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table-tennis balls placed between two wooden blocks. What is the diameter of one ball?",
    "options": {
      "A": "4 cm",
      "B": "5 cm",
      "C": "6 cm",
      "D": "8 cm"
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"page": 2,

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"difficulty": "easy",

"correct_answer": "B",

"explanation": "The six balls span from 32 cm to 62 cm on the ruler, giving a total length of 30 cm. Since there are 6 identical balls, each ball has a diameter of $30 \div 6 = 5$ cm.",

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"has_images": true,

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"reasoning": "From the diagram, I can see that the six table-tennis balls are lined up between two wooden blocks. The metre ruler shows measurements at 32, 38, 62, and 65 cm. The balls appear to span from the 32 cm mark to the 62 cm mark on the ruler. This gives us the total length occupied by all six balls. Since the balls are identical and touching each other, the total length equals 6 times the diameter of one ball.",

"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"

},

"calculation_steps": [

"Step 1: Identify the span of the six balls on the ruler: from 32 cm to 62 cm",

"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",

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"Step 4: Since balls are touching, this length represents the diameter of one ball"
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with time. Which statements can be true?",
  "options": {
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    "B": "1 and 4",
    "C": "2 and 3",
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"D": "3 and 4"

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"image_filename": "question_02_enhanced.png",

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"marks": 1,

"subject": "physics",

"difficulty": "medium",

"correct_answer": "B",

"explanation": "The horizontal line graph shows a constant value over time. This is consistent with either a stationary train at constant distance (statement 1) or a moving train at constant speed (statement 4).",

"extraction_method": "enhanced_multi_strategy_detection",

"detection_strategy": "standalone_number",

"confidence": 0.9,

"has_images": true,

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"reasoning": "The graph shows y as a horizontal line, 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 (\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 (\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 $y=0$ (\u2713). Statement 4 - If the train is moving at constant speed, y remains constant over time, matching the horizontal line (\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 ",

"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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    "B": "54N",
    "C": "740N",
    "D": "2000N"
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  "subject": "physics",
  "difficulty": "easy",
  "correct_answer": "C",
  "explanation": "Weight equals mass times gravitational acceleration:  $W = mg = 200 \text{ kg} \times 3.7 \text{ m/s}^2 = 740 \text{ N}$ ",
  "extraction_method": "enhanced_multi_strategy_detection",
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  "confidence": 0.9,
  "has_images": true,
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"reasoning": "Weight is the gravitational force acting on an object and is calculated using $W = mg$, where m is mass and g is gravitational acceleration. On Mars, the gravitational acceleration is different from Earth's (9.8 m/s^2), being only 3.7 m/s^2 . The mass of the vehicle remains constant at 200 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 m/s^2) instead of Mars' gravity (3.7 m/s^2), or forgetting to multiply mass by gravitational acceleration"

},

"calculation_steps": [

"Step 1: Identify given values - mass (m) = 200 kg , Mars gravity (g) = 3.7 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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    "options": {  
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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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    "difficulty": "easy",  
    "correct_answer": "D",  
    "explanation": "Mass is an intrinsic property of matter that remains constant regardless  
of location, so an astronaut's mass is the same on Earth and the Moon.",  
    "extraction_method": "enhanced_multi_strategy_detection",  
    "detection_strategy": "standalone_number",  
    "confidence": 0.9,  
    "has_images": true,  
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"detailed_explanation": {

"reasoning": "Let me analyze each option: A) A floating ship still has weight (gravitational force) acting on it, balanced by buoyant force. B) Mass and weight are different - mass is the amount of matter, weight is gravitational force. C) Mass is measured in kilograms, not newtons (which measure force/weight). D) Mass is an intrinsic property that doesn't change with location - only weight changes due to different gravitational fields.",

"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"

},

"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 (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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  "marks": 1,

  "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).",

  "extraction_method": "enhanced_multi_strategy_detection",
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"detection_strategy": "standalone_number",

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"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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"topic": "Density and Measurement",

"confidence_score": 0.98,

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  "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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"subject": "physics",

"difficulty": "medium",

"correct_answer": "A",

"explanation": "Option A shows equilibrium because the equal downward forces at both ends create equal and opposite torques about the pivot, resulting in zero net torque and zero net force.",

"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 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 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."

