INSIGHT

Year 12 *Trial Exam Paper*

2013
PHYSICS
Written examination

Worked solutions
Section A – Core studies

This book contains:

- correct solutions with full working
- mark allocations
- explanatory notes
- tips and guidelines

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SECTION A – Core studies

Area of study – Motion in one and two dimensions

Question 1a.

Worked solution

Constant speed means acceleration = 0, $\Sigma F = 0$.

$$\begin{aligned} N &= mg \\ &= 60 \times 10 \\ &= 600 \text{ N} \end{aligned}$$

600 N

Mark allocation: 2 marks

- 1 mark for $\Sigma F = 0$.
- 1 mark for the correct answer.

Tip

- *Remember that apparent weight is the normal reaction force, which is often different from the weight force (although it wasn't in this case).*

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Question 1b.

Worked solution

$$a = \frac{\Delta v}{\Delta t}$$
$$= \frac{0 - 1.1}{2}$$
$$= -0.55 \text{ m s}^{-1}$$

Using u = 1.1 m s^{-1}, we define downwards as positive. Therefore, an acceleration of –0.55 m s^{-2} is upwards.

0.55 m s^{-2}	**Direction: upwards / downwards (circle one)**

Mark allocation: 3 marks

- 1 mark for substituting values correctly into the formula.
- 1 mark for finding the correct magnitude.
- 1 mark for the correct direction.

Tip

- *If necessary, draw an arrow on your diagram to indicate which direction (i.e. up or down) is defined as positive by the information given.*

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Question 1c.

Worked solution

$$\Sigma F = ma$$
$$N - mg = ma$$
$$N - 60 \times 10 = 60 \times 0.55$$
$$N = 633 \text{ N}$$

633 N

Mark allocation: 3 marks

- 1 mark for correct the relationship $N - mg = ma$ (or equivalent).
- 1 mark for substituting values correctly into the correct equation.
- 1 mark for the correct answer.
- Consequential marks for 600 + 600 × (Ans. **1b**).

Tip

- *It can be difficult to work out how to combine* N *and* mg *to get the expression for* ΣF. *Draw a diagram and include arrows showing the direction of* N, mg *and* ΣF. *Arrows that point in the same direction can be given the same sign in the equation. In this case,* N *and* ΣF *both point up so they are positive, whereas* mg *is in the opposite direction. So the equation becomes* ΣF = N – mg = ma.

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Question 2a.

Worked solution

$a = 10 \text{ m s}^{-2}$

$t = 3.5 \text{ s}$

$u = 0 \text{ m s}^{-1}$

$x = ?$

$$x = ut + \frac{1}{2}at^2$$
$$= 0.5 \times 10 \times 3.5^2$$
$$= 61.25 \text{ m}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *Use* a $= 10$ *m s*$^{-2}$ *and not* a $= -10$ *m s*$^{-2}$ *so that the downwards direction is defined as positive.*

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Question 2b.

Worked solution

Consider only the vertical component of the motion.

$$a = 10 \text{ m s}^{-2}$$
$$u_v = 0 \text{ m s}^{-1}$$
$$x = 2 \text{ m}$$
$$x = ut + \frac{1}{2}at^2$$
$$2 = 0 + 0.5 \times 10 \times t^2$$
$$t = \sqrt{\frac{2}{5}} = 0.63 \text{ s}$$

Mark allocation: 2 marks

- 1 mark for statement indicating that only the vertical component of motion is being considered.
- 1 mark for the correct calculations.

Tip

- *When asked to show your working, make sure you explicitly show all your assumptions as well as what equations you are using. Don't be tempted to rush through. Show all the steps in your thinking.*

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Question 3a.

Worked solution

Total momentum before = total momentum after

$$m_1v_1 = m_2v_2$$

$$80 \times 8.0 = 130 \times v_2$$

$$v_2 = \frac{80 \times 8.0}{130}$$

$$= 4.9 \text{ m s}^{-1}$$

$\boxed{\mathbf{4.9\ m\ s^{-1}}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- *Only moving objects have momentum. The trolley was not moving before the collision and so its mass does not need to be included until after the collision.*

Question 3b.

Worked solution

$$a = g\sin\theta$$

$$= 10 \times \sin 12°$$

$$= 2.08 \text{ m s}^{-2}$$

$\boxed{\mathbf{2.1\ m\ s^{-2}}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *On your summary sheet, have a labelled diagram of the forces that act on an inclined plane. Students are often confused when they try to draw one from scratch.*

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Question 3c.

Worked solution

$$a = 2.1 \text{ m s}^{-2}$$
$$x = 15 \text{ m}$$
$$u = 2.0 \text{ m s}^{-1}$$
$$v = ?$$
$$v^2 = u^2 + 2ax$$
$$v^2 = 2^2 + 2 \times 2.1 \times 15$$
$$v = \sqrt{67}$$

$\boxed{\textbf{8.2 m s}^{\mathbf{-1}}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.
- Consequential marks for $v = \sqrt{4 + 30 \times (\text{Ans. } \mathbf{3b})}$.

Tip

- *When using constant acceleration formulae, list the three values that you DO know and then the one value that you DON'T know. This will help you identify which formula to use.*

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Question 4a.

