants can be regrown), 2) Fossil fuels – non-renewable (take

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millions of years to form), 3) Tidal energy – renewable (tides are continuous due to gravitational forces), 4) Geothermal – renewable (Earth's heat is continuously generated), 5) Hydroelectric – renewable (water cycle continuously replenishes water sources), 6) Solar energy – renewable (Sun provides continuous energy for billions of years), 7) Nuclear fuel – non-renewable (uranium is finite and not replenished on human timescales). This gives us 5 renewable resources.",

"key\_concepts": "Renewable vs non-renewable energy resources, sustainability, natural replenishment cycles, energy classification",

"common\_mistakes": "Students often confuse nuclear energy as renewable because it's clean, or think geothermal isn't renewable because it uses Earth's finite heat. Some may also incorrectly classify biofuels as non-renewable because they involve burning."

},

"calculation\_steps": [

"Step 1: List all resources and classify each as renewable or non-renewable",

"Step 2: Renewable: biofuels (1), tidal energy (2), geothermal (3), hydroelectric (4), solar (5)",

"Step 3: Non-renewable: fossil fuels, nuclear fuel",

"Step 4: Count renewable resources = 5"

],

"topic": "Energy Resources and Sustainability",

"confidence\_score": 0.98,

"solved\_by\_ai": true,

"needs\_review": false,

"flag\_reason": "",

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"model\_used": "claude-sonnet-4-20250514"

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{

"id": "physics\_q10",

"question\_number": 10,

"question\_text": "A microwave oven is rated at 900 watts.

Which statement correctly describes the meaning of this value?",

"options": {

"A": "900 joules are transferred every second.",

"B": "900 amperes are transferred every second.",

"C": "900 volts are transferred every second.",

"D": "900 ohms are transferred every second."

},

"image\_filename": "question\_10\_enhanced.png",

"page": 6,

"marks": 1,

"subject": "physics",

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    "difficulty": "easy",
    "correct_answer": "A",
    "explanation": "Power is defined as energy transferred per
unit time, so 900 watts means 900 joules are transferred every
second.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
        "reasoning": "Power is the rate of energy transfer or the
amount of energy converted per unit time. The watt (W) is the SI
unit of power, defined as one joule per second (J/s). When a
microwave oven is rated at 900 watts, this means it can transfer or
convert 900 joules of electrical energy every second. Options B, C,
and D are incorrect because: amperes measure current (not
transferred per second), volts measure potential difference (not
transferred), and ohms measure resistance (not transferred).",
        "key_concepts": "Power definition, units of power (watts),
energy transfer rate, distinction between power and other electrical
quantities",
        "common_mistakes": "Students often confuse power with other
electrical quantities like current, voltage, or resistance. They may
not understand that watts specifically measure energy per unit time,
not the transfer of other electrical properties."
    },
    "calculation_steps": [
        "Step 1: Recall the definition of power:  $P = E/t$  (power =
energy/time)",
        "Step 2: Recognize that 1 watt = 1 joule/second",
        "Step 3: Apply this to the given value: 900 watts = 900
joules/second"
    ],
    "topic": "Electricity and Power",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
    "flag_reason": "",
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{
    "id": "physics_q11",
    "question_number": 11,
    "question_text": "Why is it easier to push a sharp nail,
rather than a blunt nail, into a piece of wood?",

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"options": {
  "A": "The sharp nail exerts a larger force on the wood.",
  "B": "The sharp nail exerts a smaller force on the wood.",
  "C": "The sharp nail exerts a larger pressure on the wood.",
  "D": "The sharp nail exerts a smaller pressure on the wood."
},
"image_filename": "question_11_enhanced.png",
"page": 6,
"marks": 1,
"subject": "physics",
"difficulty": "easy",
"correct_answer": "C",
"explanation": "A sharp nail has a smaller contact area, so
for the same applied force, it exerts a larger pressure on the wood
(Pressure = Force/Area), making it easier to penetrate.",
"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "When pushing a nail into wood, the force
applied by your hand is essentially the same regardless of whether
the nail is sharp or blunt. However, pressure is defined as force
per unit area ( $P = F/A$ ). A sharp nail has a much smaller contact
area at its tip compared to a blunt nail. Since pressure is
inversely proportional to area, the smaller area of the sharp nail
results in much higher pressure being exerted on the wood fibers.
This concentrated pressure more effectively breaks through the wood
fibers, making penetration easier.",
  "key_concepts": "Pressure = Force/Area relationship; inverse
relationship between contact area and pressure for constant force;
mechanical advantage through area reduction",
  "common_mistakes": "Students often confuse force and
pressure, thinking that a sharp nail somehow generates more force.
The applied force is the same – it's the concentration of that force
over a smaller area that creates the advantage."
},
"calculation_steps": [
  "Step 1: Recognize that applied force  $F$  is constant for both
nails",
  "Step 2: Apply pressure formula  $P = F/A$ ",
  "Step 3: Compare areas:  $A_{\text{sharp}} \ll A_{\text{blunt}}$ ",
  "Step 4: Therefore:  $P_{\text{sharp}} = F/A_{\text{sharp}} \gg P_{\text{blunt}} = F/A_{\text{blunt}}$ "
],
"topic": "Mechanics – Pressure and Force",
"confidence_score": 0.98,
"solved_by_ai": true,
"needs_review": false,
"flag_reason": "",
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"api_usage": {

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{
  "id": "physics_q12",
  "question_number": 12,
  "question_text": "A sealed bottle of constant volume contains
air. The air in the bottle is heated by the Sun. What is the effect
on the average speed of the air particles in the bottle and the
average distance between them?",
  "options": {
    "A": "average speed decreases, average distance decreases",
    "B": "average speed decreases, average distance stays the
same",
    "C": "average speed increases, average distance increases",
    "D": "average speed increases, average distance stays the
same"
  },
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  "page": 6,
  "marks": 1,
  "subject": "physics",
  "difficulty": "medium",
  "correct_answer": "D",
  "explanation": "When air is heated in a sealed container, the
average kinetic energy (and thus speed) of particles increases, but
since the volume is constant and the amount of gas is fixed, the
average distance between particles remains the same.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "When the air in the sealed bottle is heated by
the Sun: 1) The temperature increases, which directly increases the
average kinetic energy of gas particles according to the kinetic
theory of gases ( $KE_{avg} = 3/2 kT$ ). Since kinetic energy is
proportional to the square of velocity, higher temperature means
higher average particle speeds. 2) The bottle is sealed with
constant volume, and the amount of gas (number of particles) remains
fixed. Since particle density =  $N/V$ , and both  $N$  (number of
particles) and  $V$  (volume) are constant, the average distance between
particles cannot change.",
    "key_concepts": "Kinetic theory of gases, relationship
between temperature and kinetic energy, constant volume processes,
particle density in gases",
    "common_mistakes": "Students often think that heating causes
expansion and increased particle separation, forgetting that the
container has a fixed volume. Another mistake is thinking

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temperature doesn't affect particle speed."
    },
    "calculation_steps": [
        "Step 1: Identify the constraints – sealed bottle (constant volume), fixed amount of gas",
        "Step 2: Apply kinetic theory – higher temperature \u2192 higher average kinetic energy \u2192 higher average speed",
        "Step 3: Consider particle spacing – with constant volume and constant number of particles, average distance remains unchanged"
    ],
    "topic": "Thermodynamics/Kinetic Theory of Gases",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
    "flag_reason": "",
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        "output_tokens": 540,
        "cost": 0.01167,
        "model_used": "claude-sonnet-4-20250514"
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    "model_used": "claude-sonnet-4-20250514"
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{
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    "question_number": 13,
    "question_text": "Which graph shows the relationship between the pressure p of a fixed mass of gas and its volume V at a constant temperature?",
    "options": {
        "A": "Linear relationship – pressure increases linearly with volume",
        "B": "Horizontal line – pressure remains constant as volume changes",
        "C": "Inverse relationship – pressure decreases as volume increases (hyperbolic curve)",
        "D": "Exponential-like curve – pressure increases exponentially with volume"
    },
    "image_filename": "question_13_enhanced.png",
    "page": 6,
    "marks": 1,
    "subject": "physics",
    "difficulty": "medium",
    "correct_answer": "C",
    "explanation": "At constant temperature, pressure and volume are inversely related according to Boyle's Law ( $pV = \text{constant}$ ), which produces a hyperbolic curve where pressure decreases as volume increases.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",