},

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  "Step 2: Calculate torque for each force ( $\tau = F \times d$ , 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 = 100N  $\times$  d (clockwise), Right torque = 100N  $\times$   
d (counterclockwise), Net torque = 0"  
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"options": {

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

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

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

"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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"confidence": 0.9,

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"reasoning": "To find the moment of a force about a pivot point, we use the formula: Moment = Force \times perpendicular distance from pivot. Looking at the diagram, force Y is located at distance b from the pivot (triangle symbol). Force X is at distance a from the pivot. The moment of force Y about the pivot is therefore $Y \times b$, where b is the perpendicular distance from the line of action of force Y to the pivot point.",

"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: $\text{Moment} = \text{Force} \times \text{distance} = Y \times b$ "

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"topic": "Mechanics - Moments and Equilibrium",

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"question_text": "A mass bounces up and down on a steel spring. The diagram shows the mass and the spring at different points during the motion. At which point is the least energy in the gravitational potential store of the mass and at which point is the most energy in the elastic store of the spring?",

"options": {

"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).",

"extraction_method": "enhanced_multi_strategy_detection",

"detection_strategy": "standalone_number",

"confidence": 0.9,

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"extraction_focus": "web_interface_compatible",

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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",

"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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"topic": "Mechanics - Simple Harmonic Motion and Energy",

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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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"correct_answer": "C",

"explanation": "Five resources are renewable: biofuels, tidal energy, geothermal energy, hydroelectric energy, and solar energy. Fossil fuels and nuclear fuel are non-renewable.",

"extraction_method": "enhanced_multi_strategy_detection",

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  "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 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."

},

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

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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",
"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,
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{
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  "question_number": 11,
  "question_text": "Why is it easier to push a sharp nail, rather than a blunt nail, into a piece of wood?"
```



```
"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."  
},
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"image_filename": "question_11_enhanced.png",
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"page": 6,
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"marks": 1,
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```
"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 ( $\text{Pressure} = \text{Force}/\text{Area}$ ), making it easier to penetrate.",
```

```
"extraction_method": "enhanced_multi_strategy_detection",
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```
"detection_strategy": "standalone_number",
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"confidence": 0.9,
```

```
"has_images": true,
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"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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"model_used": "claude-sonnet-4-20250514"

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{  
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  "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"  
  },  
  "image_filename": "question_12_enhanced.png",  
  "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 ($KE_{avg} = \frac{3}{2} kT$). 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 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 \Rightarrow higher average kinetic energy \Rightarrow 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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"api_usage": {

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"input_tokens": 1190,
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{
  "id": "physics_q13",
  "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",

"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",

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"confidence_score": 0.98,
"solved_by_ai": true,
"needs_review": false,
"flag_reason": "",
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  "cost": 0.010629,
  "model_used": "claude-sonnet-4-20250514"
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  "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."
  },
  "image_filename": "question_14_enhanced.png",
  "page": 7,
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"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 α is the coefficient of linear expansion, L is the original length, and ΔT 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": "",
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"model_used": "claude-sonnet-4-20250514"
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{
  "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",  
  "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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},  
{  
  "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"  
},
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"page": 7,
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"marks": 1,
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"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",
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```
"detection_strategy": "standalone_number",
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"confidence": 0.9,
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```
"has_images": true,
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```
"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 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": "",

"solved_at": "2025-08-26T12:12:42.555356",

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  "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,
  "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 $\sim 3 \times 10^8$ 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": "",

"solved_at": "2025-08-26T12:13:03.841268",

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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,
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"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,

"needs_review": false,

"flag_reason": "",

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"processing_time": 16.65447,

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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",
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"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,

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"options": {

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"B": "54N",

"C": "740N",

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"D": "2000N"
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"explanation": "Cannot determine correct answer without seeing the complete question",
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  "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)",
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{
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  "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",
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"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",