Worked solution

$$\Sigma F = \frac{mv^2}{r}$$
$$= \frac{1200 \times 14^2}{12}$$
$$= 19\,600$$

$$\boxed{\mathbf{2.0 \times 10^4\ N}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Question 4b.

Worked solution

The dummy will continue to move in the direction of its instantaneous velocity at the time when the centripetal force stops acting. At the instant shown, that direction is represented by arrow A.

$\boxed{\mathbf{A}}$

Mark allocation: 1 mark

Tip

- *Objects released from horizontal circular motion will continue at a tangent to their circular path.*

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Question 5a.

Worked solution

$$\begin{aligned}\Sigma F &= \frac{mv^2}{r}\\ &= \frac{60\times 5.0^2}{8.5}\\ &= 176.47\end{aligned}$$

$$\boxed{\mathbf{180\ N}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *Although you will not lose marks in a Physics exam for incorrect use of significant figures, it is still good practice to consider them when giving your answer.*

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Question 5b.

Worked solution

On the inside top of vertical circular motion, $\Sigma F = N + mg = \frac{mv^2}{r}$.

In this case, apparent weightlessness occurs at the top and so $N = 0$.

Therefore, $\Sigma F = mg = \frac{mv^2}{r}$ or, more simply, $g = \frac{v^2}{r}$.

$$10 = \frac{v^2}{8.5}$$
$$v = \sqrt{85}$$
$$= 9.21$$

$$\boxed{\mathbf{9.2\ m\ s^{-1}}}$$

Mark allocation: 3 marks

- 1 mark for the correct expression $\Sigma F = mg = \frac{mv^2}{r}$ or equivalent.
- 1 mark for substituting the values correctly into the equation.
- 1 mark for the correct answer.

Tip

- *For situations where* N = 0*, the equations* $v_{min} = \sqrt{rg}$ *for the inside top and* $v_{max} = \sqrt{rg}$ *for the outside top of vertical circular motion are good to know, but you should also understand how they are derived.*

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Question 6a.

Worked solution

$$\begin{aligned} KE &= \frac{1}{2}mv^2 \\ &= 0.5 \times 273 \times 3.2^2 \\ &= 1398 \end{aligned}$$

$\boxed{\textbf{1400 J}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *Don't forget to square the velocity when calculating kinetic energy.*

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Question 6b.

Worked solution

$$KE = SPE$$

$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$$

$$\frac{1}{2}\times 273\times 2.0^2 = \frac{1}{2}\times k\times 0.10^2$$

$$k = 109\,200$$

$\boxed{\mathbf{109\ kN\ m^{-1}}}$

Mark allocation: 3 marks

- 1 mark for the correct equation kinetic energy = strain potential energy.
- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *When a unit is already given in the answer box, you may change it. For example, you may prefer to give your answer to this question in N m^{-1} rather than kN m^{-1}. If so, just cross out the existing unit and write in a different one. The only time you cannot do this is when the question explicitly states in which unit to give your answer, such as 'Give your answer in kN m^{-1}.'.*

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Question 7a.

Worked solution

$$a = \frac{4\pi^2 r}{T^2}$$
$$= \frac{4 \times \pi^2 \times 4.22 \times 10^7}{(24 \times 60 \times 60)^2}$$
$$= 0.223$$

$$\boxed{\mathbf{0.22\ m\ s^{-2}}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *A geostationary satellite has an orbital period of 24 hours, therefore* $T = 24 \times 60 \times 60 = 86\,400$ s.

Question 7b.

Worked solution

Orbital acceleration is equal to the gravitational field strength.

$$\boxed{\mathbf{0.22\ N\ kg^{-1}}}$$

Mark allocation: 1 mark

- 1 mark for the correct answer.
- Consequential mark if answer to part **a** is used.

Tip

- *As the only force that acts on an object in space is the gravitational attraction to Earth (since gravitational attraction to other objects is so small it can be disregarded), then*
  $\Sigma F = mg = ma$
  $a = g$

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Question 7c.

Worked solution

$$\frac{R_\mathrm{N}^{\ 3}}{T_\mathrm{N}^{\ 2}} = \frac{R_\mathrm{G}^{\ 3}}{T_\mathrm{G}^{\ 2}}$$

$$\frac{(7.22\times10^6)^3}{(T_\mathrm{N})^2} = \frac{(4.22\times10^7)^3}{86\,400^2}$$

$$T_\mathrm{N} = \sqrt{\frac{(7.22\times10^6)^3\times86\,400^2}{(4.22\times10^7)^3}}$$

$$= 6114$$

6100 s

Mark allocation: 3 marks

- 1 mark for using correct equation $\frac{R_\mathrm{N}^{\ 3}}{T_\mathrm{N}^{\ 2}} = \frac{R_\mathrm{G}^{\ 3}}{T_\mathrm{G}^{\ 2}}$ or equivalent.
- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *This question uses Kepler's law, which states that the ratio* $\frac{R^3}{T^2}$ *is constant for all bodies in orbit around the same object. In this case, both satellites are orbiting Earth and so the equation* $\frac{R_\mathrm{N}^{\ 3}}{T_\mathrm{N}^{\ 2}} = \frac{R_\mathrm{G}^{\ 3}}{T_\mathrm{G}^{\ 2}}$ *can be used.*

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Area of study – Electronics and photonics

Question 8a.

Worked solution

There is a 1.5 V drop across the diode and so there is a 10.5 V drop across the resistor.

