Neap

Trial Examination 2021

HSC Year 12 Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Calculators approved by NESA may be used
- A data sheet, formulae sheet and Periodic Table are provided at the back of this paper

Total marks: 100

Section I – 20 marks (pages 2–8)

- Attempt Questions 1–20
- Allow about 35 minutes for this section

Section II – 80 marks (pages 9–29)

- Attempt Questions 21–37
- Allow about 2 hours and 25 minutes for this section

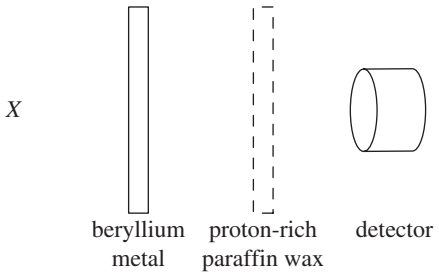
Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2021 HSC Year 12 Physics examination.

SECTION I

20 marks
Attempt Questions 1–20
Allow about 35 minutes for this section

Use the multiple-choice answer sheet for Questions 1–20.

1 James Chadwick discovered the neutron. He achieved this by observing the properties of the neutron, performing an experiment similar to the experiment shown in the diagram.



What is *X*?

A. alpha emitter
B. beta emitter
C. visible light
D. cathode ray

2 Which of the following is NOT a component of a DC motor?

A. magnet
B. coil
C. slip-ring commutator
D. brushes

3 The laminated iron core in a transformer

A. increases the size of eddy currents to generate more electricity.
B. reduces the size of eddy currents to improve the efficiency of the transformer.
C. reduces the size of eddy currents to increase heat energy to better control the efficiency of the transformer.
D. increases the size of eddy currents to provide a constant supply of electricity.

4 The emission spectrum of hydrogen is divided into several series.
Which series is in the visible part of the electromagnetic spectrum?

A. Lyman series
B. Paschen series
C. Rydberg series
D. Balmer series

5 The carbon-nitrogen-oxygen (CNO) cycle fuses four protons into helium in the core of stars that have a mass greater than 2×10^{30} kg.

What fundamental particle is emitted during the net process of fusion?

A. quark

B. electron

C. hydrogen atom

D. neutrino

6 A class of Physics students analysed a video of a frog jumping from a horizontal surface.

The students calculated the angle of the frog's leap to be 50° to the horizontal with a speed of 1.35 m s^{-1}.

What is the speed of the frog at its highest point?

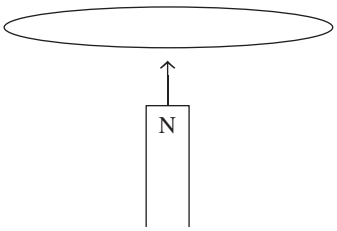
A. 0.03 m s^{-1}

B. 0.87 m s^{-1}

C. 1.35 m s^{-1}

D. 2.15 m s^{-1}

7 The North pole of a magnet is moved upwards towards a stationary horizontal coil, as shown in the diagram.



Which of the following statements is correct?

A. When viewed from above, the induced current in the coil will flow anti-clockwise.

B. When viewed from above, the induced current in the coil will flow clockwise.

C. There will be no induced current in the coil.

D. When viewed from above, the induced current in the coil will flow perpendicular to the movement of the magnet.

8 According to the Standard Model, the quark composition of a proton is UUD (up quark, up quark, down quark).

What is the quark composition of a neutron?

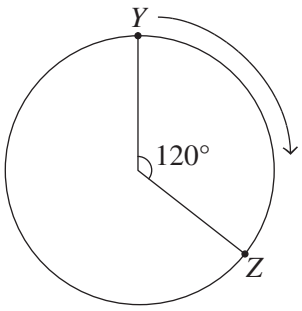
A. UUU

B. UUD

C. UDD

D. DDD

9 A child has a marble racetrack toy. The toy has a marble of mass 0.075 g that rolls around a circular frictionless track. The marble can complete three rotations around the track in a clockwise direction every two seconds. The diagram shows the frictionless track with two points *Y* and *Z* labelled.



How long does it take the marble to move from point *Y* to point *Z*?

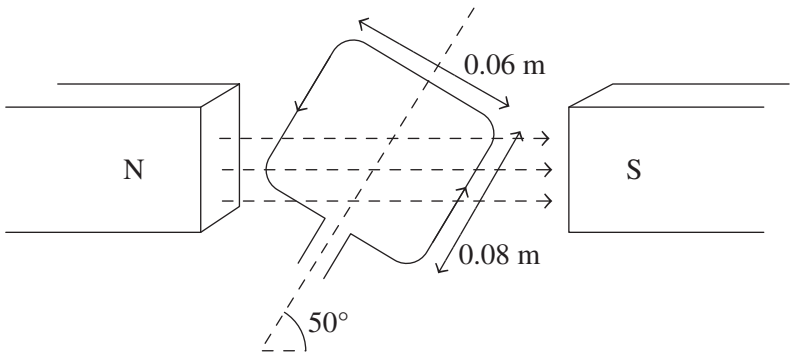
A. 0.11 seconds

B. 0.16 seconds

C. 0.20 seconds

D. 0.22 seconds

10 A coil contains 20 loops and is placed in a magnetic field with its plane at an angle of 50° to the magnetic field, as shown in the diagram.



The magnetic field is calculated to be 2.4 mT. An ammeter connected to the coil reads 0.6 mA.

What is the magnitude of the torque acting on the coil and the direction of the coil's rotation?

A. 8.89×70^{-8} Nm clockwise

B. 8.89×70^{-8} Nm anticlockwise

C. 1.96×70^{-7} Nm clockwise

D. 1.96×70^{-7} Nm anticlockwise

11 What is the energy in electron volts of a photon of light that has wavelength 535 nm?

A. 1.79 eV

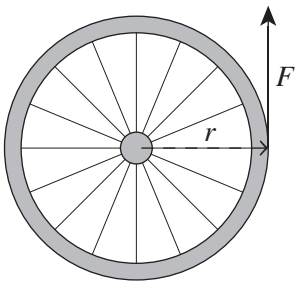
B. 2.00 eV

C. 2.11 eV

D. 2.32 eV

12 On which of the following bicycle wheels is the largest torque acting?

A.



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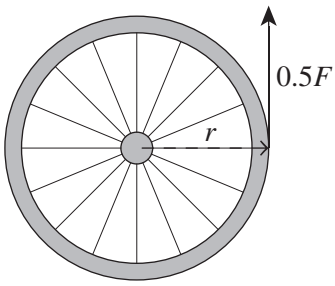

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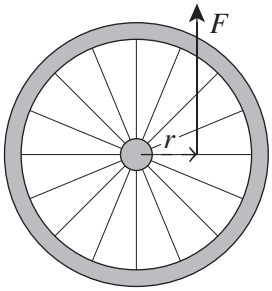
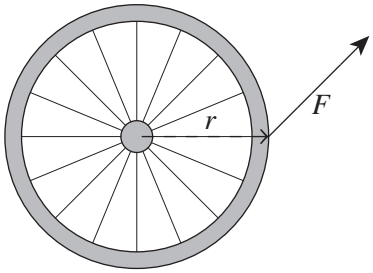


D.



13 De Broglie contributed to quantum theory by investigating matter waves.
At what velocity will an electron have a wavelength of 1 mm?

A. 7.3×10^{-4} m s^{-1}

B. 0.73 m s^{-1}

C. 3.0×10^{8} m s^{-1}

D. An electron is a particle and cannot have a wavelength.

14 Which of the following does NOT provide supporting evidence for Einstein's two postulates of special relativity?

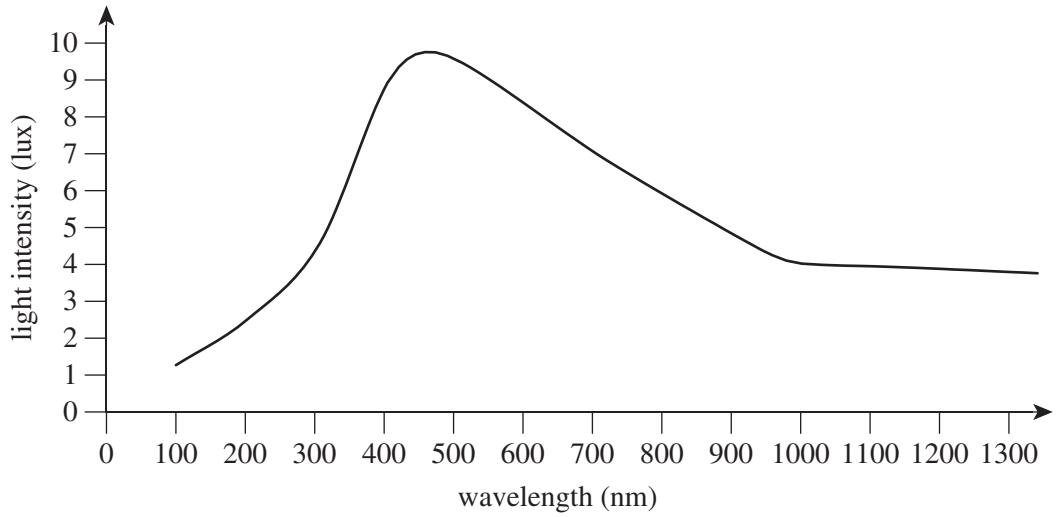
A. the Michelson–Morley experiment

B. the Hafele–Keating experiment

C. cosmological studies

D. the Geiger–Marsden experiment

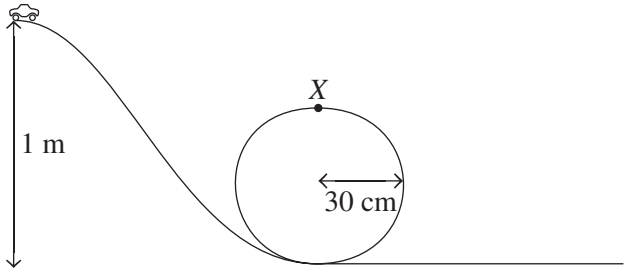
15 The black body radiation curve for a star is shown in the graph.



