Important Topics

Analysis of June R Papers from Examiner Reports:

Area / Topic	Common Pitfalls (What Students Do Wrong)	Examiner Advice (How to Score Full Marks)	Additional Preparation (What to Do Before the Exam)
General Exam Technique	**Ignoring the command word** (e.g., giving a description for an 'explain' question). **Not using the number of marks available** as a guide for the required level of detail. **Providing vague or generic answers** like "human error" or "it's expensive" without specific details. **Not reading the question carefully** and providing irrelevant information.	**Pay close attention to command words** ('describe', 'explain', 'calculate', 'comment on') to understand what is required. **Use the marks for each question** to judge how much detail to include in your answer **Attempt all questions,** as partial credit can be awarded.	**Practice past papers under timed conditions** to improve exam technique. Create a list of command words and what each one requires you to do in your answer **(attached below).** **Review mark schemes** to understand how marks are allocated for different types of questions.

Calculations & Quantitative Skills	**Unit Conversion Errors:** Forgetting to convert to standard SI units (e.g., kJ to J, cm to m, minutes to seconds, mJ to J) **Formula Errors:** Incorrectly rearranging formulae or substituting values into the wrong places. **Calculator & Rounding Errors:** Making power-of-ten errors. Incorrect use of calculators, especially with brackets. Inappropriate rounding or not showing enough significant figures in "show that" questions. **Conceptual Errors:** Forgetting that change in momentum is the same with and without an airbag, but the *rate* of change is different.	**Show all stages of your working clearly.** This allows examiners to award partial marks even if the final answer is wrong. **Always convert quantities to standard SI units** before substituting them into a formula. For "show that" questions, **calculate the value to more significant figures** than the one given to prove it rounds correctly. Know how to use your calculator correctly for **standard form and complex** fractions.	Thoroughly practice rearranging and using every formula listed in the specification. Create drills for converting between common prefixes (kilo, centi, milli) and base units. Work through a wide variety of calculation questions from past papers, focusing on showing every step.

Experimental Skills & Data Handling	**Designing Methods:** Describing impractical methods , omitting key equipment (like measuring instruments) , or giving vague steps. **Data & Graphs:** Incorrectly drawing tables by putting units in the data cells instead of headings. Using inappropriate scales on graphs or failing to label axes with units. Drawing poor lines of best fit **Analysis:** Not identifying and ignoring anomalous results when calculating a mean. Describing a simple pattern ("as X increases, Y increases") instead of a proper relationship (e.g., "directly proportional"). **Terminology:** Showing misunderstanding of key terms like 'precision' and 'accuracy'.	Provide detailed, coherent, and logical steps when describing an experiment Use labelled diagrams to support written descriptions of experimental setups. When asked to improve an experiment, be specific. For accuracy, suggest plotting a graph and finding the gradient or taking more readings over a wider range. Use the grid lines on graphs and oscilloscopes to draw precise plots and waves Be prepared to comment on data, identify anomalies, and suggest improvements.	Thoroughly revise all required practicals, understanding the method, variables, and expected results. Practice constructing results tables and drawing graphs from data sets. Learn the precise definitions of experimental terms: accuracy, precision, reliability, validity, resolution, and anomaly

Written Explanations & Subject Knowledge	**Incomplete Answers:** Only explaining one part of a comparison (e.g., describing vectors but not scalars) or failing to link a cause to an effect (e.g., stating an airbag increases time but not linking it to force). **Misconceptions:** Confusing related but distinct concepts (e.g., wave power vs. tidal power , heat vs. thermal energy , electrostatics vs. magnetism) **Focus:** Describing the wrong aspect of a topic (e.g., describing particle *arrangement* when asked for *movement*). **Vague Language:** Using imprecise terms, such as "it breaks," when the correct term is "it passes its limit of proportionality".	Structure longer answers carefully to ensure all aspects of the question are addressed in a logical order. Use precise scientific terminology (e.g., "rate of change of momentum," "total internal reflection"). Ensure explanations are complete by linking observations to the underlying physics principles. Successful candidates demonstrate a strong and detailed knowledge of the specification content.	Ensure a comprehensive understanding of all eight topics in the specification. Create concept maps or detailed notes to clarify the links between ideas within a topic. Practice writing out full explanations for multi-mark "explain" and "discuss" questions, then compare them against the mark scheme.

Command Words & Examiner Expectations

Command Word	What It Means	What the Examiner Expects	Common Mistakes to Avoid

State	Give a short, clear answer.	1-word or phrase response. No explanation required.	Adding unnecessary details or explanations.
Give	Provide a fact, name, or quantity.	Brief, accurate fact.	Writing an explanation when not needed.
Identify	Point out a specific item or idea.	Precise reference to what's being asked.	Giving vague or broad answers.
Describe	Say what you see or what happens.	Sequential, relevant observations or facts.	Mixing description with explanation.
Explain	Give reasons "why" something happens.	Clear reasoning linked to physics principles. Use cause → effect logic.	Only describing or stating a fact.
Compare / Contrast	Say how things are similar or different.	At least one similarity and one difference clearly stated. Use “whereas”, “however”.	Mixing features of only one item.
Calculate	Use a formula to find a value.	Show formula, substitution, and final answer (with units & sig. figs).	Missing working, incorrect units or rounding.
Determine	Use data to find an answer.	Use provided data to work through and conclude with a value.	Not showing steps or incorrectly using data.
Deduce	Use logic to conclude from given information.	Step-by-step reasoning using what's provided.	Making assumptions without justification.
Suggest	Apply knowledge in a new or unfamiliar context.	Reasoned answer with plausible logic.	Giving vague or textbook answers not suited to the context.

Evaluate	Consider advantages vs disadvantages. Make a judgment.	Balanced assessment and clear conclusion.	Listing pros only or failing to conclude.
Discuss	Present detailed ideas including pros, cons, and implications.	Developed explanation with contrasting views or impacts.	Repeating the same idea or staying too general.
Show that	Prove a given result by working through it.	All steps shown clearly; final answer should match the one given.	Skipping steps, giving wrong value, not showing method.
Plot	Draw a graph with labelled axes and correct scale.	Points plotted accurately, suitable scale, labelled axes with units.	Missing units, wrong scale, no line of best fit.
Sketch	Rough diagram with general shape or trend.	Shape/trend accurate even if no numbers; label features if asked.	Not showing key features (e.g. curve, peak).