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{10.5}{1000} \\ &= 0.0105 \end{aligned}$$

$$\boxed{\textbf{11 mA}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *Since a diode is a non-ohmic device, Ohm's law* (V = IR) *doesn't apply to it. It is always best to use Ohm's law to calculate current through the resistor that is in series with a diode.*

Question 8b.

Worked solution

As the new diode is connected in reverse bias, no current will flow through it or the 500 Ω resistor.

The current through the ammeter will be unchanged from the current in part **a**.

$$\boxed{\textbf{11 mA}}$$

Mark allocation: 1 mark

- 1 mark for stating the same current as that for Question **8a**.

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Question 8c.

Worked solution

The two resistors are now in parallel and so have a lower effective resistance.

$$\frac{1}{R_{\text{eff}}} = \frac{1}{1000} + \frac{1}{500}$$
$$= \frac{3}{1000}$$
$$R_{\text{eff}} = \frac{1000}{3}$$
$$I = \frac{V}{R}$$
$$= \frac{10.5 \times 3}{1000}$$
$$= 0.0315$$

32 mA

Mark allocation: 3 marks

- 1 mark for correctly calculating the effective resistance.
- 1 mark for substituting the correct values into the correct equations.
- 1 mark for the correct answer.

Tip

- *Adding resistors in parallel will allow a second path for current to flow and will always reduce the effective resistance. Expect a lower value for R_{eff} than that for a single resistor.*

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Question 9a.

Worked solution

Reading from the graph:
$20°\text{C} \rightarrow 20\ \text{k}\Omega$

20 kΩ

Mark allocation: 1 mark

- 1 mark for the correct value.

Question 9b.

Worked solution

$$\frac{V_{\text{out}}}{V_{\text{in}}} = \frac{R_2}{R_1 + R_2}$$

$$\frac{4}{12} = \frac{20\,000}{R_1 + 20\,000}$$

$$R_1 = 40\,000$$

40 kΩ

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equations.
- 1 mark for the correct answer.

Tip

- *When using the voltage divider equation shown above, remember that* V_{out} *occurs across* R_2*, regardless of how the circuit is arranged.*

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Question 9c.

Worked solution

NO.
As the temperature rises, the resistance of the thermistor will decrease.
As the resistance of the thermistor decreases, the voltage across it will decrease, causing the fan to switch off.

Mark allocation: 3 marks

- 1 mark for selecting "NO".
- 1 mark for relating a rise in temperature to a fall in resistance of the thermistor.
- 1 mark for relating a fall in resistance to a reduction in voltage supplied to the fan.

Tip

- *If you have trouble following the chain of reasoning like that given in the solution here, pick a larger value of* T *and calculate* V_{out} *again. You will see what effect rising temperature will have on* V_{out}.

Question 9d.

Worked solution

INCREASED.
At a lower temperature, the thermistor will have a higher resistance. To maintain the ratio of voltages, R_1 must also increase.

Mark allocation: 3 marks

- 1 mark for selecting INCREASED.
- 1 mark for stating that the resistance of the thermistor will increase at a lower temperature.
- 1 mark for observing that the voltage ratio needs to be maintained (or similar).

Tip

- *Understanding how voltage dividers work in terms of ratios is much more important than just applying an equation to find unknown values. Consider a voltage divider with identical resistors.*

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Question 10a.

Worked solution

$$\text{Gain} = \frac{V_{\text{out}}}{V_{\text{in}}}$$
$$= \frac{12}{0.30}$$
$$= 40$$

$$\boxed{\mathbf{40}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct formula.
- 1 mark for the correct answer.

Tip

- *When taking values from a pair of graphs such as this, make sure you choose points that have the same time value and are not clipped.*

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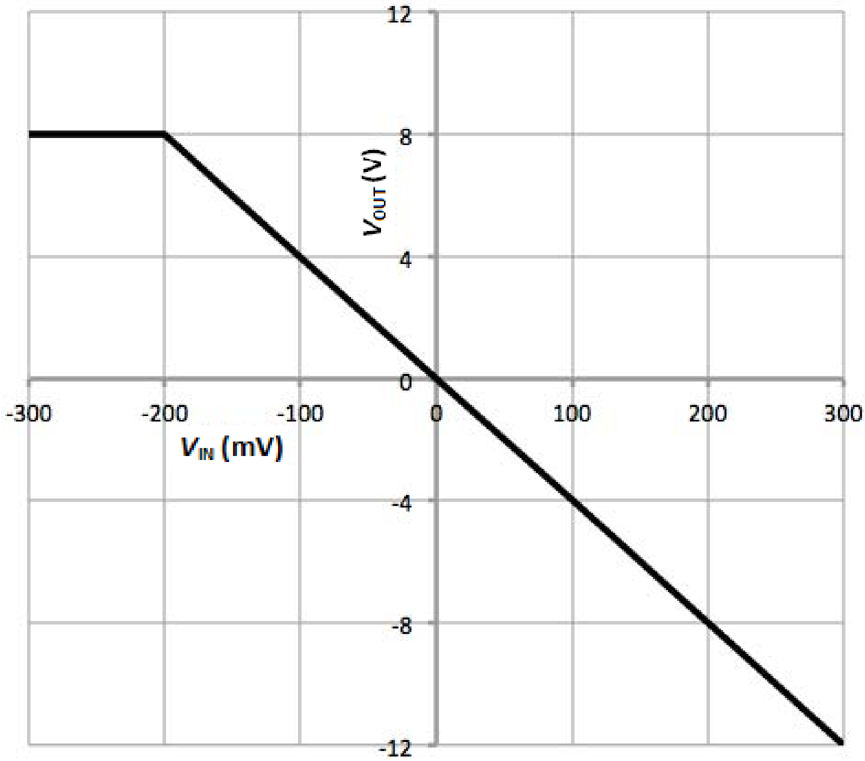
Question 10b.

