Neap:

HSC Trial Examination 2019

Physics

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- NESA approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- For questions in Section II, show all relevant working in questions involving calculations

Total marks: 100

Section I – 20 marks (pages 2–6)

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

Section II – 80 marks (pages 7–21)

- Attempt Questions 21–39
- Allow about 2 hours and 25 minutes for this section

sStudents are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2019 HSC Physics Examination.

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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.

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1. A paper plane was thrown horizontally out of a window 22.8 m high with a velocity of 0.76 m s^{-1}.

Using the acceleration due to gravity and ignoring air resistance, how long did it take for the plane to hit the ground?

(A) 2.16 s
(B) 2.55 s
(C) 3.14 s
(D) 4.65 s

2. A circular race track was constructed for car enthusiasts. It had a radius of 4.5 km and it banked at an angle of 8° to the horizontal. A car of mass 1375 kg and a driver of mass 75 kg were riding on a section of the race track.

What is the velocity of the car and driver if there is no friction between the tyres of the car and the race track?

(A) 2.49 m s^{-1}
(B) 17.8 m s^{-1}
(C) 78.7 m s^{-1}
(D) 87.7 m s^{-1}

3. A plane propeller has blades that are 8 m in length that rotate with a period of 0.32 s.

At what speed do the tips of the propellers travel?

(A) 79 m s^{-1}
(B) 155 m s^{-1}
(C) 157 m s^{-1}
(D) 2035 m s^{-1}

4. What is the correct unit for angular velocity?

(A) rad s^{-1}
(B) rad
(C) m s^{-1}
(D) θ

5. Which one of the following is NOT one of Kepler's Laws?

(A) The planets move in elliptical orbits with the Sun at one focus.

(B) The line connecting a planet to the Sun sweeps out equal areas in equal intervals of time.

(C) For every planet, the ratio of the cube of the average orbital radius, r, to the square of the period of revolution, T, is the same constant, k, as in the equation $\frac{r^3}{T^2} = k$.

(D) The weight of an object on the Earth's surface is due to the gravitational attraction of Earth.

6. An old television was pulled apart in class. The teacher noticed that one side of the plate had a potential of 240 V and the plate directly opposite had a potential of 0 V. The distance between these two plates that were of parallel arrangement was 102 cm.

What would be the work done to move a proton a distance of 0.47 m towards the negative plate?

(A) 8.86×10^{-18} J

(B) 200 V m^{-1}

(C) 1.77×10^{-17} J

(D) 3.76×10^{-17} J

7. A proton travels at half the speed of light at an angle of 7.5° to the direction of the magnetic field in a particle accelerator. The accelerator has a magnetic field strength of 2.0×10^{-2} T.

What is the magnitude of the force that the particle will experience from the magnetic field?

(A) 2.356×10^{-13} N

(B) 6.273×10^{-14} N

(C) 6.172×10^{-14} N

(D) 1.19×10^{-15} Nm

8. A first-hand investigation was conducted in class to determine the forces between parallel current-carrying conductors with different currents applied, all in the same direction. One of the students learned the following data:

- The current in wire 1 was 1.37 A.
- The current in wire 2 was 0.74 A.
- The distance between both wires was 2 cm.

What would the force per unit length be using the data gained?

(A) 1.0×10^{-5} N m^{-1} attractive

(B) 1.0×10^{-5} N m^{-1} repulsive

(C) 1.0×10^{-6} N m^{-1} attractive

(D) 2.0×10^{-5} N m^{-1} repulsive

9. An ideal laptop charger with 1600 turns in the primary coil and 800 turns in the secondary coil draws a current of 3.34 A.

What is the current in the primary coil?

(A) 0.67 A
(B) 1.67 A
(C) 1.73 A
(D) 6.68 A

10. When turning a spanner to tighten a bolt, which one of the following describes how to achieve maximum effect?

(A) The force should be applied at right-angles to the spanner at the smallest distance possible from the point of the bolt.
(B) The force should be applied at 45° to the spanner at the smallest distance possible from the point of the bolt.
(C) The force should be applied at right-angles to the spanner at the middle distance between the bolt and end of the spanner.
(D) The force should be applied at right-angles to the spanner at the largest distance possible from the point of the bolt.