Which row of the table correctly shows the surface temperature and colour of the star?

	Temperature (°K)	*Colour*
A.	6440	blue
B.	7245	yellow
C.	6440	orange
D.	6000	orange

16 A Physics teacher is teaching a class about the effect of friction. They assemble a track that has a vertical loop of radius 30.0 cm. A toy car of mass 50.0 g is released from rest at a height of 1.00 m at the beginning of the track. The car rolls down the track and follows the loop before exiting the track. The teacher asks the class to calculate the speed of the toy car if the coefficient of friction were 0.



What is the calculated speed of the toy car as it reaches point *X*?

A. 1.49 m s^{-1}

B. 2.21 m s^{-1}

C. 2.80 m s^{-1}

D. 7.84 m s^{-1}

17 The planet Saturn has a mass of 5.70×10^{26} kg and a diameter of 139 820 km. A satellite in orbit around Saturn has a mass of 400 kg and is in orbit 1600 km above the surface of the planet.

What is the gravitational potential energy of the satellite?

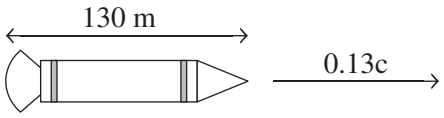
A. -1.98×10^{11} J

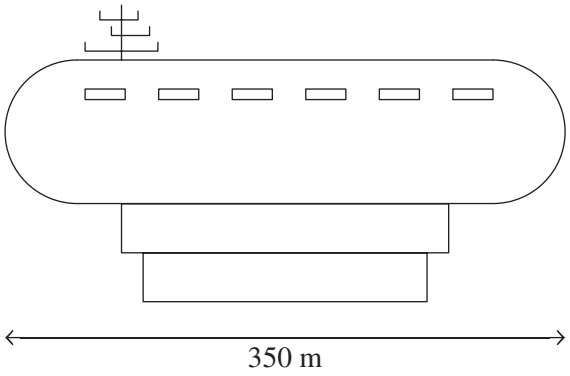
B. -2.07×10^{11} J

C. -2.13×10^{11} J

D. 2.13×10^{11} J

18 An astronaut is travelling aboard a spacecraft. The spacecraft has a length of 130 m and is flying at a speed of 0.13c. The spacecraft travels past a space station that has a length of 350 m, as shown in the diagram.





Which of the following correctly shows the length of the space station as perceived by the astronaut?

A. 347 m

B. 349 m

C. 350 m

D. 353 m

19 An alpha particle is travelling horizontally from right to left with a velocity of 0.60×10^{8} m s^{-1} in a uniform magnetic field. The field is perpendicular to the alpha particle's motion and has a strength of 0.80 T.

What is the radius of the alpha particle as it moves in the field?

A. 1.0 m

B. 1.3 m

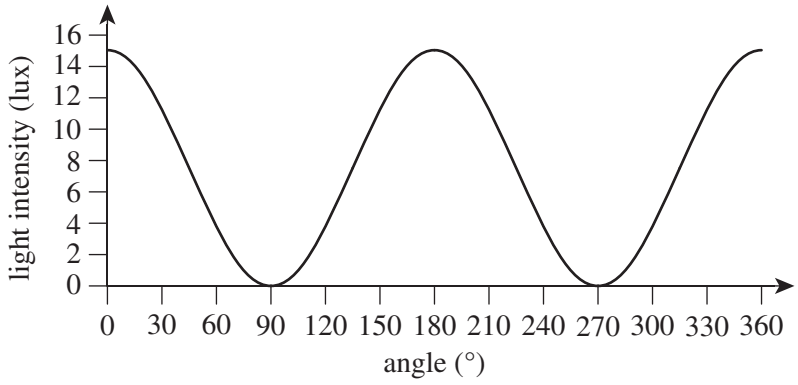
C. 1.6 m

D. 2.2 m

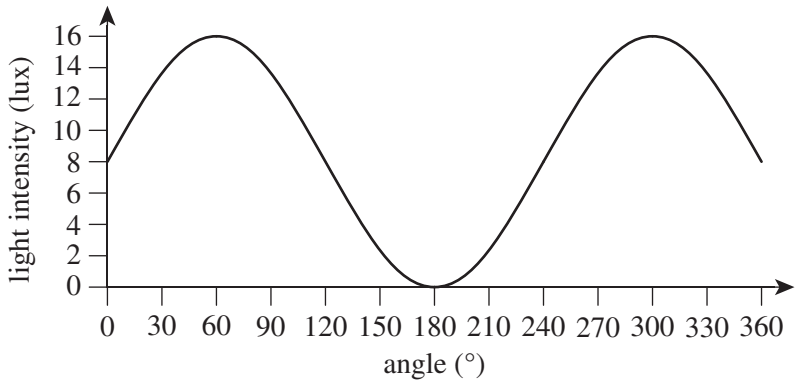
20 A student conducted an investigation to demonstrate Malus' Law. The student used two polarising filters and changed the filters' axes of polarisation to different angles. They recorded their results in a graph.

Which graph shows an expected result for the experiment?

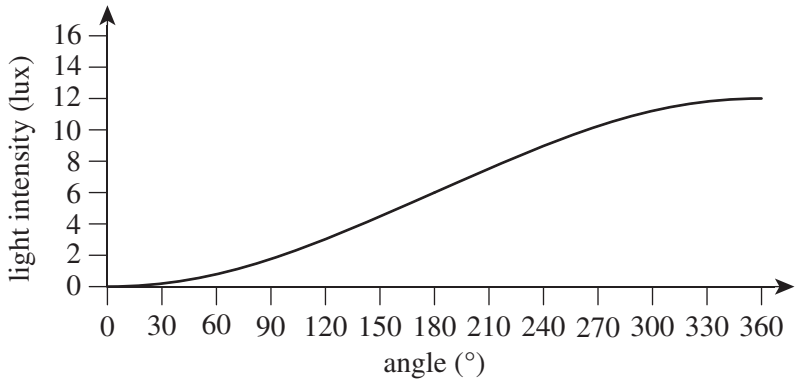
A.



B.



C.



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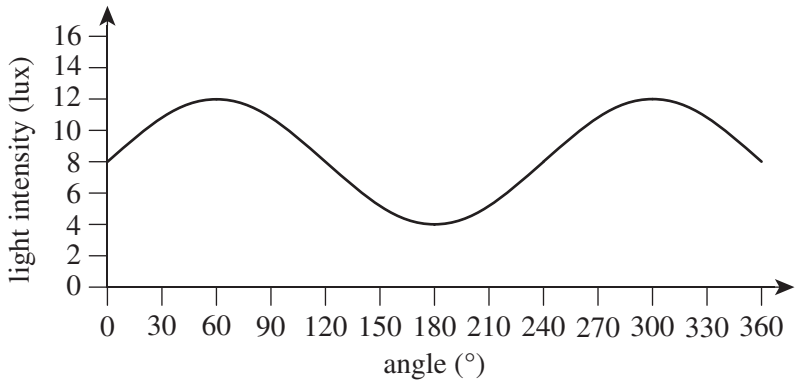


HSC Year 12 Physics

Section II Answer Booklet

Section II

80 marks

Attempt Questions 21–37

Allow about 2 hours and 25 minutes for this section

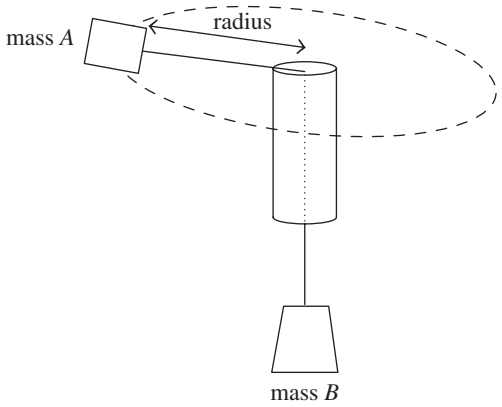
Instructions

- Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
- Show all relevant working in questions involving calculations.
- Extra writing space is provided at the back of this booklet. If you use this space, clearly indicate which question you are answering.

Please turn over

Question 21 (9 marks)

A student conducted several tests on circular motion. In the tests, mass *A* was swung on a circular path. Mass *B* provided the necessary force to balance mass *A*, resulting in a known radius as shown in the diagram.



The student varied the masses and radius for each test. They measured the time for mass *A* to make 10 rotations three times for each mass and radius, then averaged the three results to produce the table shown.

Test	*Mass of A (g)*	*Mass of B (g)*	*Radius of circle (m)*	*Time for 10 rotations (s)*
1	50	50	0.125	10
2	50	50	0.200	13
3	50	50	0.250	14
4	50	50	0.375	17
5	50	75	0.125	8
6	50	100	0.125	7
7	50	200	0.125	5
8	125	50	0.125	16
9	250	50	0.125	22
10	750	50	0.125	27

Question 21 continues on page 11

Question 21 (continued)

(a) Outline THREE different experiments conducted using the information from the table. **3**

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(b) For Tests 5, 6 and 7, identify the dependent, independent and TWO controlled variables. **3**

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(c) The student repeated all of the tests with 20 rotations. **1**

Would the experiment that used 10 rotations or the experiment that used 20 rotations be more reliable? Justify your answer.