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    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
      "reasoning": "For a fixed mass of gas at constant
temperature, we apply Boyle's Law, which states that pressure is
inversely proportional to volume ( $p \propto 1/V$ , or  $pV = \text{constant}$ ).
This means that as volume increases, pressure must decrease
proportionally to maintain the constant product. Mathematically,
this inverse relationship produces a hyperbolic curve when plotting
 $p$  vs  $V$ . Graph C shows this characteristic hyperbolic shape where
pressure approaches infinity as volume approaches zero, and pressure
approaches zero as volume increases toward infinity.",
      "key_concepts": "Boyle's Law, ideal gas behavior, inverse
proportionality, isothermal processes",
      "common_mistakes": "Students often confuse this with direct
proportionality (choosing A) or think temperature affects this
relationship when it's held constant. Some may choose B thinking
pressure stays constant, confusing this with isobaric processes."
    },
    "calculation_steps": [
      "Step 1: Identify the conditions – fixed mass of gas,
constant temperature",
      "Step 2: Apply Boyle's Law:  $pV = \text{constant}$  (at constant  $T$ )",
      "Step 3: Rearrange to  $p = \text{constant}/V$ , showing inverse
relationship",
      "Step 4: Recognize this produces a hyperbolic curve on a  $p$ - $V$ 
graph"
    ],
    "topic": "Thermodynamics – Gas Laws",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
    "flag_reason": "",
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    "model_used": "claude-sonnet-4-20250514"
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    "id": "physics_q14",
    "question_number": 14,
    "question_text": "What happens when a metal block is heated?",
    "options": {
      "A": "Its width, height and length all increase.",
      "B": "Its width increases only.",
      "C": "Its height increases only.",
      "D": "Its length increases only."
    }
  },

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    "image_filename": "question_14_enhanced.png",
    "page": 7,
    "marks": 1,
    "subject": "physics",
    "difficulty": "easy",
    "correct_answer": "A",
    "explanation": "When a metal block is heated, thermal
expansion occurs uniformly in all directions, causing width, height,
and length to all increase.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
        "reasoning": "When a solid metal is heated, the increased
thermal energy causes atoms and molecules to vibrate more
vigorously. This increased kinetic energy pushes atoms slightly
further apart on average, resulting in expansion of the material.
For an isotropic solid like most metals, this expansion occurs
equally in all three spatial dimensions. The linear expansion in
each direction follows the formula  $\Delta L = \alpha L \Delta T$ ,
where  $\alpha$  is the coefficient of linear expansion,  $L$  is the
original length, and  $\Delta T$  is the temperature change. Since this
applies to each dimension independently, all three dimensions
(width, height, length) increase proportionally.",
        "key_concepts": "Thermal expansion, coefficient of linear
expansion, isotropic materials, kinetic theory of matter",
        "common_mistakes": "Students might think expansion only
occurs in one direction, or confuse this with anisotropic materials
that expand differently in different directions. Some may not
realize that expansion is a three-dimensional phenomenon."
    },
    "calculation_steps": [
        "Step 1: Recognize this is about thermal expansion of
solids",
        "Step 2: Apply the principle that isotropic materials expand
equally in all directions",
        "Step 3: Conclude that all three dimensions must increase
when heated"
    ],
    "topic": "Thermodynamics – Thermal Expansion",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
    "flag_reason": "",
    "solved_at": "2025-08-26T12:12:15.408536",
    "processing_time": 11.895044,
    "api_usage": {
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        "cost": 0.009396,
        "model_used": "claude-sonnet-4-20250514"
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    "model_used": "claude-sonnet-4-20250514"
  },
  {
    "id": "physics_q15",
    "question_number": 15,
    "question_text": "Which statement about the temperature of the solid describes what happens when a solid is melting?",
    "options": {
      "A": "The temperature increases and there is an input of energy.",
      "B": "The temperature increases and there is no input of energy.",
      "C": "The temperature remains constant and there is an input of energy.",
      "D": "The temperature remains constant and there is no input of energy."
    },
    "image_filename": "question_15_enhanced.png",
    "page": 7,
    "marks": 1,
    "subject": "physics",
    "difficulty": "medium",
    "correct_answer": "C",
    "explanation": "During melting, temperature remains constant at the melting point while energy is continuously input to break intermolecular bonds and change the phase from solid to liquid.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
      "reasoning": "When a solid melts, it undergoes a phase transition at its melting point. During this process: 1) The temperature remains constant at the melting point temperature, 2) Energy must be continuously supplied (latent heat of fusion) to break the intermolecular forces holding the solid structure together, 3) This energy goes into changing the phase rather than increasing kinetic energy (temperature), 4) Only after all the solid has melted will additional energy input cause temperature to rise again.",
      "key_concepts": "Phase transitions, latent heat of fusion, melting point, intermolecular forces, energy conservation",
      "common_mistakes": "Students often think temperature must increase when energy is added, not realizing that during phase transitions, energy goes into breaking bonds rather than increasing molecular kinetic energy (temperature)"
    },
    "calculation_steps": [
      "Step 1: Recognize this is a phase transition question",
      "Step 2: Recall that phase transitions occur at constant temperature",
      "Step 3: Remember that energy input is required to overcome intermolecular forces",

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        "Step 4: Eliminate options with temperature change (A, B)
and no energy input (D)"
    ],
    "topic": "Thermodynamics – Phase Transitions",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
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    },
    "model_used": "claude-sonnet-4-20250514"
},
{
    "id": "physics_q16",
    "question_number": 16,
    "question_text": "A cupboard is placed in front of a heater.
Air can move through a gap under the cupboard. Which row describes
the temperature and the direction of movement of the air in the
gap?",
    "options": {
        "A": "air temperature: cool, air direction: away from the
heater",
        "B": "air temperature: cool, air direction: towards the
heater",
        "C": "air temperature: warm, air direction: away from the
heater",
        "D": "air temperature: warm, air direction: towards the
heater"
    },
    "image_filename": "question_16_enhanced.png",
    "page": 7,
    "marks": 1,
    "subject": "physics",
    "difficulty": "medium",
    "correct_answer": "B",
    "explanation": "Cool air moves towards the heater through the
gap at floor level because convection creates a circulation pattern
where cooler, denser air flows in at the bottom to replace the warm
air that rises.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
        "reasoning": "When the heater operates, it warms the air
directly in front of it. This warm air becomes less dense and rises
upward due to buoyancy forces. As the warm air rises and moves away

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from the heater area, it creates a low-pressure region near the heater at floor level. To replace this rising warm air, cooler air from the room must flow in to fill this space. The gap under the cupboard provides a pathway for this cooler air to flow towards the heater at floor level, completing the convection circulation pattern.",

"key\_concepts": "Convection currents, air density changes with temperature, buoyancy forces, pressure differences driving air movement",

"common\_mistakes": "Students often think the air in the gap would be warm (since it's near a heater) or moving away from the heater (following the overall direction of heated air). They may not realize that convection creates a complete circulation loop where cool air moves in at the bottom while warm air rises and moves away at the top."

},

"calculation\_steps": [

"Step 1: Identify the heat source (heater) and its effect on nearby air",

"Step 2: Recognize that heated air rises, creating circulation",

"Step 3: Determine that cooler air must flow in at floor level to replace rising warm air",

"Step 4: Conclude that air in the gap is cool and moving towards the heater"

],

"topic": "Thermodynamics - Convection",

"confidence\_score": 0.96,

"solved\_by\_ai": true,

"needs\_review": false,

"flag\_reason": "",

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{

"id": "physics\_q17",

"question\_number": 17,

"question\_text": "Which statement about waves is correct?",

"options": {

"A": "All waves can travel through a vacuum.",

"B": "All waves travel at the same speed.",

"C": "Seismic S-waves can be modelled as longitudinal waves.",

"D": "Waves transfer energy without transferring matter."