11. What did James Clerk Maxwell find through the unification of the theories of electricity and magnetism?

(A) Light is a mechanical wave.
(B) Light is comprised of corpuscular particles.
(C) Light is a form of an electromagnetic wave.
(D) Light travels slower in denser materials.

12. The star Rigel emits a continuous electromagnetic spectrum with a peak wavelength of approximately 550 nm.

Based on this wavelength, what is the surface temperature of Rigel?

(A) 5.269 K
(B) 5169 K
(C) 5269 K
(D) 6000 K

13. A laser with an unknown wavelength is bought from a market stall. It is pointed through a card that has a pair of small slits cut 90 μm apart. A wall is 6 m away from the card. When the laser is shone through the slits, bright spots appear on the wall and are measured to be 3 cm apart.

What is the wavelength of the laser?

(A) 427 nm
(B) 439 nm
(C) 450 nm
(D) 459 nm

14. Which one of the following statements best describes polarisation?

(A) Polarisation occurs when a transverse wave is allowed to vibrate in only one direction.
(B) Polarisation occurs when a longitudinal wave is allowed to vibrate in only one direction.
(C) Polarisation occurs when a transverse wave is allowed to vibrate in two directions.
(D) Polarisation occurs when a longitudinal wave is allowed to vibrate in two directions.

15. A stationary observer on Earth measures a spaceship travelling at 2.75×10^8 m s^{-1}. When stationary, the spaceship's length is 42 m.

What is the length of the spaceship as seen by the stationary observer?

(A) 16.79 m
(B) 39.21 m
(C) 40.21 m
(D) 45.14 m

16. During recent experiments at the Large Hadron Collider, scientists accelerated electrons to travel at 2.2×10^6 m s^{-1}.

Calculate the de Broglie wavelength of these electrons.

(A) 0.03 nm
(B) 0.13 nm
(C) 0.23 nm
(D) 0.33 nm

17. Which one of the following best defines nuclear fission?

(A) Nuclear fission is the combining of light nuclei to form heavier nuclei.
(B) Nuclear fission is when a nucleus is split into two or more fragments and releases a number of protons and positrons.
(C) Nuclear fission is when a nucleus is split into two or more fragments and releases a number of neutrons.
(D) Nuclear fission is when an atom is split into smaller atoms through electrolysis.

18. Consider the following list of characteristics for particles.

I heavy
II light
III charge +2
IV charge of –1
V charge of +1

Which of the above characteristics would describe an alpha particle when compared to a beta particle?

(A) I and IV
(B) I, IV and V
(C) II and III
(D) I and III

19. Which one of the following terms describes something that is required to separate a nucleus from its constituent nucleons?

(A) the CNO cycle
(B) gravitational potential energy
(C) elastic potential energy
(D) binding energy

20. Which one of the following is NOT one of the four fundamental forces of nature?

(A) gravity
(B) electrostatic charge
(C) weak nuclear
(D) strong nuclear

Section II

Attempt Questions 21–39
Allow about 2 hours and 25 minutes for this section

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.

Question 21 (7 marks)

A teacher's demonstration with a bottle rocket was conducted on an oval. The teacher had the bottle rocket on a tabletop 80 cm above the ground. The students used a data logger to calculate that the initial velocity of the bottle was 17 m s^{-1} at an angle of 45° above the horizontal. The maximum height above the ground that the bottle rocket reached, according to the students, was 8.17 m.

(a) How long did it take for the bottle rocket to reach the ground? **3**

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(b) What was the final velocity and angle of the bottle rocket? **4**

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Question 22 (4 marks)

An astronaut on the International Space Station was conducting maintenance on the exterior. The astronaut used a spanner to tighten a lock on a window. They used a spanner that was 46 cm long and applied a force of 92 N perpendicular to the radius.