Frequently Tested Topics

Rank	Topic	Years Tested	Total Number of Questions
1	**Forces and Motion** **(Includes moments, momentum, forces, work done, springs, and scalars/vectors)**	**2019, 2020, 2022, 2023**	**7**
2	**Waves** **(Includes speed of sound, oscilloscopes, refraction, and the Doppler effect)**	**2019, 2020, 2022, 2023**	**6**
2	**Solids, Liquids and Gases** **(Includes specific heat capacity, changes of state, and particle theory)**	**2019, 2020, 2022, 2023**	**6**

4	Electricity (Includes electrostatics and transformers/National Grid)	2019, 2020, 2022, 2023	5
5	Astrophysics (Includes stellar evolution, H-R diagrams, redshift, and the Big Bang theory)	2019, 2020, 2022, 2023	4
5	Energy Resources and Energy Transfer (Includes renewable/non-renewable resources and energy calculations)	2019, 2020, 2023	4
5	Magnetism and Electromagnetism (Includes electromagnets, transformers, and induction)	2019, 2020, 2022, 2023	4
8	Radioactivity and Particles(Includes half-life)	2020	1

Frequently Tested Topics (Including those in 2024 June R)

Most Frequently Tested Topics in IGCSE Physics Paper 2PR

Rank	Topic	No. of Questions	Total Marks	Years Tested
1	Waves (incl. Sound & Light)	6	36	2020, 2022, 2024
2	Electricity & National Grid	5	28	2020, 2022, 2024
3	Thermal Physics	4	25	2020, 2022, 2024

4	**Forces & Motion**	**4**	**24**	**2020, 2022, 2024**
5	**Radioactivity & Nuclear Physics**	**3**	**19**	**2020, 2022**
6	**Astrophysics (H-R diagram, stars)**	**3**	**15**	**2022, 2024**
7	**Particles & States of Matter**	**2**	**12**	**2020, 2024**
8	**Magnetism & Electromagnetism**	**2**	**11**	**2020, 2022**
9	**Energy Transfers & Efficiency**	**2**	**10**	**2020, 2022**
10	**Momentum**	**1**	**8**	**2024**
11	**Centre of Mass & Moments**	**1**	**7**	**2020**
12	**Big Bang & Cosmology**	**1**	**5**	**2020**

Notes:

- The most reliably tested core topics are: Waves, Electricity, and Thermal Physics.
- Practical-related content (e.g. oscilloscope, graph interpretation, experiment diagrams) often appears within Waves, Thermal, and Forces.
- Some topics like Momentum or Astrophysics are tested less frequently, but when they appear, they carry high mark weight.

Frequently Tested Formulas (Formula Sheet will be provided)

Rank	Formula	Description	Frequency (in 4 exams)
1	**Q = m*c*T**	**Change in thermal energy, used for specific heat capacity calculations.**	**6**

2	p=m*v	Momentum and related concepts like conservation of momentum and force as the rate of change of momentum.	4
2	v=f*lambda	The wave speed equation, linking wave speed, frequency, and wavelength.	4
4	Principle of Moments	Clockwise moments = Anticlockwise moments, used in problems involving balance and levers.	3
5	Vp/Vs=Np/Ns	The transformer turns ratio formula, linking primary and secondary voltages and turns.	2
5	P=E/t	The relationship between power, energy, and time.	2
5	f=1/T	The relationship between frequency and period of a wave.	2
8	W=F*d	Work done by a force over a distance.	1
8	E=Q*V	Energy transferred by an electric charge moving through a potential difference.	1
8	n=sin(i)/sin(r)	Snell's Law for calculating the refractive index.	1

8	sin(c)=1/n	The formula for the critical angle in total internal reflection.	1
8	$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$	The redshift formula used to calculate the recessional velocity of galaxies.	1

Revision Notes

Revision Notes:

All the best everyone, study the other topics you feel you need revision in and I hope you score the marks you expect in the exam 🫡🌠.

Candidate Performance by Topic Area (Areas to Revise)

Rank	Topic	Performance Summary (Common Difficulties and Strengths)
1 (Most Difficult)	**Astrophysics & Waves**	**Common Difficulties:** • Explaining the **Doppler effect** in detail was challenging; many students incorrectly linked frequency changes to distance rather than relative motion. • Explaining how redshift data supports the **Big Bang theory** required a level of detail that many did not provide. • Justifying why a star becomes a supernova, by linking its large mass and very bright absolute magnitude, was a common weak point.
2	**Forces and Motion**	**Common Difficulties:** • Conceptually explaining how safety features like airbags work was a major challenge. The most common error was stating that the *change in momentum* decreases, instead of the *rate of change of momentum*. • Applying the **Principle of Moments** in complex scenarios and explaining what happens when a spring is stretched beyond its elastic limit also proved difficult.
3	**Experimental Skills & Data Analysis**	**Common Difficulties:** • Understanding the difference between **accuracy and precision** and suggesting specific improvements for each was poorly answered. • Answering **"show that"** questions; students often failed to show all steps or evaluate their answer to a higher precision than the given value.

		• Many students struggled with drawing data tables correctly (e.g., putting units in the body of the table) and handling anomalous results in mean calculations.
4	**Electricity & Magnetism**	**Common Difficulties:** • Explaining how a current is induced in a transformer's core was found to be very challenging. • Explaining the *reason* for using high voltage (i.e., to reduce current and thus energy loss) was a key detail often missed in descriptions of the National Grid. **Strengths:** • Most candidates could correctly identify step-up and step-down transformers and knew the formula for the turns ratio.
5	**Energy & States of Matter**	**Common Difficulties:** • Describing the motion and arrangement of particles during phase changes was surprisingly challenging, with vague or inaccurate descriptions being common. • Calculations involving specific heat capacity often had errors due to incorrect unit conversions or calculator use. **Strengths:** • Discussing the advantages and disadvantages of different energy sources was generally well-answered.
6 (Least Difficult)	**Basic Calculations & Factual Recall**	**Strengths:** • Straightforward calculations where the formula was provided (e.g., `momentum = mass × velocity`) were often answered correctly. • Factual recall questions, such as identifying a fossil fuel or naming parts of a generator, were typically well-performed. Most students could correctly calculate a mean from a simple data set and state basic physical relationships (e.g., as force increases, extension increases).

Key Theories Tested: Forces and Motion

- **Momentum**: This is a fundamental concept, defined by the formula **momentum = mass × velocity** (p=m×v).
  - Questions frequently test the **principle of conservation of momentum**, where the total momentum before a collision equals the total momentum after it.
  - Students are also expected to understand how **safety features, like airbags,** work by increasing the time of impact to reduce the rate of change of momentum, thereby lowering the force experienced.
  - A common mistake is confusing a decrease in the *rate of change of momentum* with a decrease in the *change in momentum* itself.
- **Newton's Third Law**: This law is often tested in the context of collisions.
  - Students must understand that during a collision, the forces exerted by the two objects on each other are **equal in magnitude and opposite in direction**.
  - A frequent error is failing to specify the direction of both forces involved.
- **Principle of Moments**: This principle states that for an object to be in equilibrium or balanced, the sum of the clockwise moments about a pivot must equal the sum of the anti-clockwise moments. Students must identify the pivot, forces, and their perpendicular distances to apply this principle correctly.
- **Hooke's Law**: Investigations explore the relationship between the force applied to a spring and its extension.
  - Successful answers describe this as a directly proportional or linear relationship.
  - Explanations must also cover what happens when the force is too large, causing the spring to exceed its limit of proportionality and become permanently stretched.

Common Calculations ALWAYS WRITE TO 2 S.F. UNLESS INSTRUCTED OTHERWISE.

- **Momentum Calculation**: Students must calculate momentum using the formula p=m×v. This includes "show that" questions where the mass must be calculated from a given momentum and velocity. To score full marks on "show that" questions, candidates should evaluate their answer to more significant figures than the value given in the question to demonstrate the rounding process.
- **Force from Change in Momentum**: A key calculation involves the formula **Force = change in momentum / time** (F=Δp/t). This is used to determine the force exerted during a collision or the time over which the collision occurs.

- **Principle of Moments Calculation**: This involves setting up and solving an equation where the clockwise moment (Force × distance) equals the anti-clockwise moment (Force × distance) to find an unknown force or distance. Successful candidates clearly write out each stage of their calculation.
- **Work Done by a Force**: Students calculate work done using the formula **Work done = force × distance** moved in the direction of the force. Errors often arise from failing to convert units, such as grams to kilograms or millimeters to meters, before calculation.