Worked solution



Mark allocation: 3 marks

- 1 mark for inverting (i.e. negative gradient).
- 1 mark for the correct gradient.
- 1 mark for clipping at 8 V.

Tips

- *Remember that an inverting amplifier will have a negative gradient.*
- *The output graph shows that no outputs can exceed 8 V. You should use a faint dotted line on the axes to remind yourself of this when sketching your graph.*

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Question 10c.

Worked solution

NO.
The sound would be distorted because the signal wave would be clipped. The input wave lies outside of the linear region of the amplifier.

Mark allocation: 2 marks

- 1 mark for selecting NO.
- 1 mark for mentioning clipping.

Note: No marks should be awarded for this question if it is mentioned in the answer that the sound would be distorted because it is inverted.

Tip

- *Inverting a sound wave does not change its characteristics. Inverted waves carry the same information as non-inverted waves.*

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Question 11a.

Worked solution

$$\phi = \frac{\text{intensity}}{\text{area}}$$
$$= \frac{0.10 \times 10^{-3}}{25 \times 10^{-6}}$$
$$= 4$$

From the graph, 4 W m^{-2} = –20 μA.

$\boxed{\textbf{20 μA}}$

Mark allocation: 3 marks

- 1 mark for correctly converting units to calculate light intensity.
- 1 mark for finding correct value of light intensity.
- 1 mark for the correct answer.

Tip

- *When converting from mm^2 to m^2, the conversion factor is 10^{-6}.*

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Question 11b.

Worked solution

From the graph, 5 W m^{-2} = 25 μA.

$V_{out} = IR$

$= 25 \times 10^{-6} \times 80 \times 10^{3}$

$= 2$

2 V

Mark allocation: 2 marks

- 1 mark for substituting the correct values for current and resistance into the correct equation.
- 1 mark for correct answer.

Tip

- *The values of photocurrent on the graph in Figure 15 are negative because they flow through the photodiode in reverse bias. You do not need to use the negative sign in calculations.*

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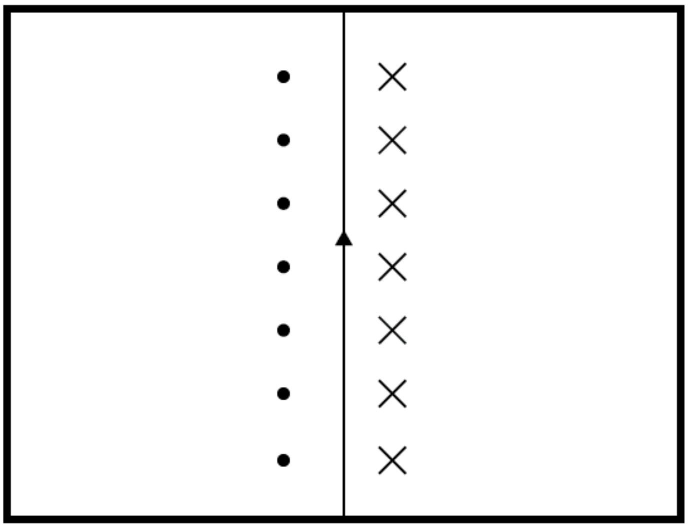
Area of study – Electric power

Question 12a.

Worked solution



Mark allocation: 2 marks

- 1 mark for showing correct direction on each side of the conductor.
- 1 mark for using correct symbols.

Tip

- *Use the right-hand grip rule to predict this, making sure it is actually your right hand that you are using.*

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Question 12b.

Worked solution

$$\begin{aligned} F &= IlB \\ &= 5 \times 0.1 \times 0.01 \\ &= 0.005 \end{aligned}$$

$$\boxed{\mathbf{5 \times 10^{-3}\ N}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- *Remember to work only in SI units. Length must be in metres to obtain an answer in newtons.*

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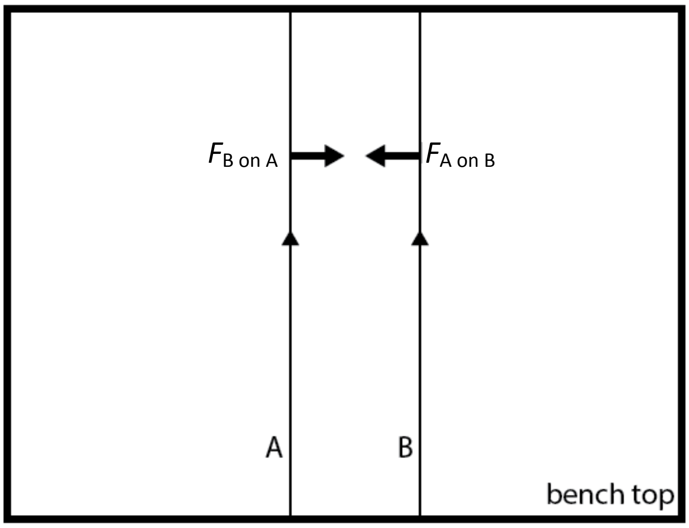
Question 13

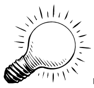
Worked solution



Conductor A creates a magnetic field around conductor B that is directed into the page (RH grip rule). This field means that conductor B experiences a force to the left of the page (RH slap rule). The opposite is true for the force on conductor A.