(a) What torque did the astronaut apply? **2**

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(b) If the force was applied at an angle of 50° to the spanner length, how much force would the astronaut need to apply in order to produce the same torque as in part (a)? **2**

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Question 23 (5 marks)

Compare the gravitational force the Sun exerts on Earth and Mercury using the following data: **5**

- mass of the Sun = 2.00×10^{30} kg
- mass of Mercury = 3.29×10^{23} kg
- mean radius of Earth's orbit around the Sun = 1.50×10^{11} m
- mean radius of Mercury's orbit around the Sun = 5.79×10^{7} km

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Question 24 (6 marks)

(a) Distinguish between escape velocity and orbital velocity. Include the formulae for both velocities in your answer. **4**

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(b) Outline ONE use for low-Earth orbit and ONE use for geostationary satellites. **2**

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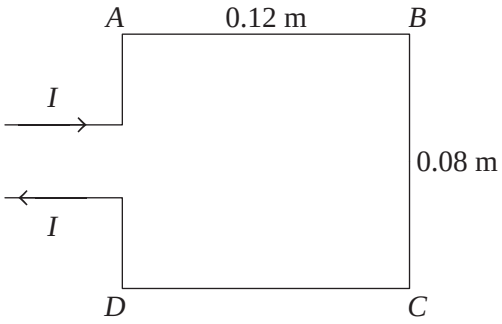
Question 25 (5 marks)

A motor uses a 150-turn coil that has dimensions of 0.08 m by 0.12 m, as shown in the diagram below. A current of 1.5 A flows through the coil. The coil is vertical and is in a magnetic field of 0.06 T directed upwards (up the page).



(a) What is the magnitude and direction of the force exerted on side *AB*? **3**

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(b) What is the magnitude and direction of the force exerted on side *BC*? **1**

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(c) On the diagram above, show the direction in which the coil will begin to rotate. **1**

Question 26 (2 marks)

Compare and explain the function of a split-ring commutator and slip rings in generators. **2**

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Question 27 (2 marks)

A coil has an area of 2.5×10^{-3} m^2. A magnetic flux of 0.15 Wb passes through the coil. **2**

Calculate the flux density inside the coil when the coil is 45° to the magnetic field.

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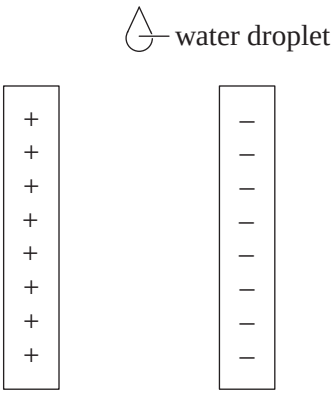
Question 28 (7 marks)

A dropper bottle was used to release a single drop of water between two vertical charged parallel plates, which fell straight down at 0.25 m s^{-1}. The average drop of water has a mass of 2.0×10^{-2} kg and a charge of –1.2 μC, and the field between the plates is 6000 V m^{-1}. The apparatus is shown below.



(a) Calculate the acceleration of the water droplet, ignoring acceleration due to gravity. **3**

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(b) Calculate the speed of the water droplet 0.5 s after it enters the field. **4**

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Question 29 (5 marks)

Throughout history, light has been a mystery that scientists have tried to explain. During the 1700s, the two prominent scientists Newton and Huygens feuded over their different hypotheses on whether light is a particle or a wave.

(a) Compare Newton's and Huygens' models of light, including ONE similarity and ONE difference between them. **3**

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(b) Justify whose model of light was correct. Give reasons for your answer. **2**