},

"image\_filename": "question\_17\_enhanced.png",

"page": 8,

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"marks": 1,
"subject": "physics",
"difficulty": "medium",
"correct_answer": "D",
"explanation": "Waves transfer energy without transferring
matter – this is a fundamental property of all wave motion where
energy propagates through a medium or space without the medium
itself moving along with the wave.",
"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "Let me analyze each option systematically: A)
Incorrect – Only electromagnetic waves can travel through vacuum;
mechanical waves (sound, seismic waves) require a medium. B)
Incorrect – Wave speeds vary greatly depending on type and medium
(light ~300000000 m/s, sound ~343 m/s in air). C) Incorrect –
Seismic S-waves (secondary/shear waves) are transverse waves where
particle motion is perpendicular to wave direction, not
longitudinal. D) Correct – This is the defining characteristic of
wave motion: energy propagates while the medium particles oscillate
around equilibrium positions without net displacement.",
  "key_concepts": "Wave propagation, energy transfer,
mechanical vs electromagnetic waves, transverse vs longitudinal
waves, seismic waves",
  "common_mistakes": "Students often confuse S-waves and P-
waves (P-waves are longitudinal, S-waves are transverse), or think
all waves need a medium to travel through"
},
"calculation_steps": [
  "Step 1: No calculations required for this conceptual
question",
  "Step 2: Analyze each statement against fundamental wave
principles",
  "Step 3: Identify the universally true statement about all
wave types"
],
"topic": "Wave Properties and Motion",
"confidence_score": 0.98,
"solved_by_ai": true,
"needs_review": false,
"flag_reason": "",
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  "output_tokens": 479,
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},

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{
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  "question_number": 18,
  "question_text": "The diagram shows a transverse wave. Which
row identifies the amplitude and the wavelength of the wave?",
  "options": {
    "A": "amplitude: P, wavelength: R",
    "B": "amplitude: P, wavelength: S",
    "C": "amplitude: Q, wavelength: R",
    "D": "amplitude: Q, wavelength: S"
  },
  "image_filename": "question_18_enhanced.png",
  "page": 8,
  "marks": 1,
  "subject": "physics",
  "difficulty": "easy",
  "correct_answer": "B",
  "explanation": "P represents the amplitude (maximum
displacement from equilibrium) and S represents the wavelength
(distance between two consecutive identical points).",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "Looking at the wave diagram: P is marked as a
vertical arrow from the equilibrium line (horizontal dashed line) to
the peak of the wave, which represents the amplitude – the maximum
displacement from the rest position. Q appears to be marking a
horizontal distance that is less than a full wavelength. R shows the
distance from one peak to the next trough, which is half a
wavelength. S shows the distance from one peak to the next peak (or
one complete cycle), which is the full wavelength. Therefore,
amplitude = P and wavelength = S.",
    "key_concepts": "Wave properties: amplitude is the maximum
displacement from equilibrium position, wavelength is the distance
between two consecutive identical points (peak to peak, trough to
trough, or any point to the corresponding point in the next cycle)",
    "common_mistakes": "Students often confuse wavelength with
the distance from peak to trough (which is half a wavelength) or
mistake other measurements for amplitude"
  },
  "calculation_steps": [
    "Step 1: Identify amplitude – P is the vertical distance
from equilibrium to maximum displacement",
    "Step 2: Identify wavelength – S spans from one peak to the
next identical peak",
    "Step 3: Verify R is peak-to-trough distance (half
wavelength) and Q is some other partial distance"
  ],
  "topic": "Waves",
  "confidence_score": 0.98,
  "solved_by_ai": true,

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"needs_review": false,
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"processing_time": 16.65447,
"api_usage": {
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  "output_tokens": 491,
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},
"model_used": "claude-sonnet-4-20250514"
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{
  "id": "physics_q19",
  "question_number": 19,
  "question_text": "A beam of light from the Sun strikes a
prism. The dispersed beam is incident on a white wall between X and
Y. Which colours are seen at X, Z and Y?",
  "options": {
    "A": "X: red, Z: green, Y: violet",
    "B": "X: red, Z: violet, Y: green",
    "C": "X: violet, Z: green, Y: red",
    "D": "X: violet, Z: red, Y: green"
  },
  "image_filename": "question_19_enhanced.png",
  "page": 8,
  "marks": 1,
  "subject": "physics",
  "difficulty": "medium",
  "correct_answer": "A",
  "explanation": "Red light is deviated least by the prism so
appears at position X, while violet light is deviated most and
appears at position Y, with green appearing at the middle position
Z.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "When white light passes through a prism, it
undergoes dispersion due to different wavelengths having different
refractive indices. Red light has the longest wavelength and lowest
refractive index, so it is deviated (bent) the least by the prism.
Violet light has the shortest wavelength and highest refractive
index, so it is deviated the most. Green light has intermediate
properties and is deviated by a medium amount. Looking at the
diagram, position X is closest to the original beam direction (least
deviation), position Y is furthest from the original beam direction
(most deviation), and position Z is in the middle (medium
deviation). Therefore: X shows red light, Z shows green light, and Y
shows violet light.",
    "key_concepts": "Dispersion of light, refraction, wavelength
dependence of refractive index, prism optics",

```

"common\_mistakes": "Students often confuse which end of the spectrum is deviated more, or forget that red light is deviated least and violet light is deviated most through a prism"

},  
"calculation\_steps": [  
"Step 1: Identify that white light contains all colors with different wavelengths",  
"Step 2: Apply principle that shorter wavelengths (violet) have higher refractive indices and are deviated more",  
"Step 3: Apply principle that longer wavelengths (red) have lower refractive indices and are deviated less",  
"Step 4: Match positions on wall with deviation amounts – X (least deviation) = red, Z (medium deviation) = green, Y (most deviation) = violet"

],  
"topic": "Optics – Dispersion and Refraction",  
"confidence\_score": 0.98,  
"solved\_by\_ai": true,  
"needs\_review": false,  
"flag\_reason": "",  
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"api\_usage": {  
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"cost": 0.013245,  
"model\_used": "claude-sonnet-4-20250514"

},  
"model\_used": "claude-sonnet-4-20250514"  
},  
{  
"id": "physics\_q20",  
"question\_number": 20,  
"question\_text": "Question text not visible in the provided  
image",

"options": {  
"A": "20N",  
"B": "54N",  
"C": "740N",  
"D": "2000N"  
},  
"image\_filename": "question\_20\_enhanced.png",  
"page": 2,  
"marks": 1,  
"subject": "physics",  
"difficulty": "Cannot assess without seeing complete  
question",  
"correct\_answer": "Unable to determine",  
"explanation": "Cannot determine correct answer without seeing  
the complete question",  
"extraction\_method": "enhanced\_multi\_strategy\_detection",  
"detection\_strategy": "standalone\_number",  
"confidence": 0.9,  
"has\_images": true,

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    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
      "reasoning": "The image only shows four force values as
answer options, but the actual question text, given values, and any
diagrams are not visible. Without knowing what physical situation is
being described or what quantity is being asked for, it's impossible
to determine which force value is correct.",
      "key_concepts": "Cannot identify without seeing the
question",
      "common_mistakes": "Cannot identify without context"
    },
    "calculation_steps": [
      "Cannot provide steps without seeing the question and given
values"
    ],
    "topic": "Physics – Forces (based on units being Newtons)",
    "confidence_score": 0.0,
    "solved_by_ai": true,
    "needs_review": true,
    "flag_reason": "Low confidence: 0.0% (below 91%)",
    "solved_at": "2025-08-26T12:13:48.042642",
    "processing_time": 10.217244,
    "api_usage": {
      "input_tokens": 728,
      "output_tokens": 403,
      "cost": 0.008229,
      "model_used": "claude-sonnet-4-20250514"
    },
    "model_used": "claude-sonnet-4-20250514"
  },
  {
    "id": "physics_q21",
    "question_number": 21,
    "question_text": "A thin converging lens in a camera produces
a real image on a photo-sensitive surface, as shown. At which
position is the image of the top of the object formed?",
    "options": {
      "A": "Position A",
      "B": "Position B",
      "C": "Position C",
      "D": "Position D"
    },
    "image_filename": "question_21_enhanced.png",
    "page": 9,
    "marks": 1,
    "subject": "physics",
    "difficulty": "medium",
    "correct_answer": "C",
    "explanation": "The image of the top of the object is formed
at position C because when light rays from the top of the object
pass through the converging lens, they converge at point C on the
photo-sensitive surface, creating an inverted real image.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",

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```

    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
      "reasoning": "To find where the image of the top of the
object forms, we need to trace the light rays from the top of the
object through the lens. For a converging lens forming a real image:
1) A ray parallel to the principal axis refracts through the focal
point on the opposite side. 2) A ray passing through the center of
the lens continues straight without deviation. 3) Where these rays
intersect is where the image forms. From the diagram, we can see
rays from the top of the object converging at point C after passing
through the lens. Since this is a real image formed by a converging
lens, it will be inverted – meaning the top of the object maps to
the bottom of the image space, which corresponds to position C.",
      "key_concepts": "Ray tracing through converging lenses, real
image formation, image inversion in optical systems, focal point
behavior",
      "common_mistakes": "Students often forget that real images
formed by converging lenses are inverted, or they may confuse which
ray corresponds to which part of the object. Some might think
position A is correct because it's 'higher up' without considering
the inversion."
    },
    "calculation_steps": [
      "Step 1: Identify that this is a converging lens forming a
real image",
      "Step 2: Recognize that real images formed by converging
lenses are inverted",
      "Step 3: Trace rays from the top of the object through the
lens",
      "Step 4: Follow the convergence point of these rays to
position C"
    ],
    "topic": "Optics – Lens Ray Tracing",
    "confidence_score": 0.96,
    "solved_by_ai": true,
    "needs_review": false,
    "flag_reason": "",
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    "api_usage": {
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      "output_tokens": 561,
      "cost": 0.011732999999999999,
      "model_used": "claude-sonnet-4-20250514"
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    "model_used": "claude-sonnet-4-20250514"
  },
  {
    "id": "physics_q22",
    "question_number": 22,
    "question_text": "The diagram shows the electromagnetic
spectrum. Which types of wave are E, F and G?",

