Neap

Trial Examination 2023

HSC Year 12 Physics

Solutions and Marking Guidelines

SECTION I

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 1 **A** Polonium-214 undergoes alpha decay and emits a helium nucleus. As X is the mass number of Pb: $X = 214 - 4$ $= 210$ As Y is the atomic number of Pb: $Y = 84 - 2$ $= 82$ The alpha particle is the helium nucleus, which is composed of two protons, each with a positive charge, and two neutrons, each with no charge. Thus, the alpha particle has a +2 charge.	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–7, 12–15 Bands 3–6
Question 2 **B** photon energy $= E_{n=4} - E_{n=3}$ $= 2.04 \times 10^{-18} - 1.94 \times 10^{-18}$ $= 1.00 \times 10^{-19}$ Thus, 1.00×10^{-19} J of energy is emitted as the electron is falling from a higher energy level to a lower energy level.	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–15 Bands 3–6
Question 3 **A** Protons have a +1 charge with 2 up quarks and 1 down quark; that is, uud. Neutrons have no charge with 1 up quark and 2 down quarks; that is, udd.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–6
Question 4 **A** $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ $\frac{168}{4200} = \frac{50}{N_s}$ $N_s = \frac{4200 \times 50}{168}$ $= 1250$ $N_p : N_s = 50 : 1250$ $= 1 : 25$	Mod 6 Electromagnetism PH12–5, 12–13 Bands 4–6

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 5 **B** **B** is correct and **D** is incorrect. The tennis ball's journey has two parts. Initially, it travels upwards after being launched by the tennis player, so the graph must begin above the *x*-axis. The ball travels upwards at a decreasing velocity, so it approaches the *x*-axis until it reaches its maximum height. After this, the ball travels downwards (that is, below the *x*-axis) at a decreasing velocity until it is caught by the tennis player at time *T*. **A** is incorrect. This graph accurately depicts the first part of the tennis ball's journey, but shows the second part of the journey as an upwards motion with increasing velocity. **C** is incorrect. This graph is parabolic, which does not represent the tennis ball's journey.	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 3–6
Question 6 **C** **C** is correct and **D** is incorrect. When a satellite that has an elliptical orbit, such as the Moon, returns to its closest point to Earth (the perigee), its gravitational potential energy will be at its lowest and its kinetic energy will be at its highest. Thus, the Moon will be moving at a high velocity. **A** is incorrect. At the furthest point in its orbit (the apogee), the Moon's gravitational potential energy will be at a maximum, not a minimum. **B** is incorrect. At the apogee, the Moon's kinetic energy will be at a minimum, not a maximum, and, as a result, it will move at a low velocity.	Mod 5 Advanced Mechanics PH12–4, 12–6, 12–12 Bands 4–6
Question 7 **D** During stage 1, the elevator moves at a constant velocity. Therefore: $\text{weight} = mg$ $= 65 \times 9.8$ $= 637 \text{ N}$ During stage 2, the elevator accelerates upwards. Therefore: $\text{weight} = mg + ma$ $= 65 \times 9.8 + 65 \times 5$ $= 962 \text{ N}$ During stage 3, the elevator accelerates downwards. Therefore: $\text{weight} = mg - ma$ $= 65 \times 9.8 - 65 \times 5$ $= 312 \text{ N}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 8 **B** According to $\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$, doubling the distance between the wires (from 0.05 m to 0.1 m) would reduce the acting force by half of its original value.	Mod 6 Electromagnetism PH12–4, 12–5, 12–13 Bands 3–6
Question 9 **C** $F = qvB$ $= -1.602 \times 10^{-19} \times 80 \times 20$ $= 2.6 \times 10^{-16}$ N The magnetic field, *B*, is directed to the right of the page and the negative charge is entering the field up the page. Thus, the force is out of the page. *Note: When applying the right-hand rule, the thumb points in the direction of the velocity of the charge (up the page), the index finger points in the direction of the magnetic field (right of the page) and the middle finger points in the direction of the force acting on the particle (into the page). As this is a negative particle, the force is in the opposite direction; thus, it is out of the page.*	Mod 6 Electromagnetism PH12–4, 12–5, 12–13 Bands 4–6
Question 10 **B** Using the right-hand rule for the top and bottom of the coil, the current, *I*, is up the page and the magnetic field, *B*, is to the right of the page. Thus, the palm indicates a force into the page, which means that the coil rotates in an anticlockwise direction. $\tau = nIAB\sin\theta$ $= 20 \times (15 \times 0.001) \times (0.03 \times 0.04) \times 3 \times \sin(65°)$ $= 20 \times 0.015 \times 0.0012 \times 3 \times 0.9063\ldots$ $= 9.79 \times 10^{-4}$ Nm	Mod 6 Electromagnetism PH12–4, 12–5, 12–13 Bands 4–6