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(d) Assuming there are no frictional forces, derive an equation for the radius of mass A in terms of v and g. Justify your answer. **2**

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End of Question 21

Question 22 (3 marks)

Determine the simplified ratio of the velocities of a low Earth orbit satellite travelling 300 km above the Earth's surface and a geostationary satellite travelling 35 700 km above the Earth's surface. **3**

Question 23 (5 marks)

Strontium-90 is a by-product of nuclear fission reactions. Strontium-90 undergoes radioactive beta decay into yttrium-90 with a half-life of 28.8 years.

(a) A sample of pure strontium-90 with an initial mass of 25 mg is used in a laboratory over many years. **2**

What is the mass of the sample after 10 years?

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(b) Write a balanced nuclear equation for the beta decay of Strontium-90. Part of the equation is shown below. **1**

$$\square^{90}\mathrm{Sr} \rightarrow \begin{matrix}\square\\ 39\end{matrix}\square + {}^{0}_{-1}e + \bar{\nu}$$

(c) Describe the concept of controlled nuclear fission in a nuclear reactor. In your answer, give ONE method of controlling nuclear fission. **2**

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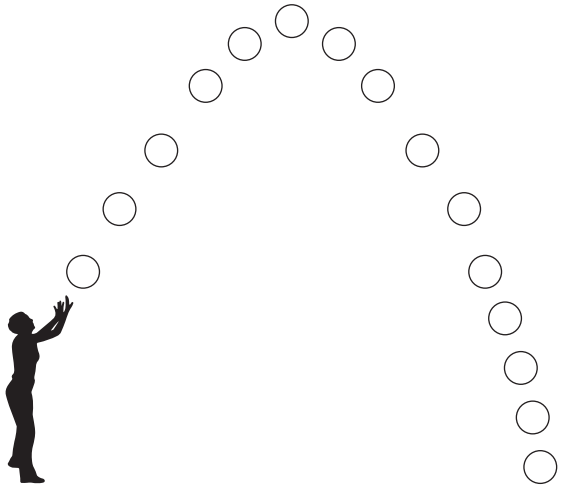
Question 24 (4 marks)

The diagram represents a time-lapse video of a person throwing a basketball into the air. A camera was used to record the video at five frames per second. The first frame was taken the moment the basketball left the person's hands.



(a) Assuming that the flight of the basketball was symmetrical, how long did it take the basketball to hit the ground after it was thrown and what was the maximum height it reached? **2**

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(b) Calculate the initial vertical velocity of the basketball. **2**

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Question 25 (7 marks)

(a) Describe the production and propagation of an electromagnetic wave. Use a diagram to support your answer. **3**

Question 25 continues on page 16

Question 25 (continued)

(b) State the FOUR observations predicted by Maxwell's electromagnetic theory. **4**

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End of Question 25

Question 26 (2 marks)

Outline how emission and absorption spectra are produced and whether the emission and absorption spectra of an element produce the same or different spectral lines. **2**

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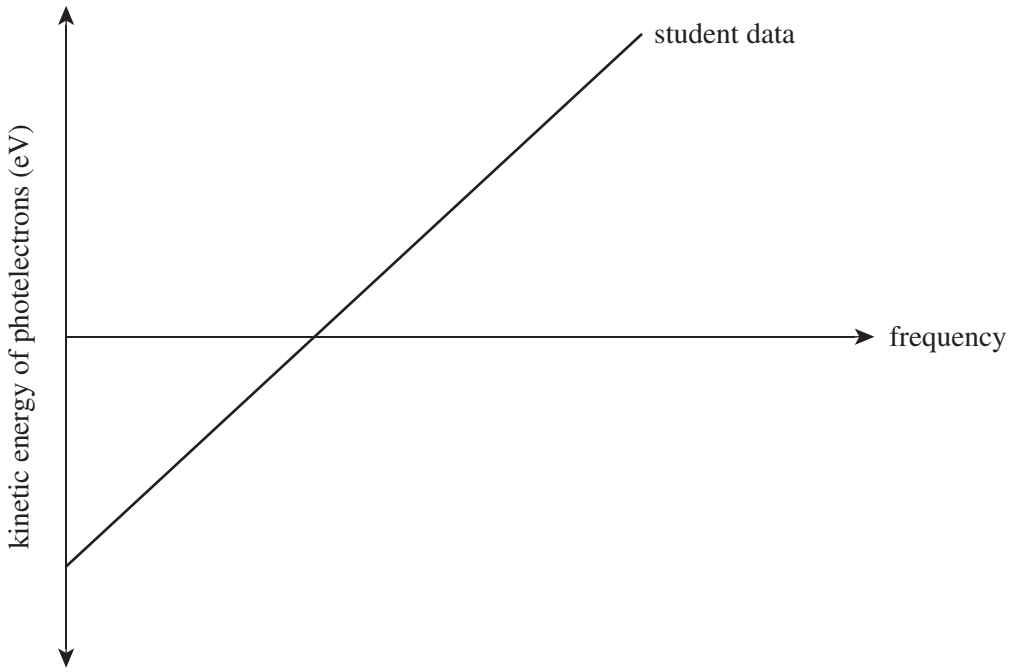
Question 27 (3 marks)

The graph shows a sample of students' results from a photoelectric effect experiment. **3**



On the graph, label the threshold frequency and work function, and explain how the results can be used to find a value for Planck's constant.

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Question 28 (8 marks)
A diffraction grating has 1250 lines per mm.

(a) What is the spacing of the slit in the grating? **1**

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(b) A student shone monochromatic light at the diffraction grating and found a first-order maximum at an angle of 16° to the central maximum. **2**

Find the wavelength of the light source.

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(c) Find the angle of the second-order maximum when light of wavelength 375 nm is shone at the grating. **2**

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Question 28 continues on page 19

Question 28 (continued)

(d) In another experiment, laser light of wavelength 630 nm was shone at a double slit with a slit separation of 50.0 μm. The double slit was placed a fixed distance from a screen and the bright fringes of the interference pattern were 3.10 cm apart. **3**

Calculate the distance of the double slit to the screen. Give your answer to three significant figures.

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End of Question 28

Question 29 (3 marks)

A student placed polarised lens *A* over polarised lens *B*, as shown in Figure 1. **3**

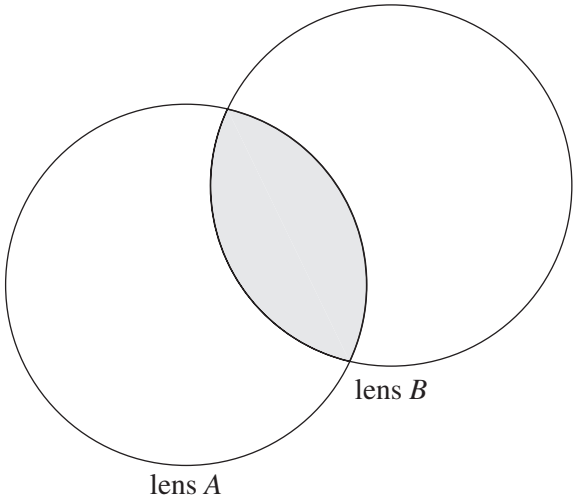

Figure 1

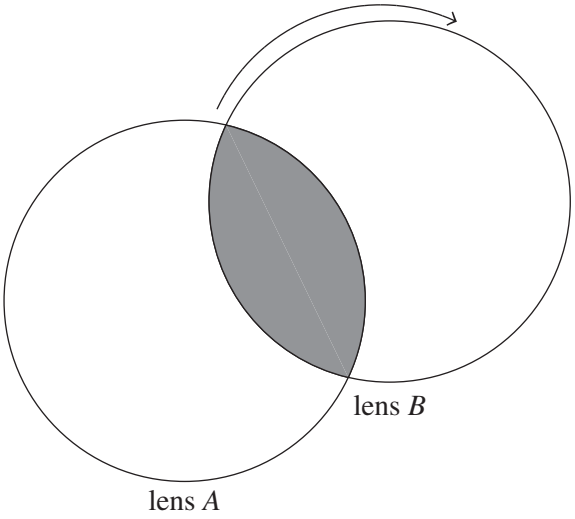

Figure 2

The student then rotated lens *B*, as shown in Figure 2.

Explain what is meant by polarisation and explain how it relates to Figure 1 and Figure 2.