Key Theories and Concepts Tested: Electricity

- **Transformers and the National Grid**: This is a frequently tested area. You're expected to know the roles of **step-up** and **step-down transformers**. A key part of this is explaining *why* they are used. Successful explanations follow a clear chain of logic:
    - a step-up transformer increases voltage,
    - which in turn decreases current.
    - This reduction in current minimizes energy (or heat) loss in the transmission cables, making the process more efficient.
    - A step-down transformer then lowers the voltage to a safer level for use in homes and schools.
- **Static Electricity**: Questions often test how objects become charged, usually by the transfer of electrons through friction (rubbing). You should be able to describe simple experiments to demonstrate that an object is charged,
    - such as using it to attract small pieces of paper
    - or a stream of water.

Explanations for why a charged object can attract a neutral one (through induced charges) are also important. Another key area is explaining why static charge buildup can be dangerous, for instance, during aircraft refueling, where a spark could cause a fire or explosion.

- **Induced Current**: This more challenging concept is also tested. You should be able to explain how a current can be induced in a conductor, such as
    - the iron core of a transformer. The core theory is that
    - a **changing magnetic field**
    - cutting through a conductor
    - induces a voltage (or electromotive force, emf).
    - Because the conductor (the iron core) has free-moving electrons,

    - this induced voltage causes a current to flow.

Common Calculations ALWAYS WRITE TO 2 S.F. UNLESS INSTRUCTED OTHERWISE.

- **Transformer Turns Ratio**: You will frequently have to use the transformer equation:

$$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$$

  This formula is used to calculate an unknown voltage or the required number of turns on a coil. You need to be confident in rearranging this formula to solve for any of the variables.

- **Energy, Charge, and Voltage**: The relationship between these three quantities is tested using the formula **Energy = Charge × Voltage** (E=Q×V). You might be asked to calculate the charge transferred in a spark, given the energy and voltage. A common pitfall is making a power-of-ten error when converting units, such as millijoules (mJ) to joules (J).

- **Power and Energy**: The formula connecting power, energy, and time, **Power = Energy / time** (P=E/t), is also assessed. You could be asked to calculate the power of a heater given the energy it supplies over a certain period. As with other calculations, ensuring all values are in standard SI units (Joules, Watts, seconds) before you begin is crucial to avoid errors.

Calculations: ALWAYS WRITE TO 2 S.F. UNLESS INSTRUCTED OTHERWISE.

Calculation Type	Formula(s)	Steps to Solve

Momentum	`momentum = mass × velocity`	1. **Substitution**: Correctly substitute the given mass and velocity into the formula. 2. **Unit Conversion**: Ensure mass is in kilograms (kg). A power-of-ten error from incorrect unit conversion is a common penalty. 3. **Evaluation**: Calculate the final answer.
Force and Momentum Change	`Force = change in momentum/time`	1. **Substitution**: Correctly substitute the values for momentum change and time. 2. **Rearrangement**: Confidently rearrange the formula to solve for the unknown variable (e.g., time). 3. **Evaluation**: Calculate the final answer.
Energy and Specific Heat Capacity	`Change in thermal energy = mass × specific heat capacity × change in temperature` ($\Delta Q = m \times c \times \Delta T$)	1. **Temperature Difference**: Correctly evaluate the change in temperature from the given data. 2. **Substitution**: Substitute the known values for mass, temperature change, and energy into the formula. 3. **Rearrangement**: Rearrange the equation to solve for the unknown (often the specific heat capacity, 'c'). 4. **Evaluation**: Calculate the final answer. Errors often occur from incorrect calculator use, so be sure to use brackets where necessary.

Principle of Moments	`moment = force × distance`
	
	`Sum of clockwise moments = sum of anticlockwise moments`
		1. **Identify Moments**: Correctly identify the clockwise and anti-clockwise moments about the pivot.
		2. **Set up Equation**: State that the sum of clockwise moments equals the sum of anti-clockwise moments for the system to be balanced.
		3. **Evaluation**: Solve the equation to find the unknown force or distance.

Transformer Voltage and Turns Ratio	$\frac{\text{input (primary) voltage}}{\text{output (secondary) voltage}} = \frac{\text{primary turns}}{\text{secondary turns}}$	1. **Substitution**: Correctly substitute the given values from a table or text into the formula. 2. **Rearrangement**: Accurately rearrange the formula to solve for the unknown variable. This is a common point where errors are made. 3. **Evaluation**: Calculate the final numerical answer.
Wave Speed, Frequency, and Wavelength	`wave speed = frequency × wavelength` ($v=f\times\lambda$)	1. **Substitution**: Place the known values into the formula. 2. **Rearrangement**: If necessary, rearrange the formula to solve for the unknown (e.g., wavelength). 3. **Evaluation**: Calculate the final answer.

Oscilloscope Wave Period and Frequency	`frequency = 1 / time period` (f=1/T)	1. **Determine Period (T)**: Read the number of horizontal squares for one complete wave from the oscilloscope screen and multiply by the timebase setting (e.g., ms/square). 2. **Unit Conversion**: Convert the time period into seconds (s) if it's in milliseconds (ms). 3. **Calculate Frequency**: Use the formula f=1/T to find the frequency in Hertz (Hz).
Redshift and Recessional Speed	$\frac{\text{change in wavelength}}{\text{reference wavelength}} = \frac{\text{velocity of a galaxy}}{\text{speed of light}}$ $\frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$	1. **Calculate Wavelength Change (Δλ)**: Find the difference between the observed and reference wavelengths. 2. **Substitution**: Substitute all known values into the redshift equation. A common error is using the incorrect value for the reference wavelength. 3. **Rearrangement**: Rearrange the equation to solve for the galaxy's velocity (v). 4. **Evaluation**: Calculate the final speed.

Solids, Liquids, and Gases

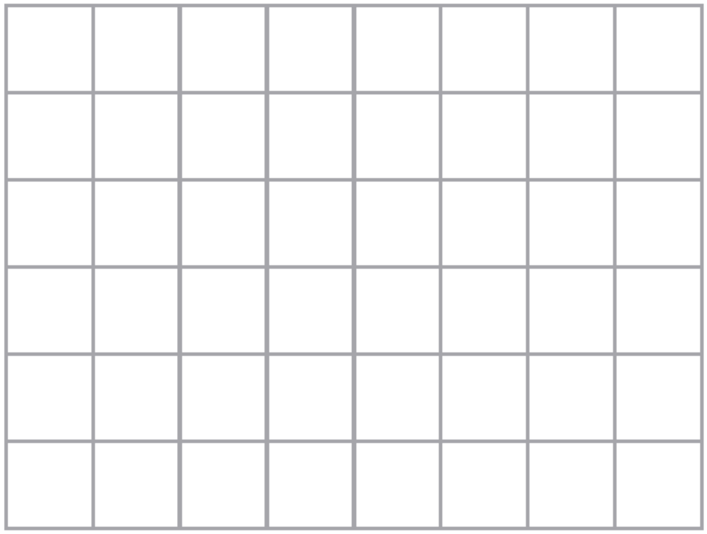
Concept	Summary of Answer / Key Principles
Particle Arrangement	• **Solids**: Particles are arranged in a regular pattern and are in contact with each other. • **Liquids**: Particles are arranged randomly but are still mostly in contact with each other. A common error is drawing liquid particles too far apart.