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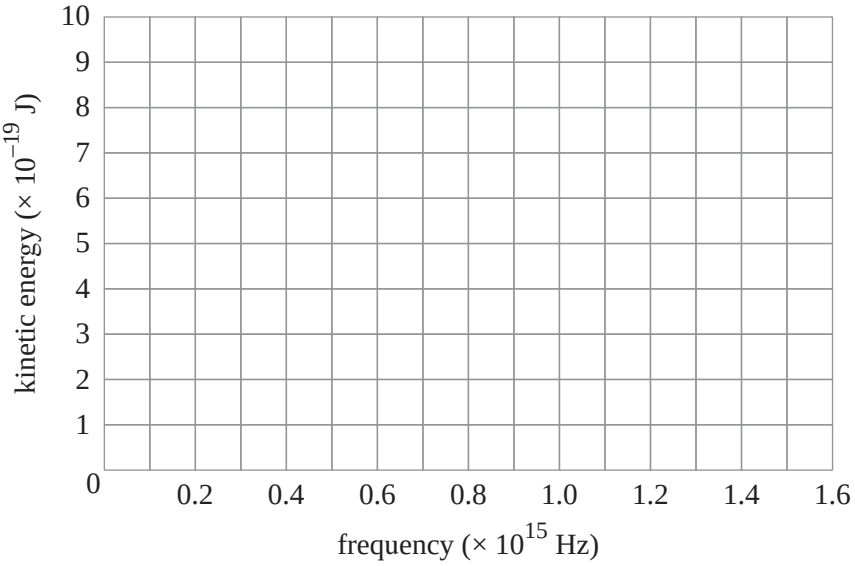
Question 30 (7 marks)

A group of students conducted a photoelectric experiment in class to measure the work function of a photo emitter. Their results are shown in the following table.

Wavelength of light (nm)	*Frequency of light ($\times 10^{15}$ Hz)*	*Energy carried by light beam (eV)*	*Kinetic energy of emitted electrons ($\times 10^{-19}$ J)*
200	1.49	6.21	7.30
300	1.00	4.09	3.97
400	0.76	3.10	2.33
500	0.59	2.50	1.34
600	0.50	2.02	0.66
700	0.43	1.77	0.23

(a) Graph the frequency of light ($\times 10^{15}$ Hz) on the horizontal axis against the kinetic energy ($\times 10^{-19}$ J) on the vertical axis. Include a line of best fit. **2**



Question 30 continues on page 16

Question 30 (continued)

(b) Use your graph from part (a) to determine the value for the work function of the emitter. Express your answer in eV. **3**

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(c) Use your graph from part (a) to determine a value for Planck's constant. Show your working. **2**

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End of Question 30

Question 31 (3 marks)

Consider the following statement that was made when the Large Hadron Collider was being used: **3**

Particle accelerators cannot accelerate particles to and beyond the speed of light.

Assess why this statement continues to be true.

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Question 32 (1 mark)

During your studies you conducted an investigation to examine a variety of spectra produced by either discharge tubes, reflected light or incandescent filaments. **1**

Outline ONE safety precaution that should be observed while conducting this investigation.

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Question 33 (8 marks)

(a) Assess the limitations of the Rutherford and Bohr atomic model. **6**

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(b) Rutherford and Bohr's model of the atom is sometime referred to as 'classical physics'. **2**

Explain why Schrödinger's quantum mechanics improved our understanding of the model of the atom.

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Question 34 (3 marks)

Describe ONE experiment conducted by a scientist that provided support for the existence of the electron and its properties. **3**

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Question 35 (2 marks)

Sketch a diagram that demonstrates the difference between nuclear fusion and nuclear fission in the space below. **2**

Question 36 (2 marks)

A class of students went on an excursion to Australia's Nuclear Science and Technology Organisation (ANSTO) in Sydney. During a routine walk around the facility, the tour guide stated that a radioactive sample scientists were studying in the building had a decay constant of 1.7×10^{-9} s^{-1}. **2**

Calculate the half-life of this sample.

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Question 37 (4 marks)

(a) State the difference between emission spectra and absorption spectra. **2**

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(b) The Hertzsprung–Russell diagram graphs spectral class against three other factors. **2**

Name TWO of the factors that you would see on a Hertzsprung–Russell diagram on either the vertical or the horizontal axis.