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 11 **C** **C** is correct and **D** is incorrect. Using the right-hand rule, the magnetic field is into the page; thus, the direction of particle *K*'s movement indicates that it is negatively charged. Given that $F = qvB$: $F = \frac{mv^2}{r}$ $r = \frac{mv^2}{F}$ $r = \frac{mv^2}{qvB}$ $r = \frac{mv}{qB}$ $\frac{q}{m} = \frac{v}{rB}$ $= \frac{2.5 \times 10^4}{0.05 \times 1.8 \times 10^{-6}}$ $= 2.8 \times 10^{11}$ C kg^{-1} **A** and **B** are incorrect. These options do not convert the radius of particle *K*'s arc from centimetres to metres.	Mod 6 Electromagnetism Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–13, 12–15 Bands 5–6
Question 12 **C** The intensity of the light refers to the rate at which the photons in the light are incident on a surface; in this case, the piece of metal. The frequency of the light refers to the energy of each photon, according to $E = hf$. Under condition 1, the maximum kinetic energy of the photoelectrons (K_{max}) would remain constant because the frequency of the light is kept constant, and the number of photoelectrons emitted would decrease because the intensity of light decreased. Under condition 2, the increased frequency of the light means that the photon energy is increased, according to $K_{max} = hf - \phi$. As ϕ is constant, this also increases the kinetic energy of the photoelectrons. As the intensity of the light is kept constant, the number of photons, and thus photoelectrons, also remains constant.	Mod 7 The Nature of Light PH12–2, 12–4, 12–14 Band 5

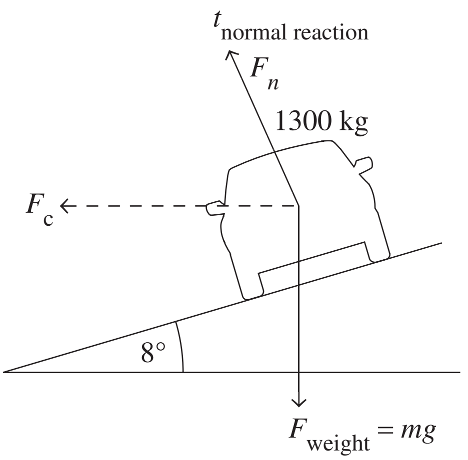
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 13 **A** **A** is correct. The speed of light is constant relative to all observers. **B**, **C** and **D** are incorrect. These statements do not account for the speed of light being constant.	Mod 7 The Nature of Light PH12–4, 12–14 Band 4
Question 14 **C** Ren and Annika are moving on the same path. Therefore, they could both be moving towards the Extrema space station, with Annika travelling at a faster speed. Thus, conclusion 1 could be correct. While her navigation system is rebooting, Ren could go off course and start moving backwards towards the Ultima space station while Annika remains stationary. Thus, conclusion 2 could be correct. Both Ren and Annika could go off course and start moving backwards towards the Ultima space station, with Ren moving faster than Annika. Thus, conclusion 3 could be correct.	Mod 7 The Nature of Light PH12–4, 12–14 Bands 4–6
Question 15 **D** Using Wien's law gives: $\lambda_{\text{max}} = \frac{b}{T}$ $= \frac{2.898 \times 10^{-3}}{4000}$ $= 7.245 \times 10^{-7}$ m $= 725$ nm	Mod 7 The Nature of Light PH12–4, 12–14 Band 4