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Question 30 (7 marks)

(a) Explain the relationship between the age and temperature of the Universe. **2**

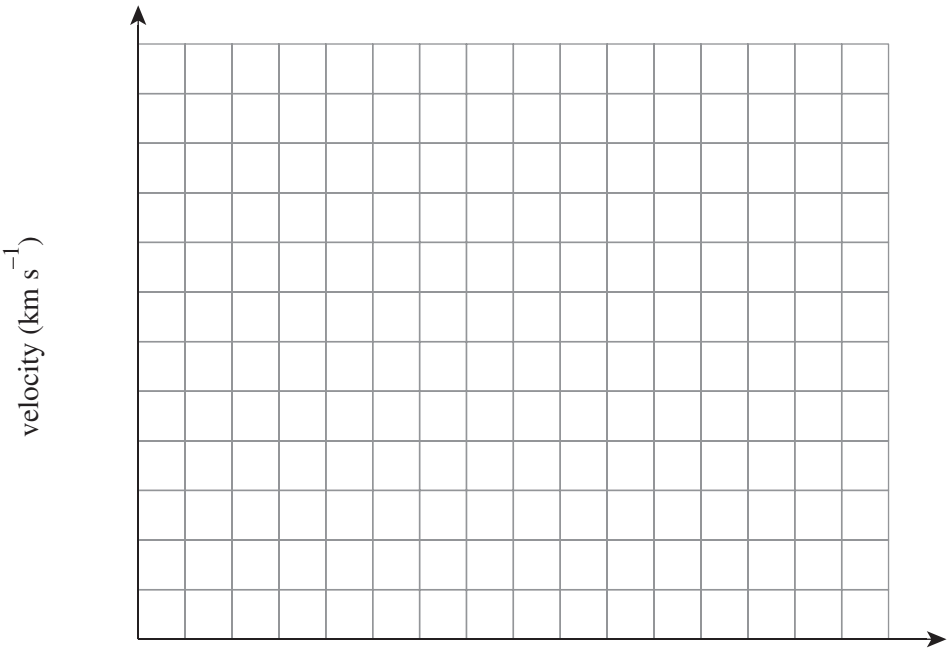
(b) Discuss how particle accelerators have increased our understanding of the early Universe following the Big Bang. **5**

Question 31 (6 marks)

The data shown in the table was shared by the Hubble Space Telescope.

Galaxy	*Distance from Earth (Mpc)*	*Recessional velocity (km s^{-1})*
Alpha	11	850
Beta	14	1050
Omega	32	1900
Lambda	51	3150
Delta	62	4000
Zeta	98	

(a) Graph the data from the table on the axes below. Include a line of best fit. **2**



(b) Using the graph from part (a), predict the recessional velocity for galaxy Zeta. **1**

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Question 31 continues on page 23

Question 31 (continued)

(c) The data in the table on page 22 shows evidence for the expansion of the Universe and gives support to the idea that the Universe began from a hot Big Bang. **3**

Describe the processes that transformed radiation and energy into matter following the Big Bang.

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End of Question 31

Question 32 (3 marks)

The carbon-oxygen-nitrogen (CNO) cycle occurs in stars that are at least 1.3 times heavier than the Sun. The first step in the cycle can be represented by the nuclear fusion equation.

$$C_6^{12} + H_1^1 \rightarrow N_7^{13} + \gamma_0^0$$

The exact masses of these isotopes are shown in the table.

Isotope	*Exact mass*
^{12}C	12.000
^{1}H	1.0078
^{13}N	13.0057

(a) Using the equation, calculate the mass defect of the first step of the CNO cycle in megaelectron volts. **2**

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(b) Using the equation, calculate the energy released during of the first step of the CNO cycle in joules. **1**

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Question 33 (3 marks)

Rutherford's model of the atom was an improvement on earlier models. Despite this, it could not explain some observations. **3**

Describe ONE limitation of Rutherford's atomic model and assess the model's contribution to the development of the nuclear model.

Question 34 (4 marks)

(a) A charged particle, particle *X*, is moving perpendicular to an electric field. Another charged particle, particle *Y*, is moving perpendicular to a magnetic field. **2**

Assuming that particles *X* and *Y* have the same initial velocity, outline ONE similarity and ONE difference between the behaviours of the particles in the fields.

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(b) Compare the trajectory of a charged particle in either an electric OR a magnetic field to the trajectory of a projectile in a gravitational field. **2**

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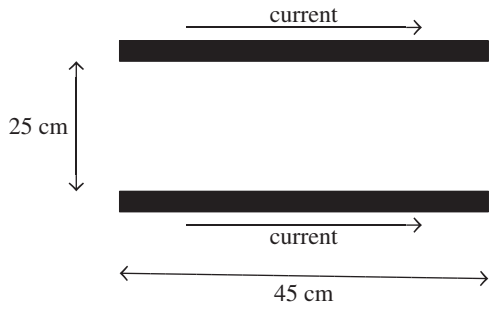
Question 35 (6 marks)

The diagram shows two current-carrying conductors placed parallel to each other. The conductors are both 45 cm in length.



The conductors are made of aluminium foil wire and each have a resistance of 0.40 Ω. A voltage of 2 V is passed through each wire.

(a) Calculate the force per unit length between the wires. **3**

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(b) With reference to the motor effect, explain whether the wires are attracting or repelling each other. Use a diagram to support your answer. **3**

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Question 36 (4 marks)

(a) A current of 3.0×10^{-2} A was input into a transformer in which the secondary winding had 20 times the number of primary turns. **2**

Calculate the output current if there were no power loss.

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(b) Outline the role of transformers in household electrical goods. **2**

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Question 37 (3 marks)

A rectangular coil with dimensions 0.02 m by 0.03 m is placed between the poles of two bar magnets that generate a field strength of 0.075 T. The coil has 200 turns and is initially in a plane parallel to the field lines. **3**

If the coil is made to rotate anticlockwise to reach a vertical position in a plane perpendicular to the field lines in 0.010 s, calculate the emf generated in the coil.

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End of paper

Section II extra writing space

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Section II extra writing space

If you use this space, clearly indicate which question you are answering.

DATA SHEET

Charge on electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
Mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 ms^{-1}
Earth's gravitational acceleration, g	9.8 ms^{-2}
Speed of light, c	3.00×10^{8} ms^{-1}
Electric permittivity constant, ε_0	8.854×10^{-12} A^2 s^4 kg^{-1} m^{-3}
Magnetic permeability constant, μ_0	$4\pi \times 10^{-7}$ N A^{-2}
Universal gravitational constant, G	6.67×10^{-11} N m^2 kg^{-2}
Mass of Earth, M_E	6.0×10^{24} kg
Radius of Earth, r_E	6.371×10^{6} m
Planck constant, h	6.626×10^{-34} J s
Rydberg constant, R (hydrogen)	1.097×10^{7} m^{-1}
Atomic mass unit, u	1.661×10^{-27} kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^{3} kg m^{-3}
Specific heat capacity of water	4.18×10^{3} J kg^{-1} K^{-1}
Wien's displacement constant, b	2.898×10^{-3} m K

FORMULAE SHEET

Motion, forces and gravity

$$s = ut + \frac{1}{2}at^2$$

$$v = u + at$$

$$v^2 = u^2 + 2as$$

$$\vec{F}_{\text{net}} = m\vec{a}$$

$$\Delta U = mg\Delta h$$

$$W = F_{\parallel}s = Fs\cos\theta$$

$$P = \frac{\Delta E}{\Delta t}$$

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

$$\sum \frac{1}{2}mv^2_{\text{before}} = \sum \frac{1}{2}mv^2_{\text{after}}$$

$$P = F_{\parallel}v = Fv\cos\theta$$

$$\Delta\vec{p} = \vec{F}_{\text{net}}\Delta t$$

$$\sum m\vec{v}_{\text{before}} = \sum m\vec{v}_{\text{after}}$$

$$\omega = \frac{\Delta\theta}{t}$$

$$a_c = \frac{v^2}{r}$$

$$\tau = r_{\perp}F = rF\sin\theta$$

$$F_c = \frac{mv^2}{r}$$

$$v = \frac{2\pi r}{T}$$

$$F = \frac{GMm}{r^2}$$

$$U = -\frac{GMm}{r}$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

Waves and thermodynamics

$$v = f\lambda$$

$$f_{\text{beat}} = |f_2 - f_1|$$

$$f = \frac{1}{T}$$

$$f' = f\frac{(v_{\text{wave}} + v_{\text{observer}})}{(v_{\text{wave}} - v_{\text{source}})}$$

$$d\sin\theta = m\lambda$$

$$n_1\sin\theta_1 = n_2\sin\theta_2$$

$$n_x = \frac{c}{v_x}$$

$$\sin\theta_c = \frac{n_2}{n_1}$$

$$I = I_{\max}\cos^2\theta$$

$$I_1r_1^2 = I_2r_2^2$$

$$Q = mc\Delta T$$

$$\frac{Q}{t} = \frac{kA\Delta T}{d}$$

FORMULAE SHEET (continued)