"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,
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{
  "id": "physics_q22",
  "question_number": 22,
  "question_text": "The diagram shows the electromagnetic spectrum. Which types of
wave are E, F and G?",
  "options": {
```



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"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,

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"output_tokens": 493,

"cost": 0.010712999999999999,

"model_used": "claude-sonnet-4-20250514"

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"id": "physics_q23",

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"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 ($v = \sqrt{B/\rho}$ 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,

"flag_reason": "",

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  "options": {  
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    "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,
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"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 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": [

    "Step 1: Identify the magnetic classification of each metal",

    "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,

"flag_reason": "",

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  "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": {
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    "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",
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"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.",

"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",


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"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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"needs_review": false,
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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"
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"topic": "Electrical Properties of Materials",
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  "question_text": "What is the unit of resistance?",
  "options": {
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"A": "ampere",
"B": "ohm",
"C": "volt",
"D": "watt"
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"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": [
    "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:  $R = \text{volts/amperes} = \text{ohms}$  (\u03a9)"
  ],
  "topic": "Electricity and Magnetism - Basic Electrical Quantities",
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{
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  "question_number": 28,
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"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 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,

"flag_reason": "",

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{
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  "question_number": 29,
  "question_text": "Resistors of resistance  $2.0\ \Omega$  and  $3.0\ \Omega$  are connected in two different circuits. What is the total resistance in each circuit?",
  "options": {
    "A": "series: less than  $2.0\ \Omega$ , parallel: less than  $2.0\ \Omega$ ",
    "B": "series: less than  $2.0\ \Omega$ , parallel: greater than  $3.0\ \Omega$ ",
    "C": "series: greater than  $3.0\ \Omega$ , parallel: less than  $2.0\ \Omega$ ",
    "D": "series: greater than  $3.0\ \Omega$ , parallel: greater than  $3.0\ \Omega$ "
  },
  "image_filename": "question_29_enhanced.png",
  "page": 11,
  "marks": 1,
  "subject": "physics",
  "difficulty": "easy",
  "correct_answer": "C",
  "explanation": "In series, resistances add ( $2.0\ \Omega + 3.0\ \Omega = 5.0\ \Omega > 3.0\ \Omega$ ). In parallel, total resistance is less than the smallest individual resistance ( $1.2\ \Omega < 2.0\ \Omega$ ).",
  "extraction_method": "enhanced_multi_strategy_detection",
  "detection_strategy": "standalone_number",
  "confidence": 0.9,
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"has_images": true,

"extraction_focus": "web_interface_compatible",

"detailed_explanation": {

    "reasoning": "For series circuits, resistances simply add together:  $R_{total} = R1 + R2$ . For parallel circuits, the reciprocal formula applies:  $1/R_{total} = 1/R1 + 1/R2$ . 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:  $R_{series} = 2.0\Omega + 3.0\Omega = 5.0\Omega$ ",

    "Step 2: Parallel calculation:  $1/R_{parallel} = 1/2.0\Omega + 1/3.0\Omega = 3/6 + 2/6 = 5/6$ ",

    "Step 3:  $R_{parallel} = 6/5 = 1.2\Omega$ ",

    "Step 4: Compare results:  $5.0\Omega > 3.0\Omega$  (series) and  $1.2\Omega < 2.0\Omega$  (parallel)"

],

"topic": "Electric Circuits - Resistance",

"confidence_score": 0.98,

"solved_by_ai": true,

"needs_review": false,

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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"
  },
  "image_filename": "question_30_enhanced.png",
  "page": 12,
  "marks": 1,
  "subject": "physics",
  "difficulty": "medium",
  "correct_answer": "B",
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"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,

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{
  "id": "physics_q31",
  "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,
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"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: $\epsilon = N B \omega \sin \omega t$ ",

"Step 3: Conclude that doubling N doubles the induced e.m.f."

],

"topic": "Electromagnetic Induction",

"confidence_score": 0.98,

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"needs_review": false,

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"api_usage": {

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"cost": 0.013662,

"model_used": "claude-sonnet-4-20250514"

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"model_used": "claude-sonnet-4-20250514"

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{

"id": "physics_q32",

"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,

"extraction_focus": "web_interface_compatible",

"detailed_explanation": {

"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,