Mark allocation: 2 marks

- 1 mark for each correct force arrow. No labels are required.



Tip

- *Know the difference between the two right-hand rules and when to use them. It is easy to get them mixed up.*

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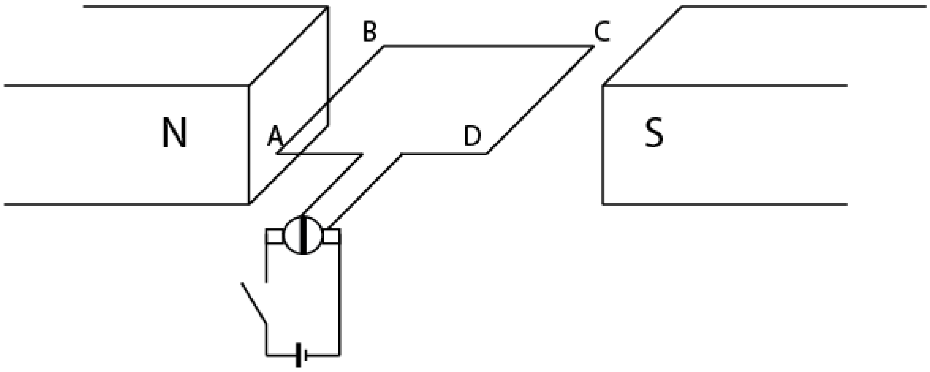
Question 14a.

Worked solution



Mark allocation: 1 mark

- 1 mark for correctly drawing the split vertically.

Tip

- *Current through the loop of a DC motor must reverse every half turn when torque is zero. The split in a split-ring commutator should be in contact with the brushes when the force on each arm no longer turns the loop.*

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Question 14b.

Worked solution

$$I = \frac{V}{R}$$

$$= \frac{12}{50}$$

$$= 0.24 \text{ A}$$

$$F = nIlB$$

$$= 100 \times 0.24 \times 0.12 \times 0.001$$

$$= 0.00288$$

$$\boxed{\mathbf{2.9 \times 10^{-3}\ N}}$$

Mark allocation: 3 marks

- 1 mark for calculating the current correctly.
- 1 mark for substituting the correct values into the correct equation for force.
- 1 mark for the correct answer.

Tip

- *Partial marks can be awarded for calculations. Make sure that your working is clear and that an assessor can easily see what quantity you are calculating with each line of working.*

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Question 14c.

Worked solution

The current through side *BC* runs parallel to the magnetic field and so no force is experienced.
The current through side *AB* runs perpendicular to the magnetic field and so a force is experienced.

Mark allocation: 2 marks

- 1 mark for mentioning that *BC* is parallel to the field (or similar, such as 0° between *I* and *B*).
- 1 mark for mentioning that *AB* is perpendicular to the field (or similar, such as 90° between *I* and *B*).

Tip

- *In VCE Physics, you can only ever be asked to calculate magnetic forces on current at 90° and at 0° to a magnetic field. However, you still need a qualitative understanding that the force is reduced as the angle between them approaches 0°.*

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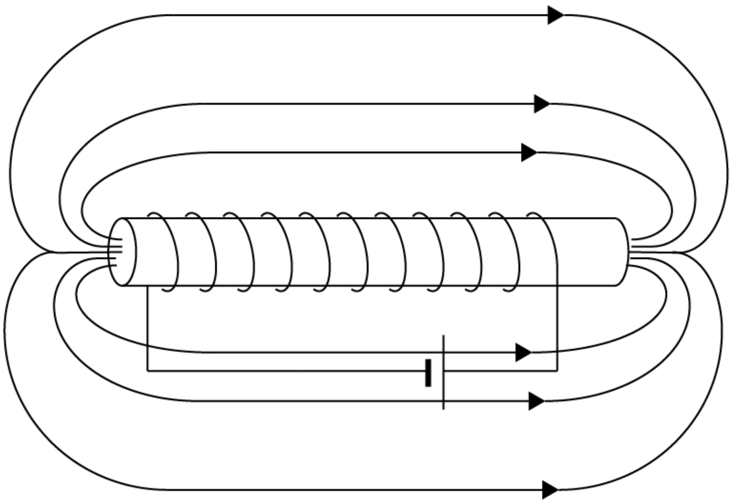
Question 15a.

Worked solution



Mark allocation: 2 marks

- 1 mark for three continuous lines that do not cross.
- 1 mark for arrows that point in the correct direction.

Tip

- *Imagine gripping the wire at the right-hand end of the solenoid with your thumb pointing up in the direction of the current and your fingers wrapping inside the coil. This shows that the magnetic field through the core runs from right to left and the magnetic field around the outside must run from left to right.*

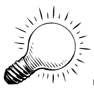
Question 15b.