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 16 B $^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{140}_{56}\text{Ba} + ^{93}_{36}\text{Kr} + 3^{1}_{0}\text{n}$ The mass of the reactants in the fission reaction is: 235.044 + 1.00866 = 236.05266 amu The mass of the products in the fission reaction is: 139.91061 + 92.93127 + (3 × 1.00866) = 235.86786 amu Therefore, the mass lost during the reaction is: 236.05266 – 235.86786 = 0.1848 amu Given that 1 amu = 1.661×10^{-27} kg, the energy released per nucleus is: $E = mc^2$ $= (0.1848 \times 1.661 \times 10^{-27}) \times (3.00 \times 10^8)^2$ $= 2.7625\ldots \times 10^{-11}$ J Given that 2% of 1 kg is 0.02 kg, the mass of uranium-235 is: $\dfrac{0.02}{1.661 \times 10^{-27}} = 1.2040\ldots \times 10^{25}$ amu number of uranium-235 nuclei $= \dfrac{1.2040\ldots \times 10^{25}}{235.044}$ $= 5.1228\ldots \times 10^{22}$ nuclei total energy released $= (2.7625\ldots \times 10^{-11}) \times (5.1228\ldots \times 10^{22})$ $= 1.4168\ldots \times 10^{12}$ $= 1.42 \times 10^{12}$ J	Mod 8 From the Universe to the Atom PH12–4, 12–5, 12–15 Bands 5–6
Question 17 A In experiment 1, the students would observe a continuous visible spectrum due to the heated filament of the incandescent lamp, which produces heat and light and emits photons across the entire visible spectrum. In experiment 2, the students would observe an emission spectrum. The yellow lines on the black background are caused by the photons of light released by excited electrons returning to the ground state from a higher energy level and correspond to the differences in these energy levels. In experiment 3, the students would observe an absorption spectrum. The incandescent lamp produces photons of all colour frequencies; however, the sodium vapour would absorb photons that cause electrons to jump to higher energy levels. As these electrons return to the ground state, the photons released would be equivalent to the wavelengths of the energy absorbed. Thus, these wavelengths would appear as black lines on the coloured background.	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–15 Bands 4–6

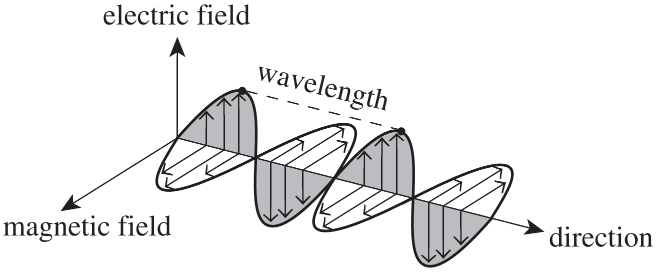
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 18 **C** $qV = \frac{1}{2}mv^2$ $v = \sqrt{\frac{2qV}{m}}$ $= \sqrt{\frac{2\times(1.602\times10^{-19})\times3200}{9.109\times10^{-31}}}$ $= 3.35\times10^7 \text{ m s}^{-1}$	Mod 8 From the Universe to the Atom PH12–6, 12–15 Band 5
Question 19 **D** $\tau = rF\sin\theta$ Given that $m = rF$, using points from the graph to find m gives: $m = \frac{200-50}{0.59-0.14}$ $= 333.3333\ldots$ Therefore: $m = rF$ $333.3333\ldots = 0.25\times F$ $F = 1333 \text{ N}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 5–6
Question 20 **C** $T = \frac{60}{10}$ $= 6 \text{ s}$ $v = \frac{2\pi r}{T}$ $= \frac{2\pi\times15.00}{6}$ $= 15.7079\ldots \text{ m s}^{-1}$ $F = \frac{mv^2}{r}$ $= \frac{(550.0+65.00)\times15.7079\ldots^2}{15.00}$ $= 10\,116 \text{ N}$	Mod 5 Advanced Mechanics PH12–4, 12–6, 12–12 Bands 5–6