	• **Gases**: Particles are arranged randomly and are far apart from each other.
Particle Motion	• **Solids**: Particles vibrate in fixed positions. • **Liquids**: Particles slide over each other. • **Gases**: Particles move freely and randomly.
Changes of State (Boiling/Heating)	• When a substance is heated, its temperature rises until it reaches its boiling point. • During boiling (the change of state), the temperature remains constant even as energy is supplied. This is because the energy is being used to break the bonds between particles rather than increasing their kinetic energy. This is represented by a horizontal line on a heating curve.
Changes of State (Freezing/Cooling)	• When a substance cools, its temperature decreases until it reaches its freezing point. • During freezing, the temperature remains constant as the substance changes from a liquid to a solid.
Sound Transmission	• Sound travels faster through liquids than through gases. • This is because the particles in a liquid are closer together, allowing vibrations to be passed on more effectively and quickly between them.

Waves

In the 2024 June R Paper, there was a question for 5 marks for drawing a wave in an oscilloscope using the key provided:

(b) The diagram shows the screen of the oscilloscope and the oscilloscope settings.



oscilloscope settings:

y direction: 1 square = 2V
x direction: 1 square = 0.001 s

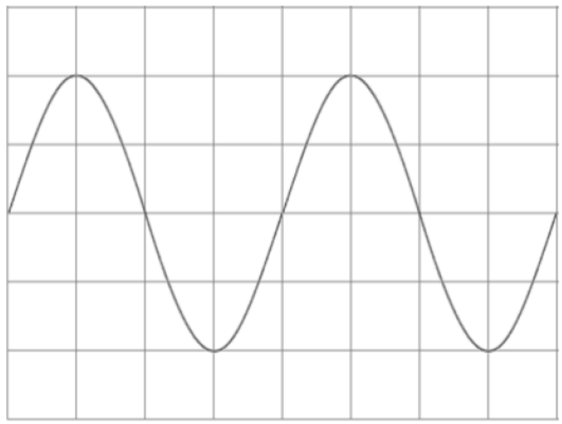
A sound wave of frequency 250 Hz is detected.

The sound wave produces a trace on the oscilloscope of amplitude 4V.

Complete the diagram by drawing the trace of this sound wave on the oscilloscope screen.

(5)

For this you need to calculate the time period using f = 1/t and then check the key to draw the waves.

(b)	any roughly sine-shaped wave drawn on the screen;
	amplitude of trace = 2 squares;
	substitution into f = 1 / T;
	
	evaluation of time period = 0.004 (s);
	trace drawn on oscilloscope has period of 4 squares;
	
	e.g.
	
		allow triangle wave
		
		e.g. 250 = 1/T
		or T = 1/250
		
		automatically scores last three marking points
			5

Concept	Summary of Answer / Key Principles
Wave Properties	• **Sound waves** are longitudinal waves. • **Light waves** are transverse waves, • The relationship between wave speed, frequency, and wavelength is given by the formula: `wave speed = frequency × wavelength` (v=f×lambda).
Oscilloscope Calculations	• The **time period (T)** of a wave is found by multiplying the number of horizontal squares for one complete wave by the timebase setting (e.g., ms/square). • The **frequency (f)** is the reciprocal of the time period, calculated using the formula f=1/T. • A **quieter** sound has a **lower amplitude** on the oscilloscope trace. • A sound with a **lower pitch** has a **lower frequency** (and therefore a longer wavelength/period) on the trace.

Doppler Effect	● The Doppler effect causes a change in the observed pitch (frequency) of a wave when the source is moving relative to the observer. ● When a sound source moves **towards** an observer, the pitch heard is **higher**. ● When the source moves **away** from the observer, the pitch heard is **lower**. ● A **greater speed** of the source results in a **greater change in pitch**.
Sound Transmission	● Sound travels via the **vibrations of particles**. ● Sound travels more effectively and faster through liquids than gases because the particles are **closer together**, allowing vibrations to be passed on more easily.
Speed of Sound Experiment	● An investigation to measure the speed of sound typically involves one person creating a sound and a visual signal (like clapping hands) while another person at a large, measured distance (e.g., 100-300m) times the interval between seeing the signal and hearing the sound. ● The speed is then calculated using `speed = distance/time`. ● Repeating the experiment and calculating an average improves reliability.
Human Hearing	● The typical range of human hearing is from 20 Hz to 20,000 Hz. Sounds outside this range, like 10 Hz or 25,000 Hz, cannot be heard by most humans.

(5 Marks) Investigating Speed of Sound (Choose any of the 3 methods) in the 2022 June R Paper

Investigation 1: Two-Person Method

This is the most common method described in the exam materials. It involves two people standing a large, measured distance apart.

Method:

1. Two people stand a significant distance apart, for example, 300 meters, which is measured beforehand.
2. One person has two objects to make a sound (like clapping their hands), and the other person has a timer or stopwatch and binoculars.
3. The first person claps their hands. The second person starts the stopwatch when they *see* the clap through the binoculars and stops it when they *hear* the sound.
4. The speed of sound is then calculated using the formula: Speed = Distance / Time.
5. To improve reliability, the experiment should be repeated several times, and an average time should be calculated.

Key Considerations:

- **Distance**: A large distance (at least 100m) is necessary to ensure the time interval is long enough to measure accurately.
- **Errors**: A primary source of error is human reaction time when starting and stopping the timer, which is why a large distance is important to minimize its effect.

Investigation 2: Echo Method

Some students opt to describe an echo method for this investigation.

Method:

1. A person stands a measured distance from a large, flat wall.
2. The person makes a sharp sound (e.g., a clap) and starts a timer.
3. The timer is stopped when the echo is heard.
4. The total distance the sound has traveled is double the distance to the wall (to the wall and back).
5. The speed is calculated using Speed = (2 × Distance) / Time.

Investigation 3: Using Microphones and an Oscilloscope

A more advanced method involves using electronic equipment.

Method:

1. Two microphones are placed a measured distance apart.
2. The microphones are connected to an oscilloscope.

3. A sound is produced, and the oscilloscope is used to measure the time interval it takes for the sound to travel between the two microphones.
4. The speed is then calculated using Speed = Distance / Time.

Key Considerations:

- A common misconception is using the oscilloscope to measure wavelength instead of the time interval.
- It is important to ensure the temperature of the air between the microphones is constant, as temperature affects the speed of sound.

Astrophysics

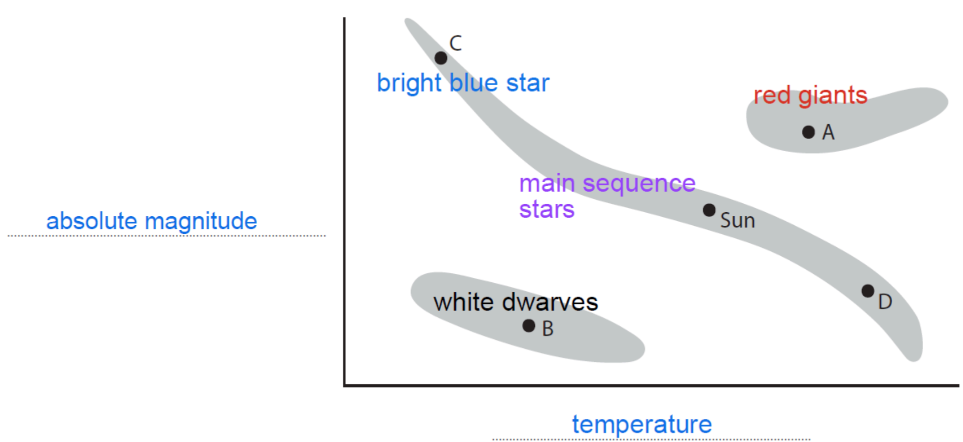
<table>
<tr><th>Concept</th><th>Summary of Answer / Key Principles</th></tr>
<tr><td>Hertzsprung-Russell (H-R) Diagram</td><td>

Y-axis: Represents luminosity, absolute magnitude, or power.
X-axis: Represents temperature, color, or spectral class. <u>(Usually it's Y-axis: Absolute Magnitude and X-axis: Temperature. Answer whatever you have been taught from the above options.)</u>

Absolute magnitude is a measure of a star's brightness as viewed from a standard distance.