```

```

"options": {
  "A": "E: radio, F: visible light, G: X-rays",
  "B": "E: radio, F: X-rays, G: ultrasound",
  "C": "E: X-rays, F: radio, G: ultrasound",
  "D": "E: X-rays, F: visible light, G: radio"
},
"image_filename": "question_22_enhanced.png",
"page": 9,
"marks": 1,
"subject": "physics",
"difficulty": "medium",
"correct_answer": "D",
"explanation": "Position E (between gamma-rays and
ultraviolet) is X-rays, position F (between ultraviolet and
infrared) is visible light, and position G (after microwaves) is
radio waves.",
"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "The electromagnetic spectrum is arranged by
frequency (decreasing from left to right) and wavelength (increasing
from left to right). From the diagram: gamma-rays \u2192 E \u2192
ultraviolet \u2192 F \u2192 infrared \u2192 microwaves \u2192 G.
Position E, between gamma-rays and ultraviolet, must be X-rays (high
frequency, short wavelength). Position F, between ultraviolet and
infrared, must be visible light. Position G, after microwaves at the
low frequency end, must be radio waves (low frequency, long
wavelength).",
  "key_concepts": "Electromagnetic spectrum order, frequency
and wavelength relationship, classification of electromagnetic
radiation",
  "common_mistakes": "Students often confuse the order of
electromagnetic waves or mix up electromagnetic waves with
mechanical waves like ultrasound"
},
"calculation_steps": [
  "Step 1: Identify the given spectrum order from left to
right",
  "Step 2: Recall that EM spectrum goes from high frequency/
short wavelength to low frequency/long wavelength",
  "Step 3: Match positions E, F, G with correct wave types
based on their positions in the spectrum"
],
"topic": "Electromagnetic Spectrum",
"confidence_score": 0.98,
"solved_by_ai": true,
"needs_review": false,
"flag_reason": "",
"solved_at": "2025-08-26T12:14:17.477257",
"processing_time": 9.639242,
"api_usage": {

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    "input_tokens": 1106,
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  "model_used": "claude-sonnet-4-20250514"
},
{
  "id": "physics_q23",
  "question_number": 23,
  "question_text": "A sound is produced and an echo is heard after the sound reflects off a wall. How do the properties of the echo compare to the original sound wave?",
  "options": {
    "A": "amplitude: lower, frequency: lower, speed: lower",
    "B": "amplitude: lower, frequency: same, speed: same",
    "C": "amplitude: same, frequency: lower, speed: lower",
    "D": "amplitude: same, frequency: same, speed: same"
  },
  "image_filename": "question_23_enhanced.png",
  "page": 10,
  "marks": 1,
  "subject": "physics",
  "difficulty": "medium",
  "correct_answer": "B",
  "explanation": "When sound reflects off a wall to create an echo, the frequency and speed remain the same since these are intrinsic properties of the wave in the same medium, but the amplitude decreases due to energy loss during reflection and transmission through the medium.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "When a sound wave reflects off a wall to produce an echo, we need to analyze each wave property: 1) Amplitude: Energy is lost during reflection (not 100% reflection occurs) and during the additional travel through air, so amplitude decreases. 2) Frequency: This is determined by the source and remains constant during reflection – the wall doesn't change the rate of oscillation. 3) Speed: This depends only on the properties of the medium (air temperature, pressure, etc.), which remain the same, so speed is unchanged.",
    "key_concepts": "Wave reflection, conservation of frequency during reflection, energy loss in wave propagation, relationship between wave speed and medium properties",
    "common_mistakes": "Students often think frequency changes during reflection, or that speed changes when amplitude changes. Another mistake is assuming no energy loss occurs during reflection, leading to choice D."
  },
  "calculation_steps": [