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Question 38 (3 marks)

(a) Describe 'redshift'. **2**

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(b) Name the scientist who used redshift to support the Big Bang Theory. **1**

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Question 39 (4 marks)

(a) A massive star is losing mass at a rate of 5.6×10^9 kg s^{-1}. **2**

How much energy is being produced per second in total radiation in this case? Show all working.

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(b) Most stars follow the same order of stellar evolution. **2**

Complete the table below showing the stellar evolution of a typical star.

	Stage of stellar evolution
1.	
2.	main sequence star
3.	
4.	white dwarf

End of paper

Neap:

HSC Trial Examination 2019

Physics

Solutions and marking guidelines

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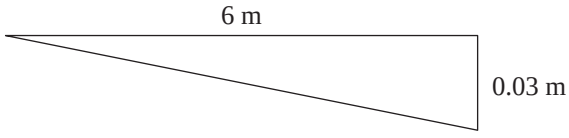
Section I

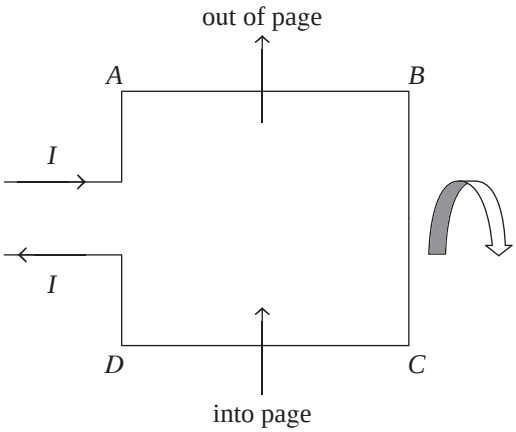
Answer and explanation	Syllabus content and course outcomes
Question 1 **A** $s = ut + \frac{1}{2}at^2$ $22.8 = 0 + \frac{1}{2} \times 9.8 \text{ m s}^{-2} \times t^2$ $t = \sqrt{\frac{22.8}{4.9}}$ $= 2.16 \text{ s}$	Mod 5 Advanced Mechanics PH12–12 Bands 3–4
Question 2 **C** $v = \sqrt{rg\tan(\theta)}$ $= \sqrt{4500 \times 9.8 \times \tan(8)}$ $= 78.7 \text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–12 Bands 3–5
Question 3 **C** $v = \frac{2\pi r}{T}$ $= \frac{2 \times \pi \times 8}{0.32}$ $= 157 \text{ m s}^{-1}$	Mod 5 Advanced Mechanics PH12–12 Bands 3–4
Question 4 **A** The units for angular velocity are either degrees^{-1} or rad s^{-1}. The only possible answer is **A**.	Mod 5 Advanced Mechanics PH12–12 Bands 2–3
Question 5 **D** **A**, **B** and **C** are all Kepler's Laws. **D** is not, but is rather relating to gravity.	Mod 5 Advanced Mechanics PH12–12 Bands 3–4
Question 6 **C** $E = \frac{V}{D}$ $= \frac{240}{1.2}$ $= 200 \text{ V m}^{-1}$ $W = qEd$ $= 1.602 \times 10^{-19} \times 200 \times 0.47$ $= 1.77 \times 10^{-17} \text{ J}$	Mod 6 Electromagnetism PH12–13 Bands 3–5
Question 7 **B** $F = qvB\sin(\theta)$ $= 1.602 \times 10^{-19} \times 1.5 \times 10^{8} \times 2.0 \times 10^{-2} \times \sin(7.5°)$ $= 6.273 \times 10^{-4} \text{ N}$ The only possible answer after rounding is **B**.	Mod 6 Electromagnetism PH12–13 Bands 4–5