Star Locations: You need to identify the regions for different stars, such as the main sequence, red giants, and white dwarfs.

The diagram shows an incomplete Hertzsprung-Russell (H-R) diagram.



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Stellar Evolution <u>(Sun-like Stars)</u>	• A nebula collapses to form a protostar. • When the core is hot enough, nuclear fusion begins, and the star enters the main sequence. • After exhausting its hydrogen, it expands into a **Red Giant**, which is brighter but has a cooler surface than a main sequence star. • Finally, it collapses to become a hot, dim **White Dwarf**.
Stellar Evolution (Massive Stars)	The process starts similarly, but for stars with a mass much larger than the Sun. • After the main sequence, the star becomes a **Red Supergiant**. • The core collapses, and fusion of heavier elements begins. • When fusion stops, the star explodes in a **supernova**. A star must have a much larger mass than the Sun and a very low (bright) absolute magnitude to become a supernova.
Absolute Magnitude	• This is a measure of a star's brightness as if it were viewed from a standard distance.
The Big Bang Theory	• The universe began from a very hot, dense single point and has been expanding and cooling ever since. • **Evidence**: Key evidence includes the redshift of distant galaxies and the existence of *Cosmic Microwave Background Radiation (CMBR)*. **<u>(I think mentioning Redshift and its explanation is enough if you haven't learnt about CMBR like me.)</u>**
Redshift	• Light from distant galaxies is redshifted, meaning its wavelength has increased. This indicates the galaxies are moving away from each other. • The **further** a galaxy is, the **greater its redshift** and the faster it is moving away. This relationship supports the theory of an expanding universe. • **Calculation**: The recessional speed (v) is calculated using the formula $\frac{\lambda - \lambda_0}{\lambda_0} = \frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$ •

	• where $\Delta\lambda$ is the change in wavelength, λ_0 is the reference wavelength, and c is the speed of light. • $\frac{\text{change in wavelength}}{\text{reference wavelength}} = \frac{\text{velocity of a galaxy}}{\text{speed of light}}$

Energy, Work and Power

Concept	Summary of Answer / Key Principles
Energy Resources	• You need to know the advantages and disadvantages of different energy sources. • **Renewable (e.g., Solar, Geothermal, Wave Power)**: Advantages include being renewable and producing no polluting gases. Disadvantages include dependency on weather/location and the potential to harm wildlife. • **Non-Renewable (e.g., Natural Gas)**: Advantages include reliability and the ability to meet demand. Disadvantages include being non-renewable and producing greenhouse gases.
Specific Heat Capacity	• **Definition**: The energy required to raise the temperature of a unit mass (1 kg) of a substance by one degree Celsius (1°C) • **Calculation**: Use the formula `Change in thermal energy = mass × specific heat capacity × change in temperature` ($\Delta Q = m*c*\Delta T$). Ensure you correctly calculate the temperature change and use standard units (Joules, kg, °C).
Power and Energy Calculation	• The relationship is given by the formula `Power = Energy / Time` ($P=E/t$). • You must be able to rearrange this formula to solve for any variable. • **Unit conversion is crucial**. Ensure **energy is in Joules, power is in Watts, and time is in seconds** before calculating. Errors often occur when time is given in minutes or energy in kilojoules (kJ).

Energy Transfers	• You should be able to describe energy transfers between different stores. For example, when fuel is burned to heat water, energy is transferred from a **chemical store** in the fuel, via **heating**, to a **thermal store** in the water. • In experiments, you should identify where energy is lost or wasted, such as to the surroundings or through the heating of pipes and equipment.
Work, Energy & Power in Motion	• The work done on an object is calculated by `Work Done = Force × Distance`. • The work done on an object equals the energy transferred to it.

Energy Resources

Energy Source	Advantages	Disadvantages
Solar Power	• It is a **renewable** resource. • It produces **no noise**. • There are **no fuel costs** as sunlight is free. • It produces **no polluting gases** or greenhouse gases.	• It is dependent on the amount of sunlight and **does not work at night**. • It requires a **large area** of land for the panels. • The output can depend on the **geographical location**.
Geothermal Power	• It is reliable and can be used **all day**. • It is a **renewable** resource. • It requires a **small amount of space**.	• It is **not available in all locations**. • It can release some **greenhouse gases**. • There is a risk of **polluting ground water**.

Natural Gas	• It is **reliable** and not dependent on the weather • The electricity generated can be changed to **meet demand**, and it has a short startup time.	• It is a **non-renewable** resource that will eventually run out. • Burning it produces **carbon dioxide** and other greenhouse gases, contributing to global warming.
Wave (Water movement) Power	• It is a **renewable** resource. • It produces **no polluting gases**.	• The waves are **not always present** and are weather-dependent. • The generators can be damaged by storms. • It may cause **harm to wildlife**.

Radioactivity

Concept	Summary of Answer / Key Principles
Nuclear Reactions	• **Nuclear Fission**: A process where a nucleus splits, releasing energy and producing radioactive daughter nuclei. • **Nuclear Fusion**: A process where nuclei combine, which requires very high pressure and temperature and also releases energy.
Nuclear Reactor Components	• **Control Rods**: Their function is to absorb neutrons to control the rate of the chain reaction. • **Moderator**: Its purpose is to reduce the speed (or kinetic energy) of neutrons, making them more likely to cause further fission.
Half-Life	• **Definition**: The time taken for the activity, number of radioactive nuclei, or count rate of an isotope to decrease by half. • **Safety Application**: After several half-lives have passed (e.g., more than two), the amount of remaining radioactive material and its activity is significantly reduced, making it safer for visitors to be near.

Charged Particles	**Neutral vs. Charged Particles**: Neutral particles have an equal number of protons and electrons, while positively charged particles (ions) have lost electrons. **Acceleration**: A positively charged particle (like a proton) will accelerate in an electric field because it is repelled by a positive plate and attracted to a negative plate, resulting in a net force on it.
Safety and Penetration	Radiation from a source is unlikely to penetrate through thick shielding materials like concrete walls, which is a key safety feature in facilities using radioactive materials.

Electricity

Concept	Summary of Answer / Key Principles
Static Electricity	**Charging Method**: An object becomes charged by gaining or losing negatively charged electrons through friction (rubbing it with another insulator). **Demonstrating Charge**: A charged rod can be used to attract neutral objects like small pieces of paper or a stream of water. It can also be used with a gold leaf electroscope, which will show deflection. **Dangers**: A build-up of static charge can be dangerous as it can create a spark, which could cause a fire or an explosion, especially during processes like aircraft refueling.
Transformers	**Function**: Step-up transformers increase voltage, while step-down transformers decrease voltage. **Turns Ratio Calculation**: The relationship between voltage and the number of turns on the primary (p) and secondary (s) coils is given by the formula: `Vp / Vs = Np / Ns`. You must be able to rearrange this to find any unknown value.