"solved_by_ai": true,

"needs_review": false,

"flag_reason": "",

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"cost": 0.011397000000000001,

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"model_used": "claude-sonnet-4-20250514"


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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"
  },
  "image_filename": "question_33_enhanced.png",
  "page": 13,
  "marks": 1,
  "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)"

],

"topic": "Electromagnetism/AC Circuits",

"confidence_score": 0.98,

"solved_by_ai": true,

"needs_review": false,

"flag_reason": "",

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"api_usage": {

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"cost": 0.009156000000000001,

"model_used": "claude-sonnet-4-20250514"

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"model_used": "claude-sonnet-4-20250514"
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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": {
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"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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"processing_time": 11.577836,

"api_usage": {

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"cost": 0.009663,

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  "question_text": "[Question text not clearly visible in the provided image]",
  "options": {
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    "B": "55\u00b0",
    "C": "70\u00b0",
    "D": "110\u00b0"
  },
  "image_filename": "question_35_enhanced.png",
  "page": 9,
  "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,
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"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,

"flag_reason": "Low confidence: 0.0% (below 91%)",

"solved_at": "2025-08-26T12:17:18.000112",

"processing_time": 13.733577,

"api_usage": {

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  "cost": 0.007785,

  "model_used": "claude-sonnet-4-20250514"
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  "question_number": 36,  
  "question_text": "Which type of radioactive decay causes the nucleus of one element to  
change into the nucleus of another element?",  
  "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"  
  },  
  "image_filename": "question_36_enhanced.png",  
  "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",
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"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 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 to proton conversion, atomic number changes by +1",

"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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"model_used": "claude-sonnet-4-20250514"
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{
  "id": "physics_q37",
  "question_number": 37,
  "question_text": "A scientist needs to use a source of \u03b3-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,
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"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.",

"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 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,
"flag_reason": "",
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{
  "id": "physics_q38",
  "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 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",
"page": 14,
"marks": 1,
"subject": "physics",
"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 (spinning on axis) with revolution (orbiting around another body), or may not know the specific time periods for different astronomical cycles"
},
"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",

"confidence_score": 0.98,

"solved_by_ai": true,

"needs_review": false,

"flag_reason": "",

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"id": "physics_q39",

"question_number": 39,

"question_text": "The nearest star to the Sun is about four light-years away from the Earth. A student makes three statements about the star. 1 Light from the star takes about four years to reach the Earth. 2 Light from the Sun takes about four years to travel to the star and back to the Earth. 3 The star is outside our galaxy. Which statements are correct?",

```
"options": {  
  "A": "1, 2 and 3",  
  "B": "1 and 3 only",  
  "C": "1 only",  
  "D": "2 and 3 only"  
},  
"image_filename": "question_39_enhanced.png",  
"page": 15,  
"marks": 1,  
"subject": "physics",  
"difficulty": "medium",  
"correct_answer": "C",
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"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,  
"extraction_focus": "web_interface_compatible",  
"detailed_explanation": {
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"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": [

"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"

],

"topic": "Astronomy and Light",

"confidence_score": 0.98,

"solved_by_ai": true,

"needs_review": false,

"flag_reason": "",

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"api_usage": {

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"output_tokens": 690,

"cost": 0.01329,

"model_used": "claude-sonnet-4-20250514"

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"model_used": "claude-sonnet-4-20250514"

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  "question_number": 40,

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Sun and one of the regions in which the Sun radiates most of its energy?",

  "options": {

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  "difficulty": "medium",

  "correct_answer": "D",

  "explanation": "Hydrogen is the most abundant element in the Sun (about 73% by mass),
and the Sun radiates most of its energy in the infrared region of the electromagnetic
spectrum.",

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"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 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"

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"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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"topic": "Stellar Physics and Electromagnetic Spectrum",

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