SECTION II

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 21	
(a) $s = h_{max}$ $v = 0$ $u = 25\sin(30°)$ $= +12.5 \text{ m s}^{-1}$ $a = -9.8 \text{ m s}^{-2}$ Substituting these values into the formula gives: $v^2 = u^2 + 2as$ $0 = 12.5^2 + 2 \times -9.8 \times h_{max}$ $-12.5^2 = 2 \times -9.8 \times h_{max}$ $h_{max} = -\frac{12.5^2}{2 \times -9.8}$ $= +7.97 \text{ m}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the maximum height of the kai using appropriate units . . . . 2 • Provides some relevant working . . . 1
(b) $v = -12.5 \text{ m s}^{-1}$ $u = +12.5 \text{ m s}^{-1}$ $a = -9.8 \text{ m s}^{-2}$ Substituting these values into the formula gives: $v = u + at$ $-12.5 = 12.5 + -9.8 \times t$ $t = \frac{25}{9.8}$ $= 2.55 \text{ s}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the flight time of the kai using appropriate units. . . . . 2 • Provides some relevant working . . . 1
(c) $v = 25\cos(30°)$ $= 21.6506 \text{ m s}^{-1}$ $t = 2.55 \text{ s}$ Substituting these values into the formula gives: $v = \frac{s}{t}$ $21.6506 = \frac{s}{2.55}$ $s = 21.6506 \times 2.55$ $= 55.2091$ $= 55.2 \text{ m}$ *Note: Consequential on answer to* ***Question 21(b)***.	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the horizontal range of the kai using appropriate units . . . . 2 • Provides some relevant working . . . 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 22	
(a) $F_c = \frac{mv^2}{r}$ $= 1300 \times \frac{\left(\frac{80}{3.6}\right)^2}{40}$ $= 16\,049$ N	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the magnitude of the centripetal force using appropriate units. . . . . 2 • Provides some relevant working . . . 1
(b) $a = \frac{v^2}{r}$ $= \frac{\left(\frac{80}{3.6}\right)^2}{40}$ $= 12 \text{ m s}^{-2}$	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 4–6 • Identifies the appropriate data and formulae. AND • Calculates the magnitude of the centripetal acceleration using appropriate units. . . . . 2 • Provides some relevant working . . . 1
(c)  $F_c = F_{net}(x)$ $\tan(8°) = \frac{F_{net}(x)}{1300 \times 9.8}$ $F_{net}(x) = \tan(8°) \times 12\,740$ $= 1790$ N OR 2×10^3 N (to 1 significant figure)	Mod 5 Advanced Mechanics PH12–4, 12–5, 12–6, 12–12 Bands 4–6 • Draws a relevant diagram that shows the vector components. AND • Labels the reaction force AND weight force. AND • Identifies $F_{net}(x)$ as the centripetal force. AND • Calculates the magnitude of the centripetal force using appropriate units. . . . . 4 • Any THREE of the above points. . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 23	
(a) Finding the formula for orbital velocity gives: $\frac{GMm}{r^2} = \frac{mv^2}{r}$ $v = \sqrt{\frac{GM}{r}}$ Substituting into the formula gives: $v = \sqrt{\frac{GM}{r}}$ $= \sqrt{\frac{(6.67\times10^{-11})\times(6.0\times10^{24})}{6.371\times10^{6}+5.0\times10^{5}}}$ $= 7632 \text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6 • Calculates the orbital velocity using appropriate units. . . . . 2 • Derives the formula for orbital velocity. OR • Calculates the orbital velocity without appropriate units 1
(b) $E_p = -\frac{Gm_1m_2}{r}$ $= -\frac{(6.67\times10^{-11})\times(6.0\times10^{24})\times250}{6.371\times10^{6}+5.0\times10^{5}}$ $= -1.4561\ldots\times10^{10}$ J $= -1.5\times10^{10}$ J	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6 • Calculates the magnitude of the gravitational potential energy using appropriate units. . . . . 2 • Calculates the magnitude of the gravitational potential energy without appropriate units. OR • Calculates the magnitude of the gravitational energy without including the radius of Earth 1
(c) $\frac{1}{2}mv^2 = \frac{GMm}{r}$ $v = \sqrt{\frac{2GM}{r}}$ $= \sqrt{\frac{2\times(6.67\times10^{-11})\times(6.0\times10^{24})}{6.371\times10^{6}+5.0\times10^{5}}}$ $= 10\ 793 \text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 5–6 • Identifies the relationship between kinetic energy and potential energy. AND • Identifies the appropriate data and formulae. AND • Calculates the escape velocity of the satellite using appropriate units. . . . . 2 • Any TWO of the above points. 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(d) As the satellite goes to a higher altitude, its gravitational potential energy increases. The work done on the satellite will equal the change in its gravitational potential energy.	Mod 5 Advanced Mechanics PH12–6, 12–12 Bands 4–6 • Identifies the change in the satellite's gravitational potential energy. AND • Explains how the work done is equal to the change in gravitational potential energy . . . . . 2 • Any ONE of the above points 1
Question 24	
(a)  A radio wave, which is an electromagnetic wave, is propagated when a changing electric field induces a changing magnetic field at right angles, which in turn induces a changing electric field.	Mod 7 The Nature of Light PH12–2, 12–7, 12–14 Bands 3–6 • Draws an electromagnetic wave. AND • Labels all THREE of: – electric field – magnetic field – direction of propagation. AND • Describes how radio waves are propagated . . . . 3 • Draws an electromagnetic wave. AND • Labels any TWO of: – electric field – magnetic field – direction of propagation. AND • Describes how radio waves are propagated . . . . 2 • Draws a recognisable electromagnetic wave without labels. OR • Describes how radio waves are propagated 1