	$N_p / N_s = V_p / V_s;$
The National Grid	• **Purpose**: The National Grid uses transformers to transmit electricity efficiently over long distances. • **Explanation**: a. A **step-up transformer** at the power station increases the voltage. b. This **decreases the current** in the transmission cables. c. The lower current **reduces energy loss** as heat in the wires. d. A **step-down transformer** near towns decreases the voltage to a safer level for homes and schools.
Induced Current	• **Theory**: A current is induced in a conductor (like the iron core of a transformer) when it is subjected to a **changing magnetic field**. • **Explanation**: The changing magnetic field induces a voltage (emf) in the conductor. Because the conductor has free electrons, this voltage causes a current to flow.
Energy & Charge	• **Calculation**: The relationship is `Energy = Charge × Voltage` (E=Q*V). • **Unit Conversion**: Be careful with unit conversions, such as millijoules (mJ) to Joules (J), as errors are common.

Static Electricity Demonstration (Choose any one to write for 2 marks)

Method	Correct Observation
Using a **Gold Leaf Electroscope (GLE)**	When the charged object is brought near the GLE, the gold leaf deflects (moves away from the rod).
Using **Small Pieces of Paper**	When the charged object is placed above small, neutral pieces of paper, the paper moves towards or is attracted to the object.

Using a **Stream of Water**	When the charged object is brought near a thin stream of running water from a tap, the water bends towards the object.
Using **Hair**	When the charged object is brought near hair, the hair moves towards or is attracted to the object.
Using **Another Charged Rod**	When the charged object is brought near another suspended charged rod, the rods will either move towards (attract) or away from (repel) each other.

Forces & Motion

Concept	Summary of Answer / Key Principles	Year Tested & Marks Allocated
Momentum & Collisions	• **Formula**: `momentum = mass × velocity` (p=m*v). • **Conservation of Momentum**: In a collision, the total momentum before the event equals the total momentum after. To solve problems: a. calculate the initial momentum, b. then calculate the final momentum of one object, c. and use subtraction to find the momentum of the second object.	**2024 (Q5)**: 6 marks **2019 (Q7)**: 6 marks
Force & Safety Features (e.g., Airbags)	• **Theory**: Airbags work by increasing the **time** of the collision. This reduces the **rate of change of momentum**, which in turn reduces the force experienced (F=Deltap/t). • A common error is stating that the change in momentum itself is reduced.	**2023 (Q4)**: 2 marks

Principle of Moments	• **Theory**: For an object to be balanced (in equilibrium), the sum of the clockwise moments about a pivot must equal the sum of the anti-clockwise moments. • **Calculation**: Use `moment = force × distance` for each force and set the clockwise total equal to the anti-clockwise total to find an unknown force or distance.	**2022 (Q7)**: 7 marks **2020 (Q3)**: 5 marks
Newton's Third Law	• **Explanation**: When two objects collide, the forces they exert on each other are **equal in size** and **opposite directions**.	**2024 (Q5)**: 2 marks **2019 (Q7)**: 2 marks
Hooke's Law & Springs	• **Relationship**: The extension of a spring is directly proportional to the force applied, which is shown as a straight line on a force-extension graph. • **Elastic Limit**: If a spring is stretched beyond its limit of proportionality, it will be permanently stretched and will not return to its original length.	**2022 (Q7)**: 4 marks
Work Done by a Force	• **Formula**: `Work Done = Force × Distance` moved in the direction of the force. The work done is equal to the energy transferred.	**2019 (Q8)**: 3 marks
Center of Gravity	• **Definition**: The point where the weight of an object can be considered to act. In diagrams, it is located at the origin of the weight force arrow.	**2020 (Q3)**: 1 mark

Momentum Question (6 Marks) - June R 2019 Paper

The principle states that the total momentum before a collision is equal to the total momentum after the collision.

1. Find the Total Initial Momentum

Before the collision, only the white ball is moving. Its momentum was calculated in part (a)(ii) of the question.

- Initial momentum of the white ball = 0.170 kg × 5.2 m/s = **0.88 kg m/s**.
- Therefore, the total initial momentum of the system is 0.88 kg m/s.

---

2. Find the Final Momentum of the Balls

After the collision, both balls are moving. Their combined momentum must also be 0.88 kg m/s.

- First, calculate the momentum of the black ball after the collision: `p_black = 0.80 kg m/s`.
- Next, use the conservation principle to find the white ball's final momentum: `Total Initial Momentum = Final Momentum of White Ball + Final Momentum of Black Ball` `0.88 = p_white + 0.80`
- Rearranging gives the final momentum of the white ball: `p_white = 0.88 - 0.80 = 0.08 kg m/s`.

---

3. Calculate the Final Velocity of the White Ball

Finally, use the momentum formula again, rearranged for velocity (v=p/m), to find the white ball's final velocity:

- `v_white = 0.08 kg m/s / 0.170 kg ≈ 0.47 m/s`.

According to the examiner's report, the best candidates showed their working meticulously. A common error that received no credit was incorrectly assuming that the two balls stuck together after the collision.

Principle of Moments

This question required you to calculate the minimum force (F) needed to open a gate by applying the **principle of moments**.

The principle states that for an object to be balanced or on the point of turning, the total clockwise moment about a pivot must equal the total anti-clockwise moment.

Step 1: Identify the Clockwise and Anti-clockwise Moments

From the diagram and the values given in the question, you need to identify the forces and their perpendicular distances from the pivot to calculate the two opposing moments.

- **Anti-clockwise Moment**: Caused by the spring mechanism, calculated as `480 N × 0.84 m`.
- **Clockwise Moment**: Caused by the force F, calculated as `F × 3.2 m`.

Step 2: Set Up the Equation

According to the principle of moments, you set the two moments equal to each other:

`Clockwise Moment = Anti-clockwise Moment`

`F × 3.2 = 480 × 0.84`

Step 3: Solve for the Unknown Force (F)

First, calculate the value of the anti-clockwise moment:

`480 × 0.84 = 403.2 Nm`

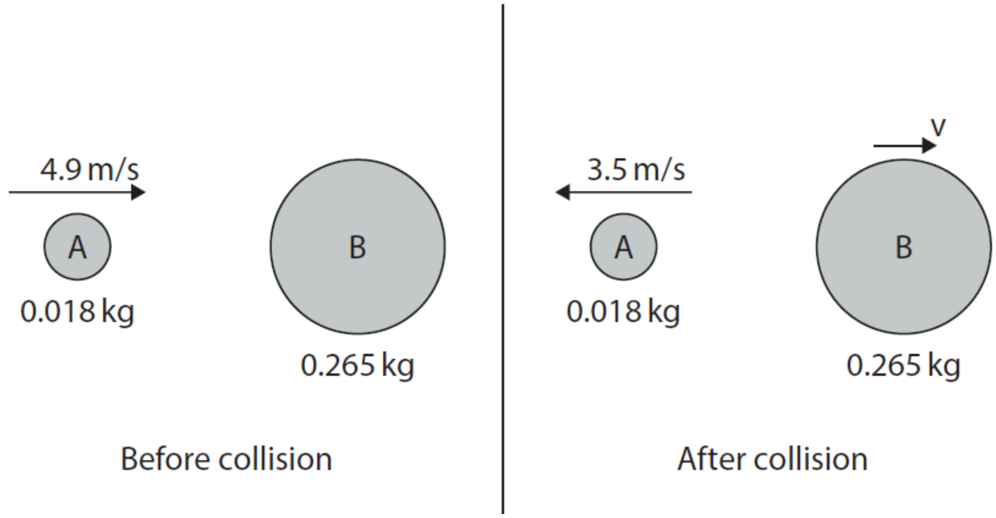
Now, rearrange the equation to solve for F:

`F = 403.2 / 3.2`

`F = 126 N`

According to the examiner's report, most candidates answered this question correctly. Showing clear working by setting up the initial equation allowed some students to score partial marks even if they made a mistake in the final calculation.