Answer and explanation	Syllabus content and course outcomes
Question 8 **A** $\frac{F}{L} = \frac{4\pi \times 10^{-7} \times 1.37 \times 0.74}{2\pi \times 0.02}$ $= 1.0 \times 10^{-5}$ N m^{-1} attractive	Mod 6 Electromagnetism PH12–13 Bands 4–5
Question 9 **B** $\frac{I_p}{I_s} = \frac{n_s}{n_p}$ $I_p = \frac{800 \times 3.34}{1600}$ $= 1.67$ amp	Mod 6 Electromagnetism PH12–13 Bands 3–4
Question 10 **D** Maximum torque is achieved when the force is applied at right angles with the largest distance possible; hence $\tau = r_{\perp} F$.	Mod 6 Electromagnetism PH12–13 Bands 3–4
Question 11 **C** Faraday related electricity and magnetism, while Maxwell linked that an electromagnetic wave consists of oscillating electric and magnetic fields that included visible light. This meant that Maxwell unified light as a form of an electromagnetic wave.	Mod 7 The Nature of Light PH12–14 Bands 2–4
Question 12 **C** $\lambda_{max} = \frac{b}{T}$ $T = \frac{b}{\lambda_{max}}$ $= \frac{2.898 \times 10^{-3}}{550 \times 10^{-9}}$ $= 5269$ K	Mod 7 The Nature of Light PH12–14 Bands 2–4
Question 13 **C**  angle $= \tan^{-1}\left(\frac{0.03}{6}\right)$ $= 28.65°$ $\lambda = \frac{90 \times 10^{-6} \times \sin(0.2865)}{1}$ $= 4.50 \times 10^{-7}$ m or 450 nm	Mod 7 The Nature of Light PH12–14 Bands 3–5
Question 14 **A** Polarisation occurs only in transverse waves and in one direction; hence, only answer **A** is possible.	Mod 7 The Nature of Light PH12–14 Bands 2–3

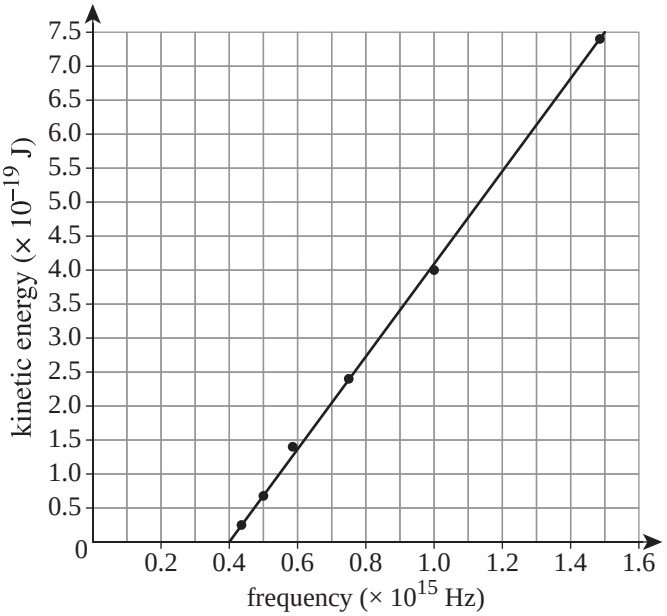
Answer and explanation	Syllabus content and course outcomes
Question 15 **A** $L = 42 \times \sqrt{\left(1 - \frac{(2.75 \times 10^8)^2}{(3.0 \times 10^8)^2}\right)}$ $= 16.79$ m	Mod 7 The Nature of Light PH12–14 Bands 4–5
Question 16 **D** $\lambda = \frac{h}{mv}$ $= \frac{6.626 \times 10^{-34}}{9.109 \times 10^{-31} \times 2.2 \times 10^6}$ $= 3.3 \times 10^{-10}$ m or 0.33 nm	Mod 8 From the Universe to the Atom PH12–15 Bands 3–4
Question 17 **C** **A** is an example of nuclear fusion; **D** is not a definition for nuclear fission; and **B** is incorrect due to the release of protons and positrons. The only correct answer is **C**.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3
Question 18 **D** Alpha particles are heavy compared to beta particles and have a charge of +2, as in the helium nucleus.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3
Question 19 **D** Binding energy is the only suitable answer as it is the separation or combining of protons and neutrons into its constituents. The CNO cycle is when stars convert hydrogen to helium, which is incorrect for this question. Gravitational potential energy and elastic potential energy do not separate nor combine atoms together to satisfy the question; neither is related.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3
Question 20 **B** All but **B** are fundamental forces of nature. Electrostatic charge is not a force.	Mod 8 From the Universe to the Atom PH12–15 Bands 2–3