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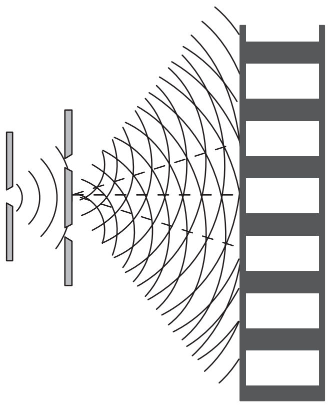
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b) Hertz could have changed the orientation of the receiver and observed whether a spark occured as he changed the angle. If the sparks were only observed when the receiver was in a particular orientation, then the radio waves would be polarised in that orientation. This is because the vibrations of a polarised transverse wave are restricted to only one direction.	Mod 7 The Nature of Light PH12–2, 12–7, 12–14 Band 6 • Explains a suitable method that could have been used to determine if radio waves were polarised. AND • Demonstrates an understanding of polarisation . . . . 2 ——— • Provides some relevant information 1
Question 25	
The diagram shows the refraction, or bending, of light. Both Huygens's and Newton's models can be used to explain how the light changes direction as it leaves the air and enters the glass prism. Huygens proposed the wave model of light, which stated that every point on the wavefront was a source of secondary wavelets that then travelled forwards at the same speed and wavelength as the original wave. When the wave encounters the glass prism, it slows down and refracts because the wavelength changes; thus, the wave also changes direction. Newton's corpuscular model of light assumes that the speed of light increases as it enters the glass prism because the light and glass particles are attracted to each other. The light particles are accelerated along the normal of the prism due to this attraction. When light exits the prism, the attraction is the same, though it opposes the direction of the light's motion. Thus, the speed of the particles decreases and the light moves away from the normal, changing direction. (continues on next page)	Mod 7 The Nature of Light PH12–1, 12–7, 12–14 Bands 4–6 • Identifies that the diagram shows refraction. AND • Outlines Huygens's wave model. AND • Outlines Newton's corpuscular model. AND • Explains how Huygens's model can be used to explain refraction. AND • Explains how Newton's model can be used to explain refraction . . . 5 ——— • Identifies that the diagram shows refraction. AND • Outlines Huygens's wave model OR Newton's corpuscular model. AND • Explains how Huygens's model can be used to explain refraction. AND • Explains how Newton's model can be used to explain refraction . . . 4

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(continued)	• Identifies that the diagram shows refraction. AND • Identifies that Huygens proposed the wave model. AND • Identifies that Newton proposed the corpuscular model. AND • Explains how Huygens's OR Newton's model can be used to explain refraction. 3
	• Identifies that diagram shows refraction. AND • Identifies that Huygens proposed the wave model. AND • Identifies that Newton proposed the corpuscular model 2
	• Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 26	
Model 1 is effective in demonstrating the motor effect by showing the basic principle behind a simple DC motor. In the model, current flowing through the copper coil is supplied by the battery. The current induces a magnetic field around the coil that interacts with the magnetic field produced by the stationary magnet on the wooden base. These forces are perpendicular to the coil's magnetic field and act on opposite sides of the coil, producing torque and causing the coil to rotate. Thus, this model effectively shows the motor effect. However, there are some elements of a DC motor that model 1 does not represent. In a DC motor, the coil is often wound around a soft iron core to increase the magnetic field, and the core and coil are usually placed in an armature. Model 1 also lacks a split ring commutator, which changes the direction of the current through the coil relative to the external circuit in a DC motor. The plum pudding in model 2 represents Thomson's theory of the atom, which demonstrated the negative charge of electrons and showed that, overall, atoms are neutral. Though this theory is no longer accepted, model 2 is an effective visualisation of the theory. Electrons are represented by the pieces of dried plum that are dispersed throughout the plum pudding; the pudding between the pieces of plums is designated as being positive. Thomson proposed this theory before the nuclear model of the atom was created; thus, it was rejected once the Geiger–Marsden experiments showed that an atom has a very small positive nucleus. Models can help the students to visualise physics concepts, but without explaining experimental evidence, they can lead to misconceptions and oversimplification of these concepts. Model 1 demonstrates the motor effect, but does not include all the parts of a DC motor, and model 2 represents an early atomic model that ultimately could not explain later findings. While each model has some limitations, models 1 and 2 are effective in representing the concepts and would aid the students' overall understanding. (continues on next page)	Mod 6 Electromagnetism Mod 8 From the Universe to the Atom PH12–1, 12–4, 12–5, 12–6, 12–7, 12–13, 12–15 Bands 4–6 • Explains in detail how model 1 demonstrates the motor effect. AND • Identifies the features of a DC motor that model 1 represents. AND • Identifies the features of a DC motor that model 1 does not represent. AND • Explains in detail how model 2 demonstrates Thomson's theory of the atom. AND • Identifies the elements of Thomson's theory that model 2 represents. AND • Outlines why Thomson's theory is no longer accepted. AND • Judges summatively the effectiveness of models 1 and 2. AND • Provides a logical and coherent response . . . . 8–9 --- • Explains in detail how model 1 demonstrates the motor effect. AND • Identifies the features of a DC motor that model 1 represents. AND • Identifies the features of a DC motor that model 1 does not represent. AND • Explains in detail how model 2 demonstrates Thomson's theory of the atom. AND