Momentum and Elasticity (June R 2024) 4 Marks



(d) A collision is considered elastic if the total kinetic energy before the collision is equal to the total kinetic energy after the collision.

Using data from the diagram, deduce whether this collision is elastic.

(4)

(d)	use of $KE = \frac{1}{2} \times m \times v^2$; evaluation of KE before collision; evaluation of KE after collision; comparison with correct conclusion that collision is not elastic/inelastic;	seen explicitly or implied from working allow 0.2, 0.22, 0.216, 0.216… (J) allow 0.15-0.16 (J) OR 0.110 AND 0.043 seen in working DOP allow ecf from KE calculations	4

Total for Question 5 = 12 marks

1. State the Principle

For the collision to be elastic, the total kinetic energy before the collision must equal the total kinetic energy after the collision.

2. Use the Kinetic Energy Formula

The formula for kinetic energy is KE=21×m×v2.

3. Calculate Kinetic Energy Before the Collision

Using the data from the previous parts of the question, calculate the total kinetic energy of the system before the collision.

4. Calculate Kinetic Energy After the Collision

Calculate the total kinetic energy of the system *after* the collision by finding the kinetic energy of each object separately and adding them together.

5. Compare and Conclude

Compare the total kinetic energy before and after the collision.

- If the kinetic energy after the collision is less than the kinetic energy before, the collision is **inelastic**.
- The mark scheme indicates that for this specific question, the kinetic energy after the collision is lower, leading to the conclusion that the collision is not elastic (it is inelastic).

Magnetism and Electromagnetism

Concept	Summary of Answer / Key Principles	Year Tested & Marks Allocated
Electromagnets	• To create an electromagnet, you need a **coil of wire**, a **current** flowing through it, and a **soft iron core** • The strength of an electromagnet can be investigated by measuring the maximum mass it can hold at different current values.	**2020 (Q7a)**: 3 marks **2023 (Q6)**: 12 marks

The Motor Effect	• When a current-carrying conductor is in a magnetic field, it experiences a force. • **Fleming's Left-Hand Rule** is used to determine the direction of this force. For example, a proton moving through a magnetic field will experience a force in a direction determined by this rule.	**2020 (Q7b)**: 1 mark
Induced Current	• A current can be induced in a conductor (like the iron core of a transformer) when it is subjected to a **changing magnetic field**. • This changing field induces a voltage (emf), which causes the free electrons in the conductor to move, creating a current.	**2022 (Q5c, ii)**: 3 marks
Experimental Data Analysis	• **Mean Calculation**: You must correctly calculate the mean from repeated readings, remembering to exclude any anomalous results. • **Graphing**: When plotting data, use a sensible scale, label axes with quantities and units, plot points accurately, and draw a line of best fit.	**2023 (Q6)**: 6 marks

“Explain how a current is induced in the core of the transformer” (3 Marks) June R 2022 Paper

(c)	(i)	thermal (store);	condone heat	1
	(ii)	any three from: MP1. field lines cut by core; MP2. idea of an induced voltage; MP3. conductors have **free** electron(s); MP4. idea that there is a force on the electron(s); MP5. idea that the movement of electrons is the current;		3

Total for Question 5 = 12 marks

An alternating current flows through the primary coil, which creates a **changing magnetic field** within the iron core. The iron core itself is an electrical conductor.

As this changing magnetic field passes through the conductive core, it **induces a voltage** (or emf). Because the iron core is a metal, it contains free-moving (delocalized) electrons. This induced voltage causes these electrons to move, creating a **current** within the core.

The examiner's report noted that many students did not understand the question and instead described how a transformer works in general. Successful answers focused specifically on how the changing magnetic field induced a voltage and subsequent current in the conductive core itself.

And that’s a wrap! All the best for the exam and hope we get the results we expected.

If you want more notes like this for IGCSE exams or, in the future, AS and A Level exams, I’d be sure to make better notes for the subjects I can and share them 🫡. Except next time, there would be more time to revise more strategically. 😉 Reach out to me on Reddit!

Wish that you excel at whatever endeavour you take on in the future 🌠.

Further Revision

Sometimes there are questions that come from the Jan R series from what I've noticed. I usually do the Jan R papers too as practice just in case. But for physics, I think they manage to bring new questions especially in recent years. Even then, they just test the main concepts. This is a summary to show the frequent topics and areas tested under Jan R papers too so that we can be extra prepared in case!

Analysis of Student Performance and Guidance

Common Pitfalls & Misconceptions	Examiner Guidance to Score Marks	Essential Topics to Revise
Formulae & Calculations		
🔹 Incorrectly rearranging formulae, especially before substituting values.	🔹 **Show All Working:** Always show your substitution into a formula. This can earn method marks even if the final answer is wrong.	🔹 **Mechanics:** Momentum (p=mv), force as rate of change of momentum (F=tmv−mu), kinetic energy (KE=21mv2), and GPE (ΔGPE=mgΔh).
🔹 Forgetting to square values (e.g., in KE=21mv2) or take a square root.	🔹 **Substitute First:** If you struggle with rearranging equations, substitute the data first. You will usually get a mark for a correct substitution.	🔹 **Electricity:** Ohm's Law (V=IR), charge flow (Q=It), power (P=IV), and energy transferred (E=QV).
🔹 Making power of ten (POT) errors, especially when dealing with standard form or unit prefixes.	🔹 **Check Units:** Always check for and perform necessary unit conversions (e.g., mA to A , cm to m , kV to V).	🔹 **Waves:** The wave speed equation (v=f×λ).
🔹 Rounding answers incorrectly or not to the specified number of significant figures.	🔹 **Follow Instructions:** Pay close attention to instructions regarding rounding and significant figures. Use at least 2 significant figures in	🔹 **Transformers:** The turns-voltage relationship (VsVp=NsNp).

	calculations unless told otherwise.	
🔹 Using the wrong wavelength in the redshift formula (e.g., using the observed instead of the source wavelength).	🔹 **Clarity in Working:** Ensure your final answer is clearly identifiable. For calculations with multiple steps, lay out your working logically.	🔹 **Astrophysics:** The redshift-velocity relationship ($\lambda\Delta\lambda=cv$).
Understanding & Application of Concepts		
🔹 Confusing series and parallel circuit rules for current, voltage, and resistance.	🔹 **Read the Question Carefully:** Note the command word (e.g., 'state', 'explain', 'calculate') and the number of marks available to gauge the required depth.	🔹 **Series vs. Parallel Circuits:** The behavior of current, voltage, and total resistance in each type of circuit.
🔹 Not considering momentum as a vector; failing to add momenta when objects collide from opposite directions.	🔹 **Use Precise Language:** Use specific physics terminology (e.g., 'rate of change of momentum' , 'electron transfer') and avoid vague terms like 'pollution' or 'cushion'.	🔹 **Conservation of Momentum:** Including its vector nature. Total momentum before a collision equals total momentum after.
🔹 Describing redshift as objects being 'further away' instead of 'moving away'.	🔹 **Answer the Question Asked:** Focus your response on the specific context of the question. For example, don't describe how a transformer is built if asked about its role in power transmission.	🔹 **Redshift & Expanding Universe:** The definition of redshift and its link to recessional velocity as evidence for an expanding universe and the Big Bang theory.