```

```

        "Step 1: Identify that this is wave reflection, not
        refraction (same medium)",
        "Step 2: Apply principle that frequency is conserved during
        reflection in same medium",
        "Step 3: Apply principle that wave speed depends only on
        medium properties ( $v = \frac{B}{\rho c}$  for sound)",
        "Step 4: Recognize that energy loss occurs during reflection
        and propagation, reducing amplitude"
    ],
    "topic": "Wave Physics – Sound Waves and Reflection",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
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    "model_used": "claude-sonnet-4-20250514"
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{
    "id": "physics_q24",
    "question_number": 24,
    "question_text": "Which metal can be attracted by a magnet?",
    "options": {
        "A": "zinc",
        "B": "lead",
        "C": "iron",
        "D": "copper"
    },
    "image_filename": "question_24_enhanced.png",
    "page": 10,
    "marks": 1,
    "subject": "physics",
    "difficulty": "easy",
    "correct_answer": "C",
    "explanation": "Iron is ferromagnetic and can be strongly
    attracted by magnets, while zinc, lead, and copper are not
    magnetic.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
        "reasoning": "Materials can be classified by their magnetic
        properties: ferromagnetic (strongly attracted), paramagnetic (weakly
        attracted), and diamagnetic (weakly repelled). Iron is one of the
        three main ferromagnetic elements (along with nickel and cobalt) at
        room temperature. It has unpaired electrons that align with external

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magnetic fields, creating strong attraction. Zinc, lead, and copper are either paramagnetic or diamagnetic with very weak magnetic responses that are not noticeable in everyday situations.",

"key\_concepts": "Ferromagnetism, magnetic properties of materials, electron spin alignment, magnetic domains",

"common\_mistakes": "Students might think all metals are magnetic, or confuse the electrical conductivity of metals like copper with magnetic properties. Some may also think that heavier metals like lead would be more magnetic."

},  
"calculation\_steps": [  
metal",  
"Step 1: Identify the magnetic classification of each  
"Step 2: Zinc – diamagnetic (weakly repelled by magnets)",  
"Step 3: Lead – diamagnetic (weakly repelled by magnets)",  
"Step 4: Iron – ferromagnetic (strongly attracted to  
magnets)",  
"Step 5: Copper – diamagnetic (weakly repelled by magnets)"

],  
"topic": "Magnetism and Materials",  
"confidence\_score": 0.98,  
"solved\_by\_ai": true,  
"needs\_review": false,  
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},  
"model\_used": "claude-sonnet-4-20250514"

{  
"id": "physics\_q25",  
"question\_number": 25,  
"question\_text": "A student uses an ammeter to measure the current in a resistor. He considers three different circuits, as shown. In which of the circuits does the ammeter measure the current in the resistor?",

"options": {  
"A": "1, 2 and 3",  
"B": "1 and 2 only",  
"C": "1 only",  
"D": "3 only"

},  
"image\_filename": "question\_25\_enhanced.png",  
"page": 10,  
"marks": 1,  
"subject": "physics",  
"difficulty": "medium",  
"correct\_answer": "B",  
"explanation": "In circuits 1 and 2, the ammeter is connected



in series with the resistor, allowing it to measure the current flowing through the resistor. In circuit 3, the ammeter is connected in parallel with the resistor, so it measures the current through its own branch, not the resistor.",

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"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "To measure current through a component, an
  ammeter must be connected in series with that component so that all
  the current flowing through the component also flows through the
  ammeter. In Circuit 1: The ammeter is clearly in series with the
  resistor – current must flow through both components sequentially.
  In Circuit 2: The ammeter is also in series with the resistor, just
  positioned differently in the circuit loop. In Circuit 3: The
  ammeter is connected in parallel with the resistor (both components
  have their own separate paths), so the current splits between the
  ammeter branch and the resistor branch. The ammeter only measures
  the current through its own branch, not the current through the
  resistor.",
```

```
  "key_concepts": "Series vs parallel connections, ammeter
  usage principles, current measurement in circuits",
```

```
  "common_mistakes": "Students often confuse parallel and
  series connections, or think that an ammeter can measure current
  through a component when connected in parallel with it"
```

```
},
"calculation_steps": [
  "Step 1: Identify the connection type in each circuit",
  "Step 2: Circuit 1 – ammeter in series with resistor
  \u2713",
  "Step 3: Circuit 2 – ammeter in series with resistor
  \u2713",
  "Step 4: Circuit 3 – ammeter in parallel with resistor
  \u2717",
  "Step 5: Only circuits 1 and 2 allow proper current
  measurement"
```

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],
"topic": "Electric Circuits and Current Measurement",
"confidence_score": 0.98,
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"api_usage": {
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  "model_used": "claude-sonnet-4-20250514"
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{
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  "question_number": 26,
  "question_text": "Which substances both contain large
concentrations of free electrons?",
  "options": {
    "A": "aluminium and glass",
    "B": "copper and water",
    "C": "copper and nylon",
    "D": "silver and gold"
  },
  "image_filename": "question_26_enhanced.png",
  "page": 10,
  "marks": 1,
  "subject": "physics",
  "difficulty": "easy",
  "correct_answer": "D",
  "explanation": "Silver and gold are both metals with metallic
bonding, which creates a 'sea' of delocalized electrons that are
free to move throughout the material.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "To answer this question, we need to identify
which materials have large concentrations of free electrons. Free
electrons are electrons that are not bound to specific atoms and can
move freely through the material. This property is characteristic of
metals due to their metallic bonding structure. Let's analyze each
option: A) Aluminum is a metal with free electrons, but glass is an
insulator with no free electrons. B) Copper is a metal with free
electrons, but water is a poor conductor with very few free
electrons. C) Copper is a metal with free electrons, but nylon is an
insulator with no free electrons. D) Both silver and gold are metals
with metallic bonding, creating a 'sea' of delocalized electrons
that can move freely throughout the material.",
    "key_concepts": "Metallic bonding, electrical conductivity,
free electrons, insulators vs conductors",
    "common_mistakes": "Students might confuse materials that
conduct electricity slightly (like water with dissolved ions) with
materials that have truly free electrons. They might also not
recognize that both substances in the pair must have free
electrons."
  },
  "calculation_steps": [
    "Step 1: Identify materials with free electrons (metals)",
    "Step 2: Identify materials without free electrons
(insulators)",
    "Step 3: Find the option where both materials are metals"
  ],
  "topic": "Electrical Properties of Materials",
  "confidence_score": 0.98,

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"solved_by_ai": true,
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"flag_reason": "",
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"api_usage": {
  "input_tokens": 812,
  "output_tokens": 471,
  "cost": 0.009500999999999999,
  "model_used": "claude-sonnet-4-20250514"
},
"model_used": "claude-sonnet-4-20250514"
},
{
  "id": "physics_q27",
  "question_number": 27,
  "question_text": "What is the unit of resistance?",
  "options": {
    "A": "ampere",
    "B": "ohm",
    "C": "volt",
    "D": "watt"
  },
  "image_filename": "question_27_enhanced.png",
  "page": 11,
  "marks": 1,
  "subject": "physics",
  "difficulty": "easy",
  "correct_answer": "B",
  "explanation": "The unit of resistance is the ohm (\u03a9),
named after German physicist Georg Ohm who formulated Ohm's law.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "Resistance is a fundamental electrical
quantity that measures how much a material opposes the flow of
electric current. According to Ohm's law ( $V = IR$ ), resistance  $R$  is
defined as the ratio of voltage ( $V$ ) to current ( $I$ ). Therefore, the
unit of resistance is volts per ampere, which is defined as the ohm
(\u03a9). The other options represent different electrical
quantities: ampere is the unit of current, volt is the unit of
voltage/potential difference, and watt is the unit of power.",
    "key_concepts": "Ohm's law, electrical resistance, SI units,
electrical quantities",
    "common_mistakes": "Students sometimes confuse the units of
different electrical quantities. They might incorrectly associate
ampere with resistance instead of current, or confuse volt
(potential difference) with ohm (resistance). Some may also think
watt is related to resistance rather than power."
  },
  "calculation_steps": [

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```

    "Step 1: Recall Ohm's law:  $V = IR$ , where  $V$  is voltage,  $I$  is
current,  $R$  is resistance",
    "Step 2: Rearrange to solve for resistance:  $R = V/I$ ",
    "Step 3: Identify units:  $R = \text{volts/amperes} = \text{ohms } (\text{\u03a9})"$ 
```

Quantities",

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    "confidence_score": 0.99,
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    "needs_review": false,
    "flag_reason": "",
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    "api_usage": {
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      "output_tokens": 454,
      "cost": 0.009246,
      "model_used": "claude-sonnet-4-20250514"
    },
    "model_used": "claude-sonnet-4-20250514"
  },
  {
    "id": "physics_q28",
    "question_number": 28,
    "question_text": "A teacher wishes to show the production of
electrostatic charges. She holds a rod and rubs it with a cotton
cloth. A copper rod, a glass rod, a plastic rod and a steel rod are
available. Which two rods would both be suitable to use?",
    "options": {
      "A": "a copper rod and a glass rod",
      "B": "a glass rod and a plastic rod",
      "C": "a plastic rod and a copper rod",
      "D": "a plastic rod and a steel rod"
    },
    "image_filename": "question_28_enhanced.png",
    "page": 11,
    "marks": 1,
    "subject": "physics",
    "difficulty": "easy",
    "correct_answer": "B",
    "explanation": "Glass and plastic rods are both insulators
that can hold electrostatic charge when rubbed with cotton cloth,
making them suitable for demonstrating electrostatic charge
production.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
      "reasoning": "To demonstrate electrostatic charge production
by rubbing with cotton cloth, the rods must be made of insulating
materials that can retain the charge. When an insulator is rubbed,
electrons can be transferred between the materials, creating a

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charge imbalance that remains localized on the surface. Copper and steel are metals (conductors) that allow charges to flow freely and dissipate quickly, making them unsuitable for this demonstration. Glass and plastic are both insulators that will retain the transferred charge, allowing students to observe electrostatic effects like attraction of small objects or hair standing up.",

"key\_concepts": "Electrostatic charging by friction, conductors vs insulators, charge retention in materials",  
"common\_mistakes": "Students often think metals would work better because they conduct electricity, not realizing that for static electricity demonstrations, we need materials that prevent charge flow (insulators)"

},  
"calculation\_steps": [  
"Step 1: Identify material properties – copper and steel are conductors, glass and plastic are insulators",  
"Step 2: Consider charge retention – insulators retain charge, conductors allow charge to dissipate",  
"Step 3: Select materials that will maintain charge after rubbing – glass and plastic"

],  
"topic": "Electrostatics",  
"confidence\_score": 0.98,  
"solved\_by\_ai": true,  
"needs\_review": false,  
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"model\_used": "claude-sonnet-4-20250514"

},  
{  
"id": "physics\_q29",  
"question\_number": 29,  
"question\_text": "Resistors of resistance 2.0\