Electricity and magnetism

$$E = \frac{V}{d}$$

$$V = \frac{\Delta U}{q}$$

$$W = qV$$

$$W = qEd$$

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{\mu_0 NI}{L}$$

$$\Phi = B_{\parallel} A = BA\cos\theta$$

$$\varepsilon = -N\frac{\Delta\Phi}{\Delta t}$$

$$\frac{V_{\mathrm{p}}}{V_{\mathrm{s}}} = \frac{N_{\mathrm{p}}}{N_{\mathrm{s}}}$$

$$\vec{F} = q\vec{E}$$

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$

$$I = \frac{q}{t}$$

$$V = IR$$

$$P = VI$$

$$F = qv_{\perp}B = qvB\sin\theta$$

$$F = lI_{\perp}B = lIB\sin\theta$$

$$\frac{F}{l} = \frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$$

$$\tau = nIA_{\perp}B = nIAB\sin\theta$$

$$V_{\mathrm{p}} I_{\mathrm{p}} = V_{\mathrm{s}} I_{\mathrm{s}}$$

Quantum, special relativity and nuclear

$$\lambda = \frac{h}{mv}$$

$$K_{\max} = hf - \phi$$

$$\lambda_{\max} = \frac{b}{T}$$

$$E = mc^2$$

$$E = hf$$

$$\frac{1}{\lambda} = R\left(\frac{1}{n_{\mathrm{f}}^2} - \frac{1}{n_{\mathrm{i}}^2}\right)$$

$$t = \frac{t_0}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$l = l_0\sqrt{\left(1 - \frac{v^2}{c^2}\right)}$$

$$p_{\mathrm{v}} = \frac{m_0 v}{\sqrt{\left(1 - \frac{v^2}{c^2}\right)}}$$

$$N_{\mathrm{t}} = N_0 e^{-\lambda t}$$

$$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

atomic number
symbol
standard atomic weight
name

79 Au 197.0 gold

1 H 1.008 hydrogen																	**2 He** 4.003 helium
3 Li 6.941 lithium	**4 Be** 9.012 beryllium											**5 B** 10.81 boron	**6 C** 12.01 carbon	**7 N** 14.01 nitrogen	**8 O** 16.00 oxygen	**9 F** 19.00 fluorine	**10 Ne** 20.18 neon
11 Na 22.99 sodium	**12 Mg** 24.31 magnesium											**13 Al** 26.98 aluminium	**14 Si** 28.09 silicon	**15 P** 30.97 phosphorus	**16 S** 32.07 sulfur	**17 Cl** 35.45 chlorine	**18 Ar** 39.95 argon
19 K 39.10 potassium	**20 Ca** 40.08 calcium	**21 Sc** 44.96 scandium	**22 Ti** 47.87 titanium	**23 V** 50.94 vanadium	**24 Cr** 52.00 chromium	**25 Mn** 54.94 manganese	**26 Fe** 55.85 iron	**27 Co** 58.93 cobalt	**28 Ni** 58.69 nickel	**29 Cu** 63.55 copper	**30 Zn** 65.38 zinc	**31 Ga** 69.72 gallium	**32 Ge** 72.64 germanium	**33 As** 74.92 arsenic	**34 Se** 78.96 selenium	**35 Br** 79.90 bromine	**36 Kr** 83.80 krypton
37 Rb 85.47 rubidium	**38 Sr** 87.61 strontium	**39 Y** 88.91 yttrium	**40 Zr** 91.22 zirconium	**41 Nb** 92.91 niobium	**42 Mo** 95.96 moybdenum	**43 Tc** technetium	**44 Ru** 101.1 ruthenium	**45 Rh** 102.9 rhodium	**46 Pd** 106.4 palladium	**47 Ag** 107.9 silver	**48 Cd** 112.4 cadmium	**49 In** 114.8 indium	**50 Sn** 118.7 tin	**51 Sb** 121.8 antimony	**52 Te** 127.6 tellurium	**53 I** 126.9 iodine	**54 Xe** 131.3 xenon
55 Cs 132.9 caesium	**56 Ba** 137.3 barium	**57–71** lanthanoids	**72 Hf** 178.5 hafnium	**73 Ta** 180.9 tantalum	**74 W** 183.9 tungsten	**75 Re** 186.2 rhenium	**76 Os** 190.2 osmium	**77 Ir** 192.2 iridium	**78 Pt** 195.1 platinum	**79 Au** 197.0 gold	**80 Hg** 200.6 mercury	**81 Tl** 204.4 thallium	**82 Pb** 207.2 lead	**83 Bi** 209.0 bismuth	**84 Po** polonium	**85 At** astatine	**86 Rn** radon
87 Fr francium	**88 Ra** radium	**89–103** actinoids	**104 Rf** rutherfordium	**105 Db** dubnium	**106 Sg** seaborgium	**107 Bh** bohrium	**108 Hs** hassium	**109 Mt** meitnerium	**110 Ds** darmstadtium	**111 Rg** roentgenium	**111 Cn** copernicium	**113 Nh** nihonium	**114 Fl** flerovium	**115 Mc** moscovium	**116 Lv** livermorium	**117 Ts** tennessine	**118 Og** oganesson

Lathanoids

57 La 138.9 lanthanum	**58 Ce** 140.1 cerium	**59 Pr** 140.9 praseodymium	**60 Nd** 144.2 neodymium	**61 Pm** promethium	**62 Sm** 150.4 samarium	**63 Eu** 152.0 europium	**64 Gd** 157.3 gadolinium	**65 Tb** 158.9 terbium	**66 Dy** 162.5 dysprosium	**67 Ho** 164.9 holmium	**68 Er** 167.3 erbium	**69 Tm** 168.9 thulium	**70 Yb** 173.1 ytterbium	**71 Lu** 175.0 lutetium

Actinoids

89 Ac actinium	**90 Th** 232.0 thorium	**91 Pa** 231.0 protactinium	**92 U** 238.0 uranium	**93 Np** neptunium	**94 Pu** plutonium	**95 Am** americium	**96 Cm** curium	**97 Bk** berkelium	**98 Cf** californium	**99 Es** einsteinium	**100 Fm** fermium	**101 Md** mendelevium	**102 No** nobelium	**103 Lr** lawrencium

Standard atomic weights are abridged to four significant figures.
Elements with no reported values in the table have no stable nuclides.
Information on elements with atomic numbers 113 and above is sourced from the International Union of Pure and Applied Chemistry Periodic Table of the Elements (November 2016 version).
The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of all other data. Some data may have been modified.

Neap

Trial Examination 2021

HSC Year 12 Physics

Solutions and marking guidelines

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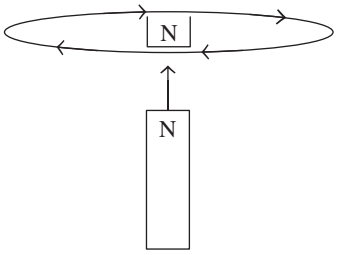
SECTION I

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 1 A **A** is correct. An alpha emitter was used during the experiment as it was penetrating but non-ionising. **B** is incorrect. A beta emitter would not eject neutrons from beryllium metal. An alpha source would eject neutrons. **C** and **D** are incorrect. Neither visible light nor cathode rays were used in any experiment leading to the discovery of the neutron.	Mod 8 From the Universe to the Atom PH12–7, PH12–14 Bands 1–2
Question 2 C **C** is correct. An AC motor uses a slip-ring commutator, whereas a DC motor uses split-ring commutators. **A** is incorrect. For a DC motor to be operational, it needs a magnetic field, and hence needs magnets. **B** is incorrect. A DC motor needs a coil to allow current to go through it so that it may experience the motor effect. **D** is incorrect. A DC motor requires brushes to maintain contact with the coil and terminals.	Mod 6 Electromagnetism PH12–13 Bands 1–2
Question 3 B **B** is correct. The laminated iron core reduces the size of eddy currents. Covering the iron core with thin, laminated portions limits the surface area of the eddy currents, which increases the efficiency of the transformer. **A** and **D** are incorrect. The role and efficiency of transformers is to reduce, not increase, the size of eddy currents. **C** is incorrect. Heat energy is wasted energy within a transformer, which reduces the efficiency of the transformer. The design of the laminated iron core is to reduce the size of eddy currents in order to reduce, not increase, the heat energy.	Mod 6 Electromagnetism PH12–13 Bands 2–3
Question 4 D **D** is correct. The Balmer series emits emission spectra within the visible part of the electromagnetic spectrum. **A** is incorrect. The Lyman series emits emission spectra within the ultraviolet part of the electromagnetic spectrum. **B** is incorrect. The Paschen series emits emission spectra within the infrared part of the electromagnetic spectrum. **C** is incorrect. There is no Rydberg series. The Rydberg equation is used to determine the wavelength of the absorption and emission spectra lines for the different series of hydrogen.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3
Question 5 D **D** is correct. The neutrino is the only fundamental particle emitted during the carbon-nitrogen-oxygen (CNO cycle). **A** and **B** are incorrect. The quark and the electron are fundamental particles, but neither are emitted during the CNO cycle. **C** is incorrect. Hydrogen is not a fundamental particle.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 6 B $U_x = u\cos\theta$ $= 1.35 \times \cos 50$ $= 0.86776 \text{ m s}^{-1}$ $\approx 0.87 \text{ m s}^{-1}$ Only horizontal motion is calculated as when the frog reaches its highest point only horizontal velocity is present. Vertical velocity is 0.	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 3–4
Question 7 B **B** is correct. Lenz's law states that an induced emf generates a current that creates a magnetic field acting to oppose the change in magnetic flux. Using the right-hand grip rule, the North pole of the magnet creates an opposing force in the opposite direction as it moves upwards. Hence, a magnetic North is created within the loop, producing a clockwise-induced emf when viewed from above.  **A** is incorrect. The induced emf in the coil will oppose the emf generated from the magnet moving upwards, so the induced emf in the coil would be clockwise, not anticlockwise. **C** is incorrect. A changing magnetic field creates an emf within an induced coil, which means a current would be flowing within the loop. **D** is incorrect. The current would flow in either a clockwise or an anticlockwise direction, not perpendicular to the movement of the magnet.	Mod 6 Electromagnetism PH12–13 Bands 3–4
Question 8 C **C** is correct. The quark composition of a neutron is UDD. **A** and **D** are incorrect. UUU and DDD are the quark compositions of a Delta baryon. **B** is incorrect. A proton and a neutron do not share the same quark composition.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3
Question 9 D 3 rotations in 2 seconds = 1080° Therefore, in 1 second, the stopper would rotate 540°. $\frac{120}{540} = \frac{2}{9}$ ≈ 0.22 seconds	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 3–4