🔹 Confusion over the operation of a DC motor, particularly the role of the split-ring commutator.	🔹 **Address All Parts:** For multi-mark questions, ensure you provide enough distinct points to earn full credit. A 2-mark question on hazards needs more than one simple effect.	🔹 **DC Motor Principles:** The function of the coil, magnetic field, split-ring commutator, and brushes to ensure continuous rotation.
🔹 Vague understanding of static electricity, often omitting the role of electron transfer.	🔹 **ECF (Error Carried Forward):** If you make a mistake in an early part of a calculation, you can still earn marks in later parts if you use your incorrect answer correctly.	🔹 **Static Electricity:** Charging by friction explained by the transfer of electrons, and the forces between like and unlike charges.
🔹 Misunderstanding the conditions for nuclear fusion (requiring high temperature and pressure to overcome electrostatic repulsion).		🔹 **Nuclear Fusion:** The conditions of high temperature and pressure needed to overcome the repulsion between nuclei.
Practical Skills & Data Handling		
🔹 Reading values from a graph inaccurately or drawing a line of best fit that does not fit the data.	🔹 **Graphs and Data:** When describing an experiment, be specific (e.g., "repeat the anomalous reading" instead of just "repeat the experiment"). Always suggest calculating a mean after repeats.	🔹 **Experimental Methods:** Designing experiments to measure quantities like the speed of sound or specific heat capacity, including control variables and methods to improve accuracy.

🔹 Misinterpreting an oscilloscope trace, leading to an incorrect period and frequency.	🔹 **Precision:** Record measurements to a realistic precision for the instrument used (e.g., a ruler can be read to ±0.1 cm, so a measurement should be given as 6.0 cm, not 6 cm).	🔹 **Data Analysis:** Interpreting heating/cooling curves , identifying anomalous points on a graph , and drawing tangents to find gradients.
🔹 In experimental descriptions, using 'weight' instead of 'mass'.	🔹 **Diagrams:** Use labelled diagrams to support written answers where appropriate.	🔹 **Using an Oscilloscope:** Determining the period, and subsequently the frequency, of a wave from the screen trace and time-base setting.

Ranking of Topics by Frequency (2020-2023)

Rank	Topic	Total Questions	Years Tested (Number of Questions per Paper)
1	**Mechanics** (Forces, Motion, Energy, Momentum, Moments)	9	2023 (1) , 2022 (2) , 2021 (3) , 2020 (3)
1	**Electricity & Magnetism** (Circuits, Transformers, Static, Motors)	9	2023 (3) , 2022 (2) , 2021 (2) , 2020 (2)
3	**Waves** (EM Spectrum, Sound, Wave Equation, Oscilloscope)	5	2023 (1) , 2022 (1) , 2021 (1) , 2020 (2)
4	**Astrophysics** (H-R Diagrams, Redshift, Cosmology)	4	2023 (2) , 2022 (1) , 2021 (1), 2020 (0)
4	**Thermal Physics** Heat Capacity, States of Matter, Heating/Cooling Curves)	4	2023 (1) , 2022 (1) , 2021 (1) , 2020 (1)
6	**Atomic & Nuclear Physics** (Fusion, Radioactivity)	1	2023 (0), 2022 (1), 2021 (0), 2020 (0)

Candidate Performance by Topic Area

Rank (Most to Least Challenging)	Topic Area	Summary of Candidate Performance (Common Issues vs. Strengths)
1	**Explanations of Complex Phenomena**	🔹 **Most Marks Lost**: This is consistently the most challenging area. Students struggle to provide detailed, logical explanations for topics like: ● the Big Bang theory based on redshift evidence, ● the detailed function of a DC motor's commutator, ● the Doppler effect, ● and energy conservation in systems like regenerative braking. Responses are often vague or fail to link different physics principles.
2	**Momentum & Forces**	🔹 **Common Issues**: Students frequently fail to treat momentum as a vector, especially in collision problems where direction changes. Explaining the physics behind safety features like crumple zones (linking increased time to reduced force) is often a weak point. 🔸 **Strengths**: Recalling the principle of conservation of momentum is usually done correctly.
3	**Data Handling & Graph Skills**	🔹 **Common Issues**: Drawing graphs from written descriptions (e.g., heating curves), accurately calculating gradients from tangents, and interpreting oscilloscope traces to find frequency are common sources of error. 🔸 **Strengths**: Identifying anomalous points on a graph is usually correct.
4	**Astrophysics**	🔹 **Common Issues**: Explaining the *meaning* of redshift and its connection to an expanding universe is found to be "surprisingly difficult". While students can often state facts, they struggle to use them as evidence in an explanation.

		🔸 **Strengths**: Identifying regions on an H-R diagram (e.g., main sequence, white dwarfs) is generally "straightforward for most candidates."
5	**Circuit Analysis**	🔹 **Common Issues**: Comparing the behavior of current and resistance in series versus parallel circuits is "very challenging" for many. 🔸 **Strengths**: Straightforward calculations using Ohm's Law (V=IR) in simple circuits are typically performed well.
6	**Atomic, Nuclear & Thermal Physics**	🔹 **Common Issues**: Explanations of static electricity often lack detail about the movement of electrons. Explaining why fusion requires high temperatures is sometimes confused. 🔸 **Strengths**: Calculations involving specific heat capacity (DeltaQ=mcDeltatheta) are answered to an "exceptionally high standard."
7	**Recall & Standard Calculations**	🔸 **Most Marks Scored**: This is the area where students perform best. Questions requiring the recall of facts (e.g., uses of the EM spectrum) or definitions (e.g., what a galaxy is) are answered with confidence. Direct calculations using provided formulae, such as the transformer equation or the wave speed equation, are completed to a high standard, especially when no complex rearrangement is needed.

Specific Heat Capacity Experiment (5 Marks)

Experimental Method

Here is a step-by-step guide to the experiment:

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1. Measure the Mass of the Water (m)

First, you need to find the mass of the water you're heating.

- Place an empty beaker on a balance and record its mass.
- Add a known volume of water to the beaker and measure the new total mass.
- The mass of the water is the difference between these two readings.

---

2. Set Up and Initial Measurements

- Place an immersion heater (with a known power rating, `P`) and a thermometer into the water.
- Record the initial temperature of the water (`θ_initial`).

---

3. Heating and Energy Measurement (ΔQ)

- Turn on the heater and simultaneously start a stopwatch.
- Heat the water for a specific, measured period of time (`t`).
- Calculate the total electrical energy supplied to the water using the formula `Energy (ΔQ) = Power × time`.

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4. Final Temperature Measurement (Δθ)

- Turn off the heater.
- Gently stir the water and continue to monitor the thermometer. The temperature will continue to rise slightly as heat distributes through the water. Record the **maximum temperature** reached. This is a step that was rarely mentioned by candidates.
- Calculate the temperature change (`Δθ`) by subtracting the initial temperature from this maximum final temperature.

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5. Calculate Specific Heat Capacity (c)

- Rearrange the specific heat capacity formula to solve for `c`: `c = ΔQ / (m × Δθ)`.
- Substitute your measured values for energy supplied (`ΔQ`), mass (`m`), and temperature change (`Δθ`) to find the specific heat capacity of water.