Worked solution

The needle deflects to the left and then returns to its central position.

Mark allocation: 2 marks

- 1 mark for stating that the needle deflects to the left.
- 1 mark for stating that the needle then returns to the central position.



Tip

- *A changing magnetic field is required to induce a current in the loop connected to the galvanometer. Switching the current on and off in the solenoid will induce a current in the loop, but leaving the solenoid current on will not.*

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Question 16a.

Worked solution

Lenz's law states that when a magnetic field through a conducting loop or coil is changed, a current will be induced to oppose that change.
As the coil rotates from the position shown, the magnetic flux through it is increased.
A current is induced in the coil to create a magnetic field to oppose this change.

Mark allocation: 3 marks

- 1 mark for stating or summarising Lenz's law correctly.
- 1 mark for stating that the magnetic field is increasing at the instant shown.
- 1 mark for stating that the induced current will create a magnetic field to oppose the change in flux.

Tip

- *When asked to refer to a particular law or theory in an answer, you should always state it by name before beginning your answer.*

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Question 16b.

Worked solution

Consider time for one-quarter rotation.

$$\text{Period} = \frac{1}{50} = 0.02 \text{ s}$$

$$t = \frac{0.02}{4} = 0.005 \text{ s}$$

$$\begin{aligned}\text{emf} &= n\frac{\Delta\phi}{\Delta t}\\ &= 25 \times \frac{0.005 \times 6 \times 10^{-4}}{0.005}\\ &= 0.015\end{aligned}$$

$$\boxed{\textbf{15 mV}}$$

Mark allocation: 3 marks

- 1 mark for the correct value for time.
- 1 mark for substituting the correct values into the equation for emf.
- 1 mark for the correct answer.

Tip

- *Always consider a quarter rotation in these types of question. It means that* $\Delta\phi$ = BA *as flux changes from maximum to zero in a quarter rotation.*

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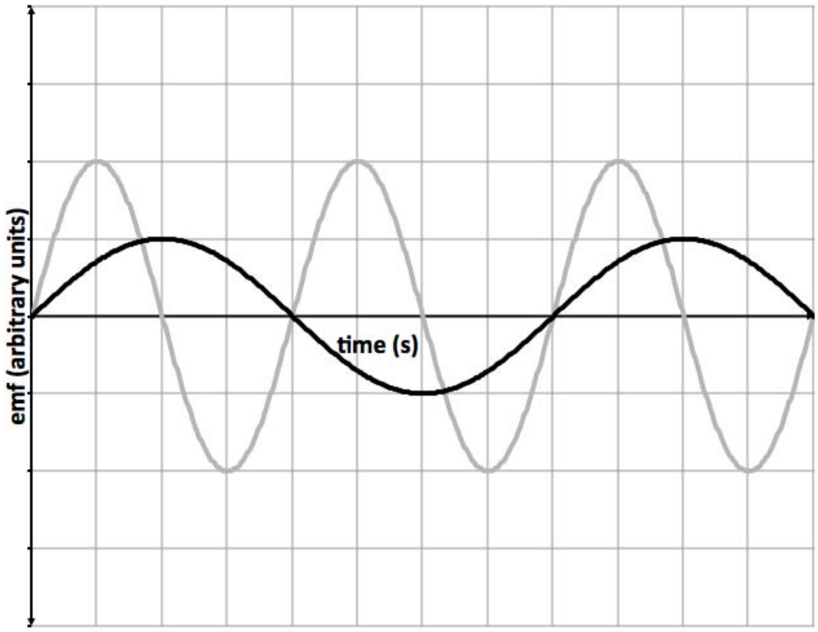
Question 17a.

Worked solution



Mark allocation: 2 marks

- 1 mark for the correct period.
- 1 mark for the correct amplitude.

Tip

- *Because emf is inversely proportional to time (Faraday's law* $emf = n\dfrac{\Delta\phi}{\Delta t}$*), doubling the period will halve the peak voltage.*

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Question 17b.

Worked solution

The slip rings could be removed and a split-ring commutator installed.

Mark allocation: 2 marks

- 1 mark for mentioning the split-ring commutator.
- 1 mark for mentioning removing the slip rings.

Tip

- *Split-ring commutators are always associated with DC power. They are used in DC motors and DC generators.*

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Question 18a.

Worked solution

Method A: Calculate the voltage drop in the transmission lines.

$$
\begin{aligned}
V &= I \times R \\
&= 30 \times 3.0 \\
&= 90 \text{ V dropping in transmission}
\end{aligned}
$$

$$240 - 90 = 150 \text{ V available to lodge}$$

Method B: Calculate the power loss in the transmission lines.

$$
\begin{aligned}
P_{\text{loss}} &= I^2 R \\
&= 30^2 \times 3 \\
&= 2700 \text{ W} \\
P_{\text{lodge}} &= P_{\text{mains}} - P_{\text{loss}} \\
&= 240 \times 30 - 2700 \\
&= 4500 \text{ W} \\
P &= IV \\
4500 &= 30 \times V \\
V &= 150
\end{aligned}
$$

150 V

Mark allocation: 3 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for correctly calculating the voltage drop or power loss in transmission (depending on method used).
- 1 mark for the correct answer.