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(continued)	• Identifies the elements of Thomson's theory that model 2 represents. AND • Outlines why Thomson's theory is no longer accepted. AND • Judges the effectiveness of models 1 and 2. 6–7
	• Explains how model 1 demonstrates the motor effect. AND • Identifies the features of a DC motor that model 1 represents. AND • Explains how model 2 demonstrates Thomson's theory of the atom. AND • Identifies the elements of Thomson's theory that model 2 represents. AND • Judges the effectiveness of models 1 and 2. 4–5
	• Outlines how model 1 demonstrates the motor effect. AND • Outlines how model 2 demonstrates Thomson's theory of the atom. AND • Judges the effectiveness of models 1 and 2 2–3
	• Provides some relevant information 1

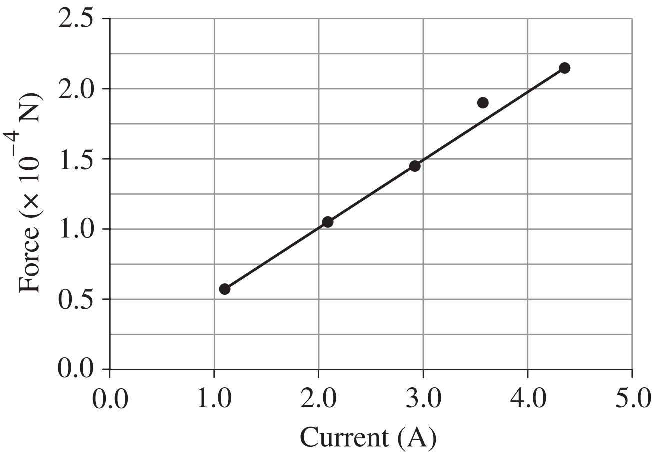
<table>
<tr><th>Sample answer</th><th>Syllabus content, outcomes, targeted performance bands and marking guide</th></tr>
<tr><td>Question 27</td><td></td></tr>
<tr><td>(a)
<table>
<tr><th>Identify risk</th><th>Control risk</th><th>Evaluate risk</th></tr>
<tr><td>Lasers can damage the eyes.</td><td>Point laser away from students.</td><td>The risk is low, if students follow directions.</td></tr>
</table>
</td><td>Mod 7 The Nature of Light
PH12–2, 12–7 Bands 2–6
• Provides relevant headings for each column.
AND
• Conducts a risk assessment for the experiment 2

• Any ONE of the above points.
OR
• Provides some relevant information . . . . 1</td></tr>
<tr><td>(b)

Note: Three light bands must be positioned at the three dotted lines where constructive (anti-nodal) interference has occurred. The dark bands represent destructive (nodal) interference and must be positioned between the light bands.</td><td>Mod 7 The Nature of Light
PH12–2, 12–3, 12–4, 12–7, 12–14
Bands 4–6
• Sketches alternating light and dark bands.
AND
• Positions the light bands in relation to the wavefronts 2

• Sketches alternating light and dark bands. . . . . 1</td></tr>
<tr><td>(c) As this is a first order diffraction, $m = 1$.
$d\sin\theta = m\lambda$
$\theta = \sin^{-1}\left(\frac{633\times10^{-9}}{0.42\times10^{-3}}\right)$
$= 0.0864°$
$\tan\theta = \frac{x}{L}$
$x = \tan(0.0864°)\times1.2$
$= 1.8\times10^{-3}$ m</td><td>Mod 7 The Nature of Light
PH12–4, 12–14 Band 4
• Calculates the distances between the bright bands 2