Sample answer	Syllabus content, course outcomes and marking guide
Question 21	
(a) You need to find t_1 and t_2 of the projectile. To find t_1, $vy = u_y + at$. $t_1 = \frac{17 \text{ m s}^{-1} \times \sin(45)}{-9.8}$ $= 1.23$ s To find t_2, $\Delta y = u_y t + a_y t^2$. $t_2 = \sqrt{\frac{2x(-y)}{g}}$ $= \sqrt{\frac{2x(-8.17)}{-9.8}}$ $= 1.29$ s To find total time, $t_1 + t_2 = 2.52$ s.	Mod 5 Advanced Mechanics PH12–12 Bands 4–6 • Gives correct equation to determine time. AND • Demonstrates manipulation of the correct equation. AND • States correct answer with units. . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points 1
(b) $u_x = u\cos(\theta)$ $= 17 \times \cos(45)$ $= 12.02 \text{ m s}^{-1}$ $v_x = u_x$ $= 12.02 \text{ m s}^{-1}$ $v_y = u_y + a_y t$ $= 0 + (-9.8) \times 1.29$ s $= -12.64 \text{ m s}^{-1}$ $v^2 = (12.02 \text{ m s}^{-1})^2 + (-12.64 \text{ m s}^{-1})^2$ $v = 17.44 \text{ m s}^{-1}$ $\tan^{-1}\left(\frac{-12.64}{12.02}\right) = 46°$ 17.44 m s^{-1} at 46° below the horizontal	Mod 5 Advanced Mechanics PH12–12 Bands 4–6 • Calculates horizontal velocity with units. AND • Calculates vertical velocity with units. AND • Calculates correct final velocity with units. AND • Gives angle . . . . . 4 • Any THREE of the above points . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points 1
Question 22	
(a) $\tau = rF\sin(\theta)$ $= (0.46) \times 92 \times \sin(90)$ $= 42.32$ N m	Mod 6 Electromagnetism PH12–13 Band 1 • Provides correct torque equation OR demonstrates calculation. AND • Gives correct answer and units . . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, course outcomes and marking guide
(b) $\tau = rF\sin(\theta)$ $F = \frac{\tau}{r\sin(\theta)}$ $= \frac{42.32}{0.46 \times \sin(50)}$ $= 120.1$ N	Mod 6 Electromagnetism PH12–13 Band 2 • Correctly identifies a valid method for measuring the force AND • Gives correct answer. . . . . 2 • Gives some correct information 1
Question 23	
For Earth: $F = \frac{GMM}{r^2}$ $= \frac{6.67 \times 10^{-11} \times 6.00 \times 10^{24} \times 2.00 \times 10^{30}}{(1.50 \times 10^{11})^2}$ $= 3.56 \times 10^{22}$ N directed towards the Sun For Mercury: $F = \frac{GMM}{r^2}$ $= \frac{6.67 \times 10^{-11} \times 3.29 \times 10^{23} \times 2.00 \times 10^{30}}{(5.79 \times 10^{10})^2}$ $= 1.31 \times 10^{22}$ N directed towards the Sun ratio = 2.71 : 1 Therefore, the Sun exerts a force 2.71 times greater on Mercury than it does on Earth.	Mod 5 Advanced Mechanics PH12–12 Band 4 • Provides correct Earth equation OR demonstrates working for Earth. AND • Gives gravitational force for Earth. AND • Provides correct Mercury equation OR demonstrates working for Mercury. AND • Gives gravitational force for Mercury. AND • Gives correct ratio . . . . . 5 • Any FOUR of the above points . . . . . 4 • Any THREE of the above points . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
Question 24	
(a) Escape velocity is when a projectile wants to escape the influence of gravity by a planet/moon, while orbital velocity is when a projectile is under the influence of gravity in uniform circular motion. escape velocity formula: $v_{escape} = \sqrt{\frac{2GM}{r}}$ orbital velocity formulas: $v_{orbital} = \sqrt{\frac{GM}{r}}$	Mod 5 Advanced Mechanics PH12–12 Band 1 • Defines escape velocity. AND • Defines orbital velocity. AND • States escape velocity formula. AND • States orbital velocity formula . . . . . 4 • Any THREE of the above points . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
(b) *For example*: **Geostationary satellites** GPS; communication **Low-Earth orbit satellites** weather; military surveillance; mapping	Mod 5 Advanced Mechanics PH12–12 Band 1 • Gives a correct use for geostationary satellites. AND • Gives a correct use for low-Earth orbit satellites . . . . . 2 • Any ONE of the above points. 1