Tip

- *Resistance in transmission lines is sometimes expressed as a 'per km' value instead of a total resistance. Remember that the current must run to and from the lodge along the two lines, so if you are working with a per km resistance, then you must double the distance.*

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Question 18b.

Worked solution

To calculate the voltage drop in the parallel transmission lines, find the effective resistance of three 3.0 Ω resistors in parallel.

$$\frac{1}{R_{\text{tot}}}=\frac{1}{3.0}+\frac{1}{3.0}+\frac{1}{3.0}=1.0$$

$R_{\text{tot}}=1.0\ \Omega$ (1 mark)

Treat the three lines as a single line of 1.0 Ω carrying 30 A.

$$\begin{aligned}V_{\text{lines}}&=IR\\&=30\times1.0\\&=30\text{ V}\ \ \text{(1 mark)}\end{aligned}$$

$240-30=210$ V (1 mark)

Alternative method:
The power from the mains gets shared between the power lost in the lines and the power used by the lodge: $P_{\text{mains}}=P_{\text{lodge}}+P_{\text{lines}}$.

Use $P_{\text{lines}}=3\times I^2R$ and $P=IV$ for the other terms:

$$\begin{aligned}P_{\text{lines}}&=3\times10^2\times3\\&=900\text{ W (1 mark)}\\P_{\text{mains}}&=30\times240\\&=7200\text{ W}\\7200&=P_{\text{lodge}}+900\ \ \text{(1 mark)}\\P_{\text{lodge}}&=6300\text{ W}\ \ \text{(1 mark)}\\V_{\text{lodge}}&=\frac{6300}{30}\\&=210\text{ V}\ \ \text{(1 mark)}\end{aligned}$$

210 V

Mark allocation: 3 marks

- 3 marks; see methods above.

Tip

- *When power is lost due to resistance in the transmission lines, it is the voltage that is reduced, not the current.*

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Question 19a.

Worked solution

$$\frac{N_1}{N_2} = \frac{V_1}{V_2}$$

$$\frac{1}{10} = \frac{240}{V_2}$$

$$V_2 = 2400 \text{ V}$$

2400 V

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Note: Some students may do this in their head and not show any working. Full marks may be awarded for a correct answer.

Tip

- *Although many of these questions may seem easy, remember how to use the formula* $\frac{N_1}{N_2} = \frac{V_1}{V_2} = \frac{I_2}{I_1}$ *in case you come across a more difficult example.*

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Question 19b.

Worked solution

$$\frac{N_1}{N_2} = \frac{I_2}{I_1}$$

$$\frac{10}{1} = \frac{20}{I_1}$$

$$I_1 = 2\ \text{A}$$

2 A

Mark allocation: 2 marks

- 1 mark for substituting the correct value into the correct equation.
- 1 mark for the correct answer.

Tip

- *When voltage steps up, current steps down. In this way, total power is conserved.*

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Question 19c.

Worked solution

$$
\begin{aligned}
P_{\text{loss}} &= I^2 R \\
&= 2^2 \times 5 \\
&= 20 \text{ W}
\end{aligned}
$$

$240 \times 20 - 20 = 4780$ W reaches the building site

$$
\begin{aligned}
4780 &= 20 \times V \\
V &= 239
\end{aligned}
$$

239 V

Mark allocation: 3 marks

- 1 mark for calculating the power loss in the transmission lines.
- 1 mark for calculating the power reaching the building site.
- 1 mark for the correct answer.
- Consequential marks if an incorrect value for current is taken from part **b**.

Tip

- *Be clear in your working, especially when you are using values that you calculated in previous questions, to maximise your chances of being awarded consequential marks.*

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Area of study – Interactions of light and matter

Question 20a.

Worked solution

$$E = \frac{hc}{\lambda}$$
$$= \frac{6.63\times10^{-34}\times3.0\times10^{8}}{500\times10^{-9}}$$
$$= 3.978\times10^{-19}$$

$\boxed{\mathbf{4.0\times10^{-19}\ J}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- *When asked for an answer in specific units, you must give the answer in those units. You may not change the unit in the answer box in this question. Use the value for Planck's constant that thas the units* J s *to get photon energy in joules.*

Question 20b.

Worked solution

MORE.
Red light photons carry less energy than green photons and so more are required to make up the 5 mW.

Mark allocation: 2 marks

- 1 mark for selecting MORE.
- 1 mark for explaining that red photons have less energy than green photons.

Tip

- *5 mW means 5 mJ per second. Each second, 5 mJ of energy is released as photons.*

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Question 21

Worked solution

When light from the two slits arrives at the surface exactly in phase, it undergoes constructive interference to create a bright band.
When light from the two slits arrives exactly out of phase, it undergoes destructive interference to create a dark band.
Interference effects can only be explained by modelling light as a wave and not as a particle.

Mark allocation: 3 marks

- 1 mark for a description of constructive interference.
- 1 mark for a description of destructive interference.
- 1 mark for identifying these as strictly wave phenomena.

Tip

- *A 3-mark question needs three key ideas to gain full marks. You may prefer to give your answer to these questions as dot points.*

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Question 22a.