• Provides some relevant working . . . 1</td></tr>
</table>

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 28	
The speed of light is constant for all observers in inertial frames of reference. In diagram 1, light is bounced off a mirror on the ceiling onto a detector on the floor. To the observer inside the train, the light moves up and down over a short distance in a short period of time. However, as shown in diagram 2, the observer outside the train sees the light appear to bounce off the mirror at an angle and travel a longer path. The time interval in the observer's frame of reference is longer (time dilation occurs) and the lengths in the system moving relative to the observer appear to be shorter (length contraction occurs).	Mod 7 The Nature of Light PH12–4, 12–7, 12–14 Band 5 • Explains how time dilation occurs in the thought experiment. AND • Explains how length contraction occurs in the thought experiment. . . 4 • Outlines how time dilation occurs in the thought experiment. AND • Outlines how length contraction occurs in the thought experiment. . . 3 • Outlines how time dilation occurs in the thought experiment. AND • Identifies that length contraction occurs in the thought experiment. OR • Identifies that time dilation occurs in the thought experiment. AND • Outlines how length contraction occurs in the thought experiment. . . 2 • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 29	
(a) 	Mod 6 Electromagnetism PH12–2, 12–5, 12–13 Band 4 • Identifies the y-axis as force and the x-axis as current. AND • Labels the axes, including correct units. AND • Plots the data. AND • Draws a line of best fit. . . . . 3 • Any THREE of the above points. . . 2 • Any TWO of the above points. 1
(b) *For example:* The graph shows that as current increases, there is a proportional increase in the upwards net force acting on the system, assuming that the magnetic field and current are kept constant. *Note: Responses can also refer to the angle being kept constant. Consequential on answer to* ***Question 29(a)****.*	Mod 6 Electromagnetism PH12–2, 12–5, 12–13 Band 4 • Identifies the relationship shown in the graph. AND • States TWO assumptions. . . . . 2 • Any ONE of the above points 1
(c) $\text{gradient} = \frac{\text{rise}}{\text{run}}$ $= \frac{1.5\times10^{-4} - 1.0\times10^{-4}}{3.0-2.0}$ $= 0.5\times10^{-4}$ $F = lIB\sin\theta$ $\frac{F}{l} = \frac{0.5\times10^{-4}}{1}$ $= 0.5\times10^{-4}\ \text{N m}^{-1}$ $\therefore \frac{F}{l} = BI\sin\theta$	Mod 6 Electromagnetism PH12–2, 12–5, 12–13 Band 6 • Calculates the gradient. AND • Uses relevant equations to identify what the gradient represents. . . . . 2 • Provides some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 30	
This Hertzsprung–Russell diagram graphs the luminosity of stars against their surface temperature. Matching luminosity and surface temperature helps to determine the size/mass of a star; for example, stars with a low temperature but a high luminosity are very large (super giants). A star is found in a particular region of a Hertzsprung–Russell diagram depending on its evolutionary stage. These stages are controlled by the nucleosynthesis reactions occurring in the star's core. White dwarfs are found in area A; these stars are cooling down as they have stopped all nuclear reactions. Main sequence stars are found in area B; this is where the Sun would be found, as it is approximately halfway through its life cycle and is undergoing hydrogen fusion at its centre. Red giants are found in area C; these stars have used up most of the hydrogen in their cores and are now fusing helium, meaning that they are nearing the end of their lives. Supergiants are found in area D; these massive stars have very high temperatures and other fusion reactions occurring in their core. The life cycle of a star begins when the gas inside huge interstellar clouds condenses due to gravitational attraction. In the core of the new star, hydrogen is converted into helium, which releases large amounts of energy; this occurs in main sequence stars. As a main sequence star increases in size, it consumes hydrogen more quickly and burns hotter and brighter; thus, it appears higher in area B of the diagram. The proton–proton cycle is most common in main sequence stars with a small mass, such as the Sun, while the carbon–nitrogen–oxygen (CNO) cycle takes place in stars with a large mass, such as supergiants. As stars evolve and move up the main sequence, they burn hydrogen faster. This causes the stars to form helium, which then collapses and forms heavier elements with large releases of energy; thus, the outer hydrogen shell expands. This outer surface is cooler and appears red, so the star moves off the main sequence and becomes a red giant. When stars with a small or medium mass burn out, they collapse and form white dwarfs made mainly of carbon, nitrogen and oxygen. These white dwarfs are not as luminous as and have much smaller surface areas than main sequence stars. (continues on next page)	Mod 8 From the Universe to the Atom PH12–5, 12–6, 12–7, 12–15 Bands 4–6 • Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. AND • Describes the life cycle of stars with small mass and stars with large mass. AND • Identifies all THREE of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel. AND • Provides a logical and coherent response .... 7–8 • Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. AND • Outlines the life cycle of stars with small mass and stars with large mass. AND • Identifies any TWO of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel 5–6