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 10 A $\tau = nIAB\cos\theta$ $= 20 \times 0.6 \times 10^{-3} \times (0.06 \times 0.08) \times 2.4 \times 10^{-3} \times \cos 50$ $= 8.89 \times 10^{-8}$ Nm Using right-hand grip rule, the direction is clockwise.	Mod 6 Electromagnetism PH12–13 Bands 3–4
Question 11 D $E = \frac{hc}{\lambda}$ $= \frac{6.626 \times 10^{-34} \times 3.00 \times 10^{8}}{535 \times 10^{-9}}$ $= 3.715514019 \times 10^{-19}$ Converting to eV gives: $\frac{3.715514019 \times 10^{-19}}{1.602 \times 10^{-19}} = 2.31929714$ ≈ 2.32 eV	Mod 7 The Nature of Light PH12–4, PH12–14 Bands 3–4
Question 12 A **A** is correct. Maximum torque is achieved when the force applied is perpendicular to the largest radius from the centre of the bicycle wheel ($T = rF$). **B** is incorrect. This option shows that the force is only half the original applied force. **C** is incorrect. This option shows a smaller radius than option **A**, which reduces the torque according to $T = rF$. **D** is incorrect. This option shows a force that is not perpendicular to the radius of the wheel, which would reduce the torque per the formula $T = rF\sin\theta$.	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 2–3
Question 13 B $\lambda = \frac{h}{mv}$ $\Rightarrow v = \frac{h}{m\lambda}$ $= \frac{6.3631 \times 10^{-34}}{9.109 \times 10^{-31} \times 0.001}$ $= 0.7285$ m s^{-1} ≈ 0.73	Mod 8 From the Universe to the Atom PH12–15 Bands 4–6

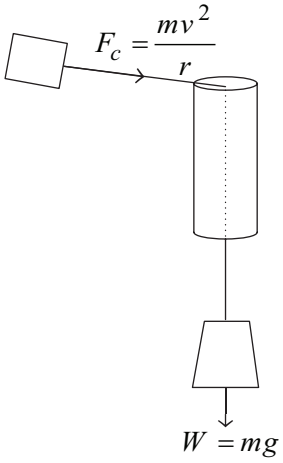
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 14 D **D** is correct. The Geiger–Marsden experiment does not prove or support Einstein's two postulates of special relativity. The experiment provided evidence that every atom has a nucleus that is the location of an overall positive charge and concentration of mass. **A** is incorrect. The Michelson–Morley experiment was a 'null' experiment that did not produce evidence for the existence of a medium for light to travel through, the 'aether', and so was an important step towards Einstein's two postulates of special relativity. **B** is incorrect. The Hafele–Keating experiment with atomic clocks suggested that all inertial frames of reference are equivalent, which supported Einstein's two postulates of special relativity. **C** is incorrect. Cosmological studies included studying muons, which further supported Einstein's two postulates of special relativity.	Mod 7 The Nature of Light PH12–14 Bands 2–3
Question 15 A **A** is correct. Using Wien's Law: $\lambda_{\max} = \frac{b}{T}$ $T = \frac{b}{\lambda_{\max}}$ $= \frac{2.898 \times 10^{-3}}{4.50 \times 10^{-9}}$ $= 6440 \text{ K}$ Of the options given, the most reasonable colour description for a star of this temperature is blue. **B** and **D** are incorrect. The temperature given is not supported by the calculation. **C** is incorrect. An orange star would be found to be closer to 4000 K.	Mod 8 From the Universe to the Atom PH12–5, PH12–15 Bands 4–5

Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 16 C Energy as the car is entering loop: $E = k + U$ $= \frac{1}{2}mv^2 + mgh$ $= 0 + 0.05 \times 9.8 \times 1.00$ $= 0.49 \text{ J}$ Speed at X: $E = \frac{1}{2}mv^2 + mgh$ $0.49 = \frac{1}{2} \times 0.05 \times v^2 + 0.05 \times 9.8 \times (0.3 \times 2)$ $0.49 = 0.025v^2 + 0.294$ $0.025v^2 = 0.196$ $v^2 = 7.84$ $v = 2.80 \text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 3–4
Question 17 C $U = -\frac{GMm}{r}$ $= -\frac{6.67 \times 10^{-11} \times 5.70 \times 10^{26} \times 400}{\left(\frac{139820000}{2}\right) + 1600000}$ $= -2.126639631 \times 10^{11} \text{ J}$ $\approx -2.13 \times 10^{11} \text{ J}$	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 3–4
Question 18 A Length of space station as perceived by the astronaut is given by: $l = l_O \times \sqrt{1 - \frac{v^2}{c^2}}$ $= 350 \times \sqrt{1 - \frac{(0.13)^2}{(1.0)^2}}$ $= 347.03 \text{ m}$	Mod 7 The Nature of Light PH12–4, PH12–14 Bands 3–4

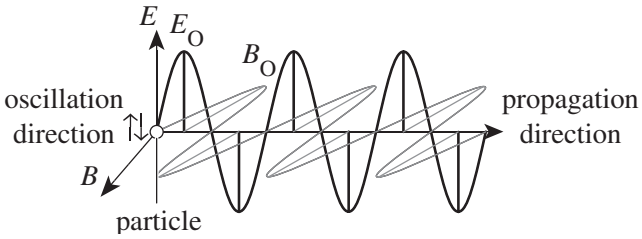
Answer and explanation	Syllabus content, outcomes and targeted performance bands
Question 19 C Charge of alpha particle: $1.602\times10^{-19}\times2=3.204\times10^{-19}$ C Mass of alpha particle (two protons and two neutrons): $m_{\text{protons}}=1.673\times10^{-27}\times2$ $=3.346\times10^{-27}$ $m_{\text{neutrons}}=1.675\times10^{-27}\times2$ $=3.350\times10^{-27}$ $\text{total mass}=3.346\times10^{-27}+3.350\times10^{-27}$ $=6.696\times10^{-27}$ kg Therefore: $r=\frac{mv}{qB}$ $=\frac{6.696\times10^{-27}\times0.60\times10^{8}}{3.204\times10^{-19}\times0.80}$ $=1.56741573$ ≈1.6 m	Mod 6 Electromagnetism PH12–13 Bands 5–6
Question 20 A **A** is correct. When unpolarised light passes through a polarised filter, its intensity is halved. If it then passes through another polarised filter, its intensity follows the function $I=\frac{I}{2}\cos(2)$. Option **A** is the only graph that follows this principle and demonstrates a cosine graph. **B**, **C** and **D** are incorrect. None of these options show a cosine graph.	Mod 7 The Nature of Light PH12–4 Bands 3–4

SECTION II

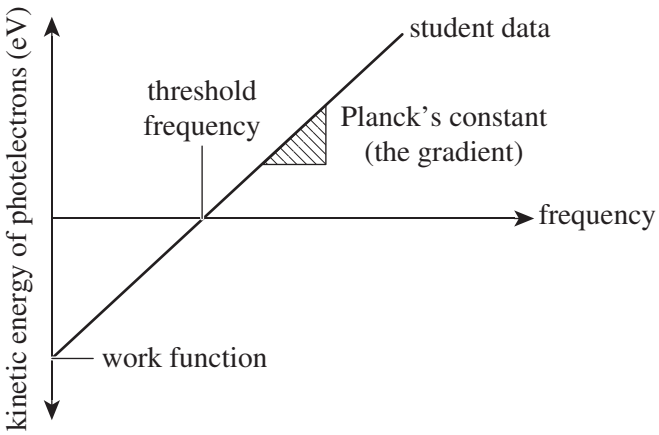
	Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 21		
(a)	Experiment 1: Examining the relationship between the mass of mass B and the period of rotation when keeping the mass of mass A and the radius of the circle constant (Data taken from Tests 1, 5, 6 and 7). Experiment 2: Examining the relationship between the mass of mass A and the period of rotation when keeping the mass of mass B and the radius of the circle constant (Data taken from Tests 1, 8, 9 and 10). Experiment 3: Examining the relationship between the period of rotation and the radius when keeping the mass of mass A and the mass of mass B constant (Data taken from Tests 1, 2, 3 and 4).	Mod 5 Advanced Mechanics PH12–6, PH12–12 Band 3 • Outlines THREE experiments . . . . . 3 • Outlines TWO experiments . . . . . 2 • Outlines ONE experiment 1
(b)	Dependent variable: time to complete 10 rotations Independent variable: mass of B Controlled variables: mass of A, radius of circle *Note: The dependent variable is the thing that is measured, the independent variable is the thing that changes and the controlled variables are the things that are kept the same.*	Mod 5 Advanced Mechanics PH11, PH12–12 Bands 3–4 • Identifies the independent variable. AND • Identifies the dependent variable. AND • Identifies TWO controlled variables . . . . . 3 • Identifies THREE variables . . . . . 2 • Identifies TWO variables 1
(c)	The experiment that measured 20 rotations would be more reliable than the experiment that measured 10 rotations. This is because the 20 measurements generate more data than the 10 measurements, which would result in a more accurate average measurement.	Mod 5 Advanced Mechanics PH12–6, PH12–12 Band 3 • States the more accurate experiment 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(d) From a free-body diagram, the centripetal force required is due to the hanging mass.  $F_c = \frac{mv^2}{r}$ $= mg$ $\frac{mv^2}{r} = mg$ $\frac{v^2}{r} = g$ $\therefore r = \frac{v^2}{g}$	Mod 5 Advanced Mechanics PH12–12 Bands 4–5 • Accurately derives an equation from the correct formulas. AND • Gives a justification for the derivation . . . . . 2 • Any ONE of the above points 1
Question 22	
$M_E = 6.0 \times 10^{24}$ kg $r_E = 6.371 \times 10^6$ m Velocity of the low Earth orbit satellite: $v = \sqrt{\frac{GM_E}{r_E + \text{altitude}}}$ $= \sqrt{\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{6.371 \times 10^6 + 300\,000}}$ $= 7745.39 \text{ m s}^{-1}$ Velocity of the geostationary satellite: $v = \sqrt{\frac{GM_E}{r_E + \text{altitude}}}$ $= \sqrt{\frac{6.67 \times 10^{-11} \times 6.0 \times 10^{24}}{6.371 \times 10^6 + 35\,700\,000}}$ $= 3084.23 \text{ m s}^{-1}$ The ratio of the velocities of the satellites is 2.51 : 1.	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 3–5 • Determines the velocity of the low earth orbit satellite. AND • Determines the velocity of the geostationary satellite. AND • Determines the simplified ratio . . . . 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) $\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$ $= \dfrac{0.693}{28.8}$ $= 0.024\,y^{-1}$ $N_c = N_0^{-\lambda t}$ $= 0.025 \times e^{-0.024 \times 10}$ $= 0.020$ kg $= 20$ mg	Mod 8 From the Universe to the Atom PH12–15 Bands 4–6 • Calculates the radioactive decay. AND • Calculates the mass of the sample after 10 years . . . . . 2 • Calculates the radioactive decay. OR • Calculates the mass of the sample after 10 years 1
(b) $^{90}_{\mathbf{38}}\mathrm{Sr} \rightarrow {}^{\mathbf{90}}_{39}\mathbf{Y} + {}^{0}_{-1}e + \overline{\nu}$	Mod 8 From the Universe to the Atom PH12–15 Bands 3–4 • Correctly balances the equation. . . . 1
(c) In order to control the rate of the nuclear fission reaction in a nuclear reactor, the overall number of neutrons released must be kept constant. This can be achieved by inserting or removing boron control rods, which absorb excess neutrons.	Mod 5 Advanced Mechanics PH12–6, PH12–12 Band 3 • Describes controlled nuclear fission in a nuclear reactor. AND • Gives ONE method of controlling nuclear fission . . . . . 2 • Gives some relevant information 1
Question 24	
(a) Each image of the basketball in the time-lapse video represents one unit of time, with a frequency of 5 Hz (frames per second). Five frames per second means each frame is 0.2 s. $14 \times 0.2 = 2.8$ s The time of maximum height is at nine frames before the basketball hits the ground, which would then take 1.8 s (9×0.2) to occur. $s = ut + \dfrac{1}{2}at^2$ $s = 0 + \dfrac{1}{2} \times 9.8 \times 1.8^2$ $= 15.876$ m above ground	Mod 5 Advanced Mechanics PH12–6, PH12–12 Band 2 • Calculates the correct time of flight. AND • Calculates the correct maximum height . . . . . 2 • Calculates the correct time of flight. OR • Calculates the correct maximum height 1