```

    "marks": 1,
    "subject": "physics",
    "difficulty": "easy",
    "correct_answer": "C",
    "explanation": "In series, resistances add ( $2.0\text{ }\Omega + 3.0\text{ }\Omega = 5.0\text{ }\Omega > 3.0\text{ }\Omega$ ). In parallel, total resistance is less than the smallest individual resistance ( $1.2\text{ }\Omega < 2.0\text{ }\Omega$ ).",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
      "reasoning": "For series circuits, resistances simply add together:  $R_{\text{total}} = R_1 + R_2$ . For parallel circuits, the reciprocal formula applies:  $1/R_{\text{total}} = 1/R_1 + 1/R_2$ . In series, the total is always greater than any individual resistor. In parallel, the total is always less than the smallest individual resistor because current has multiple paths.",
      "key_concepts": "Series and parallel resistance calculations, Ohm's law applications, circuit analysis",
      "common_mistakes": "Students often confuse which configuration gives higher or lower total resistance, or mix up the formulas for series vs parallel calculations."
    },
    "calculation_steps": [
      "Step 1: Series calculation:  $R_{\text{series}} = 2.0\text{ }\Omega + 3.0\text{ }\Omega = 5.0\text{ }\Omega$ ",
      "Step 2: Parallel calculation:  $1/R_{\text{parallel}} = 1/2.0\text{ }\Omega + 1/3.0\text{ }\Omega = 3/6 + 2/6 = 5/6$ ",
      "Step 3:  $R_{\text{parallel}} = 6/5 = 1.2\text{ }\Omega$ ",
      "Step 4: Compare results:  $5.0\text{ }\Omega > 3.0\text{ }\Omega$  (series) and  $1.2\text{ }\Omega < 2.0\text{ }\Omega$  (parallel)"
    ],
    "topic": "Electric Circuits – Resistance",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
    "flag_reason": "",
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  },
  {
    "id": "physics_q30",
    "question_number": 30,
    "question_text": "The current in an electrical heater is 5.0

```

A. The heater is connected to the mains by a flexible cable that can carry a current of up to 15 A. The mains circuit can carry a current of up to 30 A. Different fuses are available to protect the heater's cable. Which fuse is the most suitable?",

```
"options": {
  "A": "4.0 A",
  "B": "10 A",
  "C": "20 A",
  "D": "40 A"
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"image_filename": "question_30_enhanced.png",
"page": 12,
"marks": 1,
"subject": "physics",
"difficulty": "medium",
"correct_answer": "B",
"explanation": "A 10 A fuse is most suitable because it allows normal operation of the 5.0 A heater while providing protection by blowing before the 15 A cable limit is exceeded.",
"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "A fuse must be rated above the normal operating current to allow proper function, but below the maximum safe current of the component it protects. The heater draws 5.0 A normally, so the fuse must be greater than 5.0 A. The cable can safely carry up to 15 A, so the fuse should be less than 15 A to protect the cable from overload. The 10 A fuse satisfies both conditions: it's greater than 5.0 A (allows normal operation) and less than 15 A (protects the cable).",
  "key_concepts": "Electrical safety, fuse selection, overcurrent protection, circuit protection principles",
  "common_mistakes": "Students often choose the 4.0 A fuse thinking it's closest to the operating current, not realizing it would blow during normal operation. Others might choose 20 A or 40 A thinking 'bigger is safer' without understanding that fuses must blow before damage occurs."
},
"calculation_steps": [
  "Step 1: Identify constraints – Heater current: 5.0 A, Cable limit: 15 A, Mains limit: 30 A",
  "Step 2: Apply fuse selection criteria – Fuse rating must be: > 5.0 A (normal operation) and < 15 A (cable protection)",
  "Step 3: Evaluate options – A: 4.0 A (too low), B: 10 A (satisfies both criteria), C: 20 A (too high), D: 40 A (too high)"
],
"topic": "Electrical Circuits and Safety",
"confidence_score": 0.98,
"solved_by_ai": true,
"needs_review": false,
"flag_reason": ""
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"model_used": "claude-sonnet-4-20250514"
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{
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  "question_number": 31,
  "question_text": "A generator uses the principle of
electromagnetic induction. Which change would increase the induced
electromotive force (e.m.f.) in the coil?",
  "options": {
    "A": "increasing the number of turns in the coil",
    "B": "placing the magnets further apart",
    "C": "using a coil made from steel wire",
    "D": "reversing one of the magnets"
  },
  "image_filename": "question_31_enhanced.png",
  "page": 12,
  "marks": 1,
  "subject": "physics",
  "difficulty": "medium",
  "correct_answer": "A",
  "explanation": "Increasing the number of turns in the coil
increases the induced e.m.f. because according to Faraday's law, the
induced e.m.f. is directly proportional to the number of turns in
the coil.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "According to Faraday's law of electromagnetic
induction, the induced e.m.f. is given by  $\epsilon = -N(d\phi/dt)$ ,
where N is the number of turns and  $d\phi/dt$  is the rate of change
of magnetic flux. When the coil rotates in the magnetic field, it
experiences a changing magnetic flux, inducing an e.m.f. The induced
e.m.f. is directly proportional to the number of turns N. Therefore,
increasing N will directly increase the induced e.m.f. Option B
(placing magnets further apart) would decrease the magnetic field
strength and reduce e.m.f. Option C (steel wire) would not
significantly change the e.m.f. compared to copper, and steel has
higher resistance which is undesirable. Option D (reversing one
magnet) would change the field configuration but not necessarily
increase the magnitude of e.m.f.",
    "key_concepts": "Faraday's law of electromagnetic induction,
magnetic flux, generator principle, relationship between number of
turns and induced e.m.f.",
  }
}

```



"common\_mistakes": "Students might think that reversing a magnet increases e.m.f., or that using steel wire improves performance, not realizing that the number of turns has a direct linear relationship with induced e.m.f."

},  
"calculation\_steps": [  
"Step 1: Apply Faraday's law:  $\epsilon = -N(d\phi/dt)$ ",  
"Step 2: Recognize that for a rotating coil in uniform field:  $\epsilon = \omega N A B \sin \theta$ ",  
"Step 3: Conclude that doubling N doubles the induced e.m.f."

],  
"topic": "Electromagnetic Induction",  
"confidence\_score": 0.98,  
"solved\_by\_ai": true,  
"needs\_review": false,  
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{  
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"question\_number": 32,  
"question\_text": "A current passes along a wire placed between the poles of a permanent magnet. The wire experiences a force due to the magnetic field. What will change the direction of this force?",  
"options": {  
"A": "increasing the current",  
"B": "reversing the current",  
"C": "increasing the strength of the magnetic field",  
"D": "using an electromagnet with the same polarity as the permanent magnet"

},  
"image\_filename": "question\_32\_enhanced.png",  
"page": 13,  
"marks": 1,  
"subject": "physics",  
"difficulty": "medium",  
"correct\_answer": "B",  
"explanation": "Reversing the current will change the direction of the force because the direction of the magnetic force depends on the direction of current flow according to Fleming's Left Hand Rule.",  
"extraction\_method": "enhanced\_multi\_strategy\_detection",  
"detection\_strategy": "standalone\_number",  
"confidence": 0.9,  
"has\_images": true,

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    "extraction_focus": "web_interface_compatible",
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      "reasoning": "The force on a current-carrying conductor in a magnetic field is given by  $F = BIL \sin\theta$ , where the direction is determined by Fleming's Left Hand Rule (or the cross product  $F = IL \times B$ ). The direction of force depends on: 1) Direction of magnetic field (B), 2) Direction of current (I). Since the magnetic field direction is fixed by the permanent magnet poles, only changing the current direction will reverse the force direction. Increasing current magnitude (A) or field strength (C) only changes force magnitude, not direction. Using an electromagnet with same polarity (D) doesn't change the field direction.",
      "key_concepts": "Fleming's Left Hand Rule, magnetic force on current-carrying conductor, vector cross product, relationship between current direction and force direction",
      "common_mistakes": "Students often confuse magnitude changes with direction changes, or think that increasing field strength changes direction rather than just magnitude"
    },
    "calculation_steps": [
      "Step 1: Apply Fleming's Left Hand Rule – First finger (field), second finger (current), thumb (force)",
      "Step 2: Analyze each option's effect on the force vector  $F = IL \times B$ ",
      "Step 3: Only reversing current (I) changes the direction of the cross product"
    ],
    "topic": "Electromagnetism",
    "confidence_score": 0.98,
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      "output_tokens": 505,
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  {
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    "question_number": 33,
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    "options": {
      "A": "changing a direct current into an alternating current",
      "B": "changing the magnitude of an alternating voltage",
      "C": "reducing the frequency of an alternating current",
      "D": "switching off the current in a circuit when there is a fault"
    }
  },