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(continued)	• Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. OR • Outlines the life cycle of stars with small mass and stars with large mass. AND • Identifies any ONE of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel 3–4
	• Explains the relationship between luminosity and surface temperature. AND • Identifies the stars in areas A–D. OR • Identifies any ONE of: – stars with a small mass use the proton–proton cycle – stars with a large mass use the CNO cycle – stars release a large amount of energy as they burn fuel 1–2

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 31	
(a) Lenz's law states that the induced electromotive force (emf) in a conductor is in a direction that opposes the energy change that induced it. Thus, it would be expected that the magnet falls through the PVC pipe much faster than the copper pipe. Copper is metallic and therefore a conductor. As the magnet falls, the magnetic field in the copper pipe would change and the movement of the electrons in the copper atoms would induce a current. As a result, eddy currents would form in a direction opposite to the changing external magnetic field. As the falling magnets under the giant drop's seats reach the copper fins, eddy currents and magnetic forces are induced in the copper. The interaction between the magnetic forces causes electromagnetic braking to occur and slow down the seats.	Mod 6 Electromagnetism PH12–2, 12–13 Bands 4–6 • Uses Lenz's law to explain why the magnet falls much slower through the copper pipe. AND • Explains eddy currents. AND • Explains how electromagnetic braking occurs in the giant drop . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points. OR • Provides some relevant information 1
(b) The teacher's comment is correct. The size of the eddy currents is proportional to the speed of the falling seats. As the induced magnetic field interacts with the external magnetic field, the seats slow, the eddy currents reduce proportionally and the induced magnetic field decreases, resulting in a smooth deceleration. Conversely, conventional braking relies on an operator responding to the falling seats and the change in speed would be felt more suddenly by the occupants. Thus, electromagnetic brakes are smoother and more reliable.	Mod 6 Electromagnetism PH12–12 Bands 5–6 • States that the teacher's comment is correct. AND • Explains why electromagnetic braking is smoother than conventional braking . . . . 2 • Any ONE of the above points 1
Question 32	
(a) The nuclear model of the atom has a positive nucleus surrounded by electrons. Rutherford's atomic model demonstrated that the mass of an atom was concentrated in a tiny, positively charged nucleus and electrostatic forces kept the negatively charged electrons in orbit around the nucleus. This force of attraction provided the centripetal force needed to maintain stable orbits.	Mod 8 From the Universe to the Atom PH12–5, 12–7, 12–15 Bands 3–6 • Outlines the nuclear model of the atom. AND • Describes the specific features of Rutherford's model . . . . 2 • Any ONE of the above points 1

	Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b)	*For example:* One limitation of Bohr's atomic model was that it showed a single electron spiraling into the nucleus, emitting radiation and thus making the atom unstable. Bohr's model was only applicable to hydrogen atoms and ions with one electron. De Broglie proposed that electrons show wave properties such that their orbits are standing waves; thus, no energy would be lost during orbit. For example, the first orbit at $n = 1$ has a circumference of one wavelength. An electron could not be closer to the nucleus than this as the electron's wave amplitude would be less than zero. Thus, de Broglie's matter waves explained electron orbits and provided stability to the atom. De Broglie's model overcame the limitation of Bohr's model by showing that an electron could not exist closer to the nucleus than the first orbit, as only part of a single wavelength of the electron wave would fit. *Note: Other limitations of Bohr's model could include its inability to predict the brightness of spectral lines and the presence of hyperfine spectral lines; or its inability to explain the splitting of spectral lines (stark and Zeeman effects).*	Mod 8 From the Universe to the Atom PH12–5, 12–7, 12–15 Bands 4–6 • Outlines ONE limitation of Bohr's atomic model. AND • Explains how de Broglie overcame the limitation. AND • Describes de Broglie's atomic model. AND • Provides a logical and coherent response . . . . 4 • Outlines ONE limitation of Bohr's atomic model. AND • Outlines how de Broglie overcame the limitation. AND • Outlines de Broglie's atomic model . . . . 3 • Identifies ONE limitation of Bohr's atomic model. AND • Outlines de Broglie's atomic model . . . . 2 • Provides some relevant information 1
(c)	The electrostatic force of repulsion (230 N) is much greater than the gravitational force of attraction (-2.2×10^{-34} N); the difference prevents these forces from making the nucleus stable. The strong nuclear force holds the nucleus together and only acts over short distances (1.0×10^{-15} m). It is carried by gluons and attracts nucleons to each other within the nucleus.	Mod 8 From the Universe to the Atom PH12–7, 12–15 Bands 5–6 • Explains why the forces cannot account for nuclear stability. AND • Describes the properties of the strong nuclear force. AND • Refers to the data . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points 1