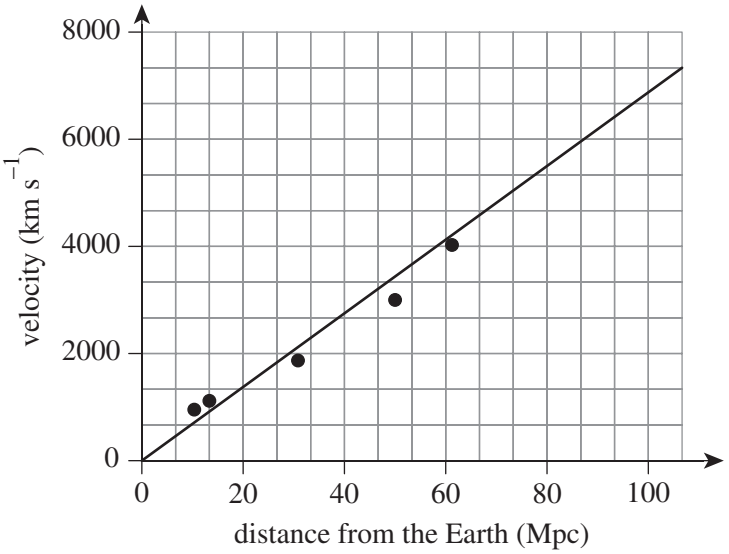
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b) $v = u + at$ (g is negative as motion is upward) $0 = u - 9.8 \times \frac{2.8}{2}$ $u = 13.72$ m s^{-1} vertically upward	Mod 5 Advanced Mechanics PH12–6, PH12–12 Bands 3–4 • Calculates the correct vertical velocity. AND • Gives the correct velocity direction . . . . . 2 --- • Any ONE of the above points 1
Question 25	
(a) An electromagnetic wave is caused by an accelerated charged particle moving through space. As the charged particle accelerates through space, it produces an oscillating electric field and an oscillating magnetic field that are perpendicular to each another. The electromagnetic wave travels through space at the speed of light; that is to say, its propagation does not require a transmission medium and can occur in a vacuum.  	Mod 6 Electromagnetism PH12–13 Bands 2–3 • Describes how electromagnetic waves are produced. AND • Describes how electromagnetic waves propagate. AND • Draws a diagram that supports answer . . . . . 3 --- • Describes how electromagnetic waves are produced AND draws a diagram that supports answer. OR • Describes how electromagnetic waves propagate AND draws a diagram that supports answer . . . . 2 --- • Describes how electromagnetic waves are produced. OR • Describes how electromagnetic waves propagate. OR • Draws a relevant diagram 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(b) • Like electric charges are repelled from each other and unlike electric charges are attracted to each other. • Magnetic field lines are continuous with two poles (north and south). • A changing magnetic field induces an electromotive force (emf) and hence an electric field. • A moving charge or changing electric field generates a magnetic field.	Mod 7 The Nature of Light PH12–14 Bands 2–3 • States FOUR of Maxwell's predictions . . . . . 4 • States THREE of Maxwell's predictions . . . . . 3 • States TWO of Maxwell's predictions . . . . . 2 • States ONE of Maxwell's predictions 1
Question 26	
An emission spectrum is produced when an excited atom falls to a lower energy level, releasing energy. An absorption spectrum is produced when atoms absorb energy and move to a higher energy level. An element will produce spectral lines of the same length on both its emission and absorption spectra, but emission spectra show the atom emitting the energy and absorption spectra show the atom absorbing the energy; this is specific to its atomic structure.	Mod 7 The Nature of Light PH12–7, PH12–14 Bands 1–2 • Explains how emission and absorption spectra are produced. AND • Explains how the emission and absorption spectra of an element produce similar spectral lines . . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 27	
 Planck's constant will be equal to the gradient of the graph. *Note: Responses do not require Planck's constant (the gradient) to be labelled on the graph.*	Mod 7 The Nature of Light PH12–5, PH12–14 Bands 3–4 • Correctly labels the threshold frequency and work function. AND • Explains how the results can be used to find a value for Planck's constant . . . . . 3 --- • Correctly labels the threshold frequency. OR • Correctly labels the work function. AND • Explains how the results can be used to find a value for Planck's constant . . . . . 2 --- • Correctly labels the threshold frequency. OR • Correctly labels the work function. OR • Explains how the results can be used to find a value for Planck's constant 1
Question 28	
(a) $\frac{0.001}{1250} = 8 \times 10^{-7}$ m	Mod 7 The Nature of Light PH12–14 Bands 2–3 • Calculates correct spacing with correct units 1
(b) From $m\lambda = d\sin\theta$: $\lambda = \frac{d\sin\theta}{m}$ $= \frac{8 \times 10^{-7} \times \sin 16}{1}$ $= 220.5$ nm	Mod 7 The Nature of Light PH12–14 Bands 3–4 • Calculates the correct wavelength. . . . . 2 --- • Rearranges formula 1