Worked solution

Convert kinetic energy from electron-volts to joules.
$250 \times 1.6 \times 10^{-19} = 4.0 \times 10^{-17}$ J

Use $E_{\mathrm{k}} = \frac{1}{2} m v^2$ to find velocity.

$$4.0 \times 10^{-17} = 0.5 \times 9.1 \times 10^{-31} \times v^2$$

$$v = \sqrt{\frac{4.0 \times 10^{-17}}{0.5 \times 9.1 \times 10^{-31}}}$$

$$= 9.4 \times 10^6$$

$\boxed{\mathbf{9.4 \times 10^6\ m\ s^{-1}}}$

Mark allocation: 3 marks

- 1 mark for the correct conversion of kinetic energy to J.
- 1 mark for substituting the correct values into the kinetic energy equation.
- 1 mark for the correct answer.

Tip

- *Kinetic energy and momentum can only ever be calculated in joules. Convert energy from electron-volts to joules first.*

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Question 22b.

Worked solution

$$\lambda = \frac{h}{mv}$$
$$= \frac{6.63\times10^{-34}}{9.1\times10^{-31}\times8.1\times10^{6}}$$
$$= 8.99\times10^{-11}\ \text{m}$$

$\boxed{\mathbf{9.0\times10^{-11}\ m}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- *Remember to use the* J s *value for Planck's constant when calculating wavelength.*

Question 22c.

Worked solution

$$v = f\lambda$$
$$3.0\times10^{8} = f\times1.6\times10^{-10}$$
$$f = 1.9\times10^{18}$$

$\boxed{\mathbf{1.9\times10^{18}\ Hz}}$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- *When particle and wave diffraction patterns match, it is because their wavelengths are the same.*

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Question 23a.

Worked solution

B
When the frequency of light is increased, the energy of each photon is increased.
Each photoelectron now has more kinetic energy and it will take a larger (i.e. more negative) voltage to stop them.

Mark allocation: 3 marks

- 1 mark for selecting B.
- 1 mark for linking increased frequency with increased photon energy.
- 1 mark for linking increased energy with increased stopping voltage.

Tip

- *A negative stopping voltage is required to stop a negatively charged particle such as an electron.*

Question 23b.

Worked solution

$$\begin{aligned} E_{\text{Kmax}} &= eV_0 \\ &= 1.6 \times 10^{-19} \times 3.4 \\ &= 5.44 \times 10^{-19} \end{aligned}$$

$$\boxed{\mathbf{5.4 \times 10^{-19}\ J}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- E_{Kmax} *and stopping voltage both apply to the fastest-moving photoelectron. Many other electrons move slower than these.*

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Question 23c.

Worked solution

$$W = hf_0$$
$$2.93 = 4.14 \times 10^{-15} \times f_0$$
$$f_0 = 7.077 \times 10^{14}$$

$$\boxed{\mathbf{7.1 \times 10^{14}\ Hz}}$$

Mark allocation: 2 marks

- 1 mark for substituting the correct values into the correct equation.
- 1 mark for the correct answer.

Tip

- *Use the value of Planck's constant that matches the energy that the work function has been expressed in. It is usual to use electron-volts to express work function but joules is equally valid.*

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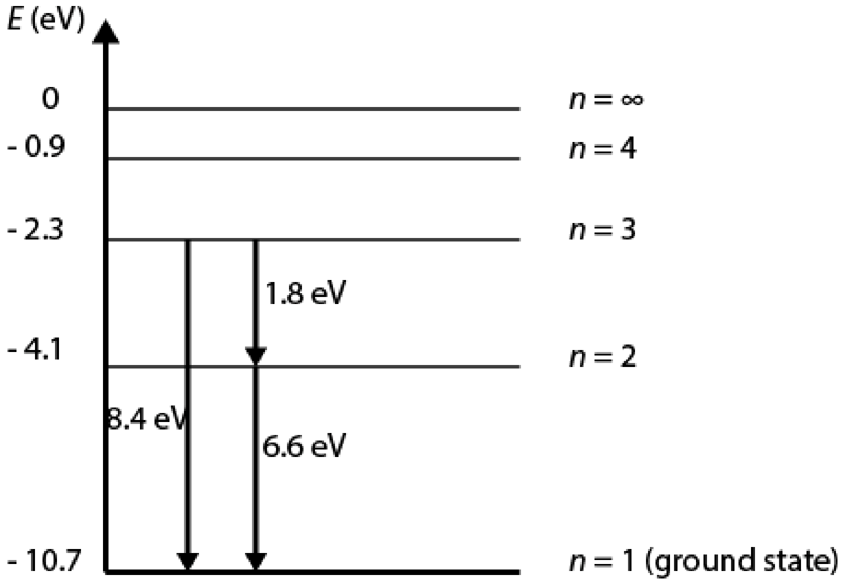
Question 24a.

Worked solution

D

The second excited state is n = 3. The transitions are as shown:



Mark allocation: 2 marks

- 2 marks for the correct answer.

Tip

- *The vertical axis on these graphs is sometimes numbered with the ground state at 0 energy. In this case, a free electron is numbered as 0 energy.*

Question 24b.

Worked solution

Electrons in orbit around an atomic nucleus have a de Broglie wavelength that corresponds to their energy.
Only energies that produce a wavelength that can form a standing wave in the orbit are allowed.

Mark allocation: 2 marks

- 1 mark for correct use of de Broglie wavelength.
- 1 mark for mentioning standing waves.

END OF CORE STUDIES SOLUTIONS BOOK

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