```

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    "image_filename": "question_33_enhanced.png",
    "page": 13,
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    "subject": "physics",
    "difficulty": "easy",
    "correct_answer": "B",
    "explanation": "A transformer is used to change the magnitude
of an alternating voltage by electromagnetic induction between
primary and secondary coils.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
    "extraction_focus": "web_interface_compatible",
    "detailed_explanation": {
        "reasoning": "A transformer consists of two coils (primary
and secondary) wound around a common iron core. When an alternating
voltage is applied to the primary coil, it creates a changing
magnetic flux in the core. This changing flux induces a voltage in
the secondary coil according to Faraday's law. The voltage ratio
depends on the turns ratio:  $V_s/V_p = N_s/N_p$ . This allows transformers
to step up or step down AC voltages while maintaining power
conservation (ignoring losses).",
        "key_concepts": "Electromagnetic induction, Faraday's law,
mutual inductance, AC voltage transformation, turns ratio",
        "common_mistakes": "Students often confuse transformers with
other electrical devices. Option A describes an inverter, Option C
is incorrect as transformers don't change frequency, and Option D
describes a circuit breaker or fuse."
    },
    "calculation_steps": [
        "Not applicable – this is a conceptual question about
transformer function",
        "Key relationship:  $V_s/V_p = N_s/N_p$  (voltage ratio equals turns
ratio)",
        "Power conservation:  $V_p I_p = V_s I_s$  (ideal transformer)"
    ],
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    "confidence_score": 0.98,
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    "needs_review": false,
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{
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"question_number": 34,
"question_text": "What are the relative charges on a proton, a
neutron and an electron?",
"options": {
  "A": "proton: 0, neutron: -1, electron: +1",
  "B": "proton: 0, neutron: -1, electron: -1",
  "C": "proton: +1, neutron: 0, electron: -1",
  "D": "proton: +1, neutron: 0, electron: +1"
},
"image_filename": "question_34_enhanced.png",
"page": 13,
"marks": 1,
"subject": "physics",
"difficulty": "easy",
"correct_answer": "C",
"explanation": "Protons have a positive charge (+1), neutrons
are neutral (0), and electrons have a negative charge (-1).",
"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "This is a fundamental concept in atomic
structure. A proton carries a positive elementary charge (+1 in
relative units), a neutron is electrically neutral (0 charge), and
an electron carries a negative elementary charge (-1 in relative
units). These charges are equal in magnitude but opposite in sign
for protons and electrons, which allows atoms to be electrically
neutral when they have equal numbers of protons and electrons.",
  "key_concepts": "Atomic structure, elementary charge,
subatomic particles, electrical neutrality",
  "common_mistakes": "Students sometimes confuse the signs of
the charges, particularly mixing up electron and proton charges, or
incorrectly assigning charge to neutrons"
},
"calculation_steps": [
  "Step 1: Recall fundamental properties of subatomic
particles",
  "Step 2: Proton = positive charge = +1 (relative)",
  "Step 3: Neutron = neutral = 0 charge",
  "Step 4: Electron = negative charge = -1 (relative)"
],
"topic": "Atomic Physics/Structure",
"confidence_score": 0.99,
"solved_by_ai": true,
"needs_review": false,
"flag_reason": "",
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provided image]",
  "options": {
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    "B": "55\u00b0",
    "C": "70\u00b0",
    "D": "110\u00b0"
  },
  "image_filename": "question_35_enhanced.png",
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  "marks": 1,
  "subject": "physics",
  "difficulty": "Cannot assess",
  "correct_answer": "Unable to determine",
  "explanation": "Cannot provide answer without seeing the
complete question and any relevant diagrams",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "The image only shows answer choices with angle
measurements, but lacks the essential context such as the problem
statement, geometric figures, or physical setup that would allow for
proper analysis and solution.",
    "key_concepts": "Unable to identify without question context
- could involve geometry, optics, mechanics, or other physics topics
dealing with angles",
    "common_mistakes": "Cannot identify potential mistakes
without knowing the specific problem type"
  },
  "calculation_steps": [
    "Step 1: Need to see the complete question text",
    "Step 2: Need to identify any given diagrams or figures",
    "Step 3: Need to understand the physical or geometric
relationships involved"
  ],
  "topic": "Unknown - requires angle measurement",
  "confidence_score": 0.0,
  "solved_by_ai": true,
  "needs_review": true,
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  "question_number": 36,
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  "options": {
    "A": "emission of an alpha-particle \u2713, emission of a beta-particle \u2713, emission of a gamma ray \u2717",
    "B": "emission of an alpha-particle \u2713, emission of a beta-particle \u2717, emission of a gamma ray \u2717",
    "C": "emission of an alpha-particle \u2717, emission of a beta-particle \u2713, emission of a gamma ray \u2713",
    "D": "emission of an alpha-particle \u2717, emission of a beta-particle \u2713, emission of a gamma ray \u2717"
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  "page": 14,
  "marks": 1,
  "subject": "physics",
  "difficulty": "medium",
  "correct_answer": "A",
  "explanation": "Both alpha and beta particle emissions change the atomic number, thus transforming one element into another. Gamma ray emission only releases energy without changing the element identity.",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
  "has_images": true,
  "extraction_focus": "web_interface_compatible",
  "detailed_explanation": {
    "reasoning": "To determine which decay types cause transmutation (change from one element to another), we need to examine how each type affects the atomic number (Z): Alpha decay: nucleus loses 2 protons and 2 neutrons (He nucleus), so Z decreases by 2 – this creates a new element. Beta-minus decay: neutron converts to proton + electron, so Z increases by 1 – this creates a new element. Beta-plus decay: proton converts to neutron + positron, so Z decreases by 1 – this creates a new element. Gamma decay: nucleus releases energy photon only, Z remains unchanged – same element, just lower energy state. Since the question asks which types cause elemental change, both alpha and beta emissions qualify, while gamma emission does not.",
    "key_concepts": "Radioactive decay, transmutation, atomic number, alpha particles, beta particles, gamma rays, nuclear physics",
    "common_mistakes": "Students often think gamma rays change