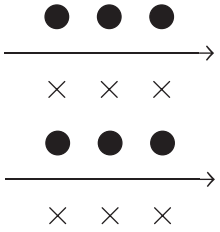
Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
(c) $m\lambda = d\sin\theta$ $2\times375\times10^{-9} = 8\times10^{-7}\times\sin\theta$ $\sin\theta = \dfrac{2\times375\times10^{-9}}{8\times10^{-7}}$ $\theta = \sin^{-1}\left(\dfrac{2\times375\times10^{-9}}{8\times10^{-7}}\right)$ $= 69.64°$	Mod 7 The Nature of Light PH12–14 Bands 3–4 • Calculates the correct angle . . . . . 2 • Gives some relevant information 1
(d) For Young's double slit: $d\sin\theta = m\lambda$ The small angle approximation gives $\sin\theta = \dfrac{x}{L}$, where x is the fringe separation and L (in m) is the slit-to-screen distance (in m). Hence, $d\dfrac{x}{L} - m\lambda$ or $L = \dfrac{dx}{m\lambda}$. Substitute values: $L = \dfrac{50\times10^{-6}\times0.031}{1\times630\times10^{-9}}$ $= 2.46$ m	Mod 7 The Nature of Light PH12–14 Bands 4–6 • Calculates the correct distance to 3 significant figures. AND • Includes correct units . . . . . 3 • Calculates the correct distance to 3 significant figures. OR • Calculates the correct distance AND includes units . . . . . 2 • Gives some relevant information 1
Question 29	
Polarisation occurs when unpolarised light waves are reflected from a polarising surface, which results in oscillations in a single plane occurring in the reflected rays. When the student placed the lenses in front of each other, as in Figure 1, the unpolarised light that first entered lens *A* would have been reduced to 50% (as demonstrated by Malus' Law). Lens *B* would have then further reduced the amount of light that could pass through provided that the plane of lens *B*'s polarisation is not the same as that of lens *A* (per Malus' Law). When the student then rotated lens *B*, as in Figure 2, the amount of light would have been reduced, showing that the planes of polarisation of the two lenses were getting closer to being perpendicular to each other. Once the planes of polarisation of the lenses were perpendicular, the filtering of light would have been at a maximum.	Mod 7 The Nature of Light PH12–7, PH12–14 Bands 3–4 • Explains polarisation. AND • Relates polarisation to BOTH figures . . . . . 3 • Explains polarisation. AND • Relates polarisation to ONE figure . . . . . 2 • Explains polarisation. OR • Relates polarisation to ONE figure 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 30	
(a) The age of and the temperature of the Universe are inversely related; as time passes, the Universe's temperature decreases.	Mod 8 From the Universe to the Atom PH12–7, PH12–15 Bands 2–3 • Explains the relationship between the age of and the size of the Universe . . . . . 2 • Gives some relevant information 1
(b) Particle accelerators have provided a wealth of information about fundamental particles and increased our understanding of matter and antimatter. Particle accelerators have provided experimental evidence that was not previously available that has increased our understanding of the early Universe following the Big Bang. This evidence was obtained predominantly from the Large Hadron Collider (LHC). Particle accelerators have also supported the Big Bang theory in their capability of replicating many environments that existed 13.7 billion years ago. Particle accelerators have provided clues to the formation of the Universe, the correct conditions for matter to form and the age and timeline of the Universe. By using particle accelerators that were able to form matter, researchers have been able to investigate particles that had previously only been theorised.	Mod 8 From the Universe to the Atom PH12–7, PH12–15 Bands 2–3 • Demonstrates a thorough understanding of the role of particle accelerators in determining the standard model of particles and how this has supported the Big Bang theory . . . . . 5 • Demonstrates a highly developed understanding of the role of particle accelerators in determining the standard model of particles and how this has supported the Big Bang theory . . . . . 4 • Demonstrates a sound understanding of the role of particle accelerators in determining the standard model of particles and how this has supported the Big Bang theory . . . . . 3 • Demonstrates a basic understanding of the role of particle accelerators in determining the standard model of particles and how this has supported the Big Bang theory . . . . . 2 • Gives some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 31	
(a)  	Mod 8 From the Universe to the Atom PH12–7 Bands 3–4 • Plots data correctly. AND • Includes a reasonable line of best fit . . . . . 2 • Any ONE of the above points 1
(b) Galaxy Zeta's recessional velocity is approximately 6700 km s^{-1}. *Note: Accept any value from 6666 to 6800 km s^{-1}.*	Mod 8 From the Universe to the Atom PH12–7 Bands 3–4 • Gives a reasonable value for the recessional velocity 1
(c) Following the Big Bang, the Universe was in an incredibly hot state and pair production of matter particles from radiation was ongoing. As the very early Universe expanded, pair production was not balanced with pair annihilation and so the amount of matter in the universe increased. A highly energetic quark-gluon plasma was also present in the early Universe and, as the temperature of the Universe fell with expansion, the quark-gluon plasma combined to form protons and neutrons.	Mod 8 From the Universe to the Atom PH12–7, PH12–15 Bands 4–5 • Describes TWO processes leading to the transformation of radiation into matter . . . . . 3 • Describes ONE process leading to the transformation of radiation into matter. AND • Identifies ONE other process leading to the transformation of radiation into matter . . . . . 2 • Describes ONE process leading to the transformation of radiation into matter. OR • Identifies TWO processes leading to the transformation of radiation into matter 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 32	
(a) The mass defect will be equivalent to the energy of the gamma ray produced. $\text{initial mass} = \text{mass}\left({}^{12}\text{C}\right) + \text{mass}\left({}^{1}\text{H}\right)$ $= 13.0078 \text{ amu}$ $\text{final mass} = \text{mass}\left({}^{13}\text{N}\right)$ $= 13.0057 \text{ amu}$ $\text{mass difference} = 13.0057 - 13.0078$ $= -0.0021 \text{ amu}$ Hence, this is equivalent to $0.0021 \times 931.5 = 1.956 \text{ MeV}.$	Mod 8 From the Universe to the Atom PH12–6, PH12–15 Bands 4–6 • Calculates the correct mass defect . . . . . 2 • Gives some relevant information 1
(b) $1.956 \times 10^{6} \times 1.602 \times 10^{-19} = 3.13375 \times 10^{-13} \text{ J}$	Mod 8 From the Universe to the Atom PH12–6, PH12–15 Bands 4–6 • Calculates the correct value 1
Question 33	
For example: Rutherford's model of the atom was the first nuclear model. It placed electrons circulating (or orbiting) the central nucleus at some distance. Although this helped to explain the results of the Geiger–Marsden experiments, it did not explain the stability of the electrons in orbit. In other situations, charges in orbits are accelerated and therefore are expected to lose energy. Consequently, these orbits should decay, which was not reflected in Rutherford's model. Although this was a serious negative limitation, Rutherford's model was still an important improvement and allowed the search to continue for a more accurate model.	Mod 8 From the Universe to the Atom PH12–7 Bands 3–5 • Describes a limitation of Rutherford's model. AND • Assesses the usefulness of the model . . . . . 3 • States a limitation of Rutherford's model. AND • Assesses the usefulness of the model . . . . . 2 • Gives some relevant information 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 34	
(a) The movement of both particles will be altered by the fields that they are moving through. However, a magnetic field and an electric field have different effects on the path of a charged particle. Particle X, moving through an electric field, will move in a parabolic arc. Particle Y, moving through a magnetic field, will undergo circular motion.	Mod 6 Electromagnetism PH12–7, PH12–13 Bands 4–6 • Outlines ONE similarity between the behaviour of the two particles. AND • Outlines ONE difference between the behaviour of the two particles . . . . . 2 --- • Outlines ONE similarity between the behaviour of the two particles. OR • Outlines ONE difference between the behaviour of the two particles 1
(b) *For example:* When a charged particle enters an electric field, it will follow the electric field lines but move in a parabolic trajectory. This is similar to how a projectile in flight experiences a gravitational field, as gravity exerts a downward force on a projectile, which trends towards a parabolic trajectory.	Mod 6 Electromagnetism PH12–7, PH12–13 Bands 4–6 • Compares the trajectory of a particle in a magnetic OR an electric field to that of a projectile in a gravitational field. . . . . 2 --- • Gives some relevant information 1
Question 35	
(a) $\frac{F}{l}=\frac{\mu_0}{2\pi}\frac{I_1 I_2}{r}$ $V = IR$ $2 = I \times 0.4$ $I = 5$ amps $\frac{F}{l}=\frac{\mu_0}{2\pi}\frac{5\times 5}{0.25}$ $=\frac{4\pi\times 10^{-7}}{2\pi}\frac{5\times 5}{0.25}$ $= 0.00002$ Nm	Mod 6 Electromagnetism PH12–6, PH12–13 Bands 2–3 • Calculates the correct current for each wire. AND • Correctly manipulates force per length on a wire. AND • Gives the correct answer in Newton metres. . . . . 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
(b)	The motor effect is the phenomenon when a current-carrying wire in a magnetic field experiences a force. In this case, there are two wires experiencing the motor effect. As both wires have current travelling in the same direction, the force between them is attractive. This is demonstrated by the right-hand grip rule, as shown in the diagram. 	Mod 6 Electromagnetism PH12–7, PH12–13 Bands 4–5 • Explains how the force is attractive. AND • Refers to the motor effect. AND • Draws a diagram that supports answer . . . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1
Question 36		
(a)	$\frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{n_p}{n_s}$ $\frac{I_p}{I_s} = \frac{n_s}{n_p}$ $I_s = \frac{I_p \times n_p}{n_s}$ $= \frac{3.0 \times 10^{-2} \times 1}{20}$ $= 0.0015 \text{ A}$	Mod 6 Electromagnetism PH12–6, PH12–13 Bands 2–3 • Correctly rearranges formula. AND • Gives the correct answer in amperes . . . . . 2 • Any ONE of the above points 1
(b)	Step-up transformers convert the original input voltage to a much higher output voltage. This was useful in old cathode-ray television sets, and microwaves still use step-up transformers. Step-down transformers convert the original input voltage to a lower output voltage. Most household electrical goods use this type of transformer, such as mobile phone chargers.	Mod 6 Electromagnetism PH12–7, PH12–13 Bands 2–3 • Outlines the role of step-up transformers in household electrical goods. AND • Outlines the role of step-down transformers in household electrical goods . . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, outcomes, targeted performance bands and marking guide
Question 37	
Perpendicular flux is maximum; parallel flux is minimum. $\varepsilon = -N\dfrac{\Delta\Phi}{\Delta t}$ $\Delta\Phi = \text{final } \Phi - \text{initial } \Phi$ $= 0.075 \times 0.02 \times 0.03 \times \cos 0 - 0.075 \times 0.02 \times 0.03 \times \cos 90$ $= 0.000045 \text{ Wb}$ $\Delta t = 0.010 \text{ s}$ $N = 200 \text{ turns}$ $\varepsilon = -\dfrac{200 \times 0.000045}{0.010}$ $= -0.9 \text{ V}$	Mod 6 Electromagnetism PH12–6, PH12–13 Bands 2–3 • States the maximum and minimum flux. AND • Determines the change in flux. AND • Gives the correct answer in volts . . . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1