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the element because they're high-energy radiation, or forget that beta decay involves changing neutrons to protons (or vice versa) which changes the atomic number"

```
    },
    "calculation_steps": [
      "Step 1: Analyze alpha decay - loses 2 protons, atomic
number changes by -2",
      "Step 2: Analyze beta decay - neutron\u2194proton
conversion, atomic number changes by \u00b11",
      "Step 3: Analyze gamma decay - only energy emission, atomic
number unchanged",
      "Step 4: Identify that alpha and beta change atomic number
(new element), gamma does not"
    ],
    "topic": "Nuclear Physics - Radioactive Decay",
    "confidence_score": 0.98,
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  {
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    "question_number": 37,
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rays as safely as possible. Which action will not reduce the total
radiation that reaches the scientist?",
    "options": {
      "A": "keeping the distance between the source and the
scientist as large as possible",
      "B": "keeping the temperature of the source as low as
possible",
      "C": "keeping the time for which the scientist uses the
source as small as possible",
      "D": "placing a lead screen between the scientist and the
source"
    },
    "image_filename": "question_37_enhanced.png",
    "page": 14,
    "marks": 1,
    "subject": "physics",
    "difficulty": "medium",
    "correct_answer": "B",
    "explanation": "Temperature has no effect on gamma ray
emission from radioactive sources, unlike distance, time, and
shielding which all reduce radiation exposure.",
  }
```

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    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
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    "detailed_explanation": {
      "reasoning": "This question tests understanding of radiation
protection principles. Let's analyze each option: A) Distance –
follows inverse square law, increasing distance reduces radiation
intensity reaching the scientist. C) Time – reducing exposure time
directly reduces total radiation dose received. D) Lead shielding –
absorbs gamma rays, reducing radiation reaching the scientist. B)
Temperature – gamma ray emission from radioactive decay is
independent of temperature; it's a nuclear process unaffected by
thermal energy at normal temperatures.",
      "key_concepts": "Radiation protection follows ALARA
principles: Time, Distance, and Shielding. Radioactive decay is a
nuclear process independent of temperature under normal
conditions.",
      "common_mistakes": "Students might think temperature affects
all forms of radiation emission, confusing thermal radiation
(blackbody radiation) with nuclear gamma ray emission from
radioactive decay."
    },
    "calculation_steps": [
      "Step 1: Identify radiation protection methods – Time,
Distance, Shielding",
      "Step 2: Evaluate each option against known physics
principles",
      "Step 3: Recognize that radioactive decay rate is
temperature-independent"
    ],
    "topic": "Nuclear Physics – Radiation Protection",
    "confidence_score": 0.98,
    "solved_by_ai": true,
    "needs_review": false,
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  {
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    "question_number": 38,
    "question_text": "Which time period is approximately equal to
24 hours?",
    "options": {
      "A": "the time for the Earth to complete one rotation on its

```



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axis",
  "B": "the time for the Earth to orbit the Sun",
  "C": "the time for the Moon to orbit the Earth",
  "D": "the time for the Sun to orbit the Earth"
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"image_filename": "question_38_enhanced.png",
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"difficulty": "easy",
"correct_answer": "A",
"explanation": "Earth's rotation on its axis takes
approximately 24 hours, which is what defines a day.",
"extraction_method": "enhanced_multi_strategy_detection",
"detection_strategy": "standalone_number",
"confidence": 0.9,
"has_images": true,
"extraction_focus": "web_interface_compatible",
"detailed_explanation": {
  "reasoning": "Let's analyze each option systematically:
Option A refers to Earth's rotation period, which is exactly what
defines a day (24 hours). Option B describes Earth's orbital period
around the Sun, which takes approximately 365.25 days or one year.
Option C refers to the Moon's orbital period around Earth, which
takes about 27.3 days (sidereal month) or 29.5 days (synodic month).
Option D is scientifically incorrect as the Sun doesn't orbit Earth;
this reflects an outdated geocentric model.",
  "key_concepts": "Earth's rotation period, day-night cycle,
distinction between rotation and revolution, astronomical time
periods",
  "common_mistakes": "Students sometimes confuse rotation
(spining on axis) with revolution (orbiting around another body),
or may not know the specific time periods for different astronomical
cycles"
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"calculation_steps": [
  "Step 1: Identify what defines a 24-hour period (one day)",
  "Step 2: Recall that one day corresponds to Earth completing
one full rotation on its axis",
  "Step 3: Compare with other astronomical periods: Earth's
orbit = 1 year, Moon's orbit = ~27-29 days"
],
"topic": "Astronomy/Earth Science - Planetary Motion",
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    "options": {
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      "B": "1 and 3 only",
      "C": "1 only",
      "D": "2 and 3 only"
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    "image_filename": "question_39_enhanced.png",
    "page": 15,
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    "correct_answer": "C",
    "explanation": "Only statement 1 is correct. Light from a star 4 light-years away takes 4 years to reach Earth. Statement 2 is incorrect because light from the Sun would take 8 years for a round trip to the star. Statement 3 is incorrect because the nearest star to the Sun (Proxima Centauri) is within our galaxy.",
    "extraction_method": "enhanced_multi_strategy_detection",
    "detection_strategy": "standalone_number",
    "confidence": 0.9,
    "has_images": true,
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    "detailed_explanation": {
      "reasoning": "Let's analyze each statement: Statement 1: If the star is 4 light-years away, by definition of a light-year, light takes exactly 4 years to travel this distance. This is correct. Statement 2: For light to travel from the Sun to the star (4 light-years) and back to Earth (another 4 light-years), the total distance is 8 light-years, so it would take 8 years, not 4. This is incorrect. Statement 3: The nearest star to the Sun is Proxima Centauri, which is part of the Alpha Centauri system. This star is within our Milky Way galaxy, not outside it. Our galaxy is about 100,000 light-years across, so a star only 4 light-years away is very close by galactic standards. This is incorrect.",
      "key_concepts": "Light-year as a unit of distance, speed of light being constant, structure of our galaxy, astronomical distances",
      "common_mistakes": "Students often confuse round-trip distances with one-way distances, or assume that nearby stars must be outside our galaxy due to the large distances involved"
    },
    "calculation_steps": [

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"Step 1: Statement 1 - Distance = 4 light-years, so time = 4 years (by definition of light-year)",

"Step 2: Statement 2 - Round trip distance = 4 + 4 = 8 light-years, so time = 8 years",

"Step 3: Statement 3 - Compare 4 light-years to galaxy size (~100,000 light-years) - star is within galaxy"

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  "options": {
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    "B": "iron, infrared",
    "C": "hydrogen, gamma",
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  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
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  "has_images": true,
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  "detailed_explanation": {
    "reasoning": "The question asks for two pieces of information: (1) one of the most common elements in the Sun, and (2) one of the regions where the Sun radiates most of its energy. For the element: The Sun is composed primarily of hydrogen (~73% by
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mass) and helium (~25% by mass). Iron, while present, makes up less than 0.1% of the Sun's mass. Therefore, hydrogen is clearly one of the most common elements. For the electromagnetic radiation: Although the Sun's surface temperature (~5778K) means its peak emission is in the visible range (according to Wien's displacement law), when considering the total energy output across all wavelengths, the Sun actually radiates a significant portion of its energy in the infrared region. The Sun's spectrum extends well into the infrared, and this region contains a substantial fraction of the total radiated energy. Gamma rays, while produced in the Sun's core during nuclear fusion, are absorbed and re-emitted at lower energies before reaching the surface, so very little gamma radiation escapes the Sun."

"key\_concepts": "Solar composition, electromagnetic spectrum, blackbody radiation, stellar physics",  
"common\_mistakes": "Students might incorrectly think iron is common in the Sun because it's common on Earth, or might assume gamma rays are the primary emission because of nuclear fusion in the core"

},  
"calculation\_steps": [  
"Step 1: Identify the most abundant element in the Sun - hydrogen (~73% by mass)",  
"Step 2: Consider the Sun's energy distribution across the electromagnetic spectrum",  
"Step 3: Recognize that while peak emission is in visible light, significant energy is radiated in infrared"

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