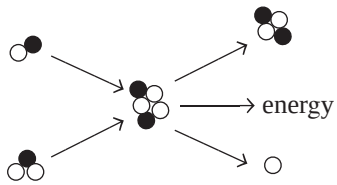
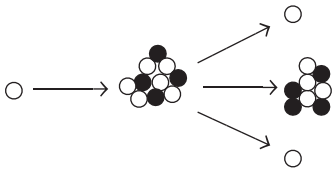
Sample answer	Syllabus content, course outcomes and marking guide
Question 25	
(a) $F = nLIB$ $= 150 \times 1.5 \times 0.12 \times 0.06$ $= 1.62$ N out of the page	Mod 6 Electromagnetism PH12–13 Band 1 • Correctly identifies $F = nLIB$. AND • Gives direction as out of the page AND • Gives the correct answer . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points 1
(b) The magnitude is zero, as it is $\sin(0)$, to which the answer is 0.	Mod 6 Electromagnetism PH12–13 Band 1 • Identifies that force is zero as current is parallel to the magnetic field 1
(c)  The coil will rotate counter-clockwise when viewed from the left of the page.	Mod 6 Electromagnetism PH12–13 Band 3 • Correctly labels or indicates direction of force 1
Question 26	
A split-ring commutator ensures that the output current to the external circuit is direct current and not alternating current. Slip rings provide electrical contact between the rotating coil and the external circuit to ensure alternating current is produced by the generator and is delivered to the external circuit.	Mod 6 Electromagnetism PH12–13 Bands 3–5 • Explains the purpose of a split-ring commutator. AND • Explains the purpose of slip rings . . . . . 2 • Any ONE of the above points 1
Question 27	
$\Phi = BA\cos(\theta)$ $B = \dfrac{\Phi}{A\cos(\theta)}$ $= 84.85$ T	Mod 6 Electromagnetism PH12–13 Band 3 • Gives correct equation for magnetic flux density. AND • Calculates correct value with units . . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, course outcomes and marking guide
Question 28	
(a) $\alpha = \frac{Eq}{m}$ $= \frac{6000 \times (1.2 \times 10^{-6})}{2.0 \times 10^{-2}}$ $= 0.36 \text{ m s}^{-2}$	Mod 6 Electromagnetism PH12–13 Band 3 • Gives correct equation for acceleration. AND • Correctly manipulates equation with correct variables. AND • States correct answer with units. . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
(b) $v_{\perp} = -0.25 \text{ m s}^{-1}$ $v_{\parallel} = u + at$ $= u + \frac{Eq}{m} \times t$ $= 0 + (0.36) \times 0.5$ $= 0.18 \text{ m s}^{-1}$ $v = \sqrt{(v_{\perp})^2 + (v_{\parallel})^2}$ $= \sqrt{(-0.25)^2 + (-0.18)^2}$ $= 0.31 \text{ m s}^{-1}$	Mod 6 Electromagnetism PH12–13 Bands 3–6 • Identifies correct perpendicular speed. AND • Identifies correct equation for parallel speed. AND • Uses Pythagoras' theorem to find final speed. AND • States correct answer with units. . . . . 4 • Any THREE of the above points . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
Question 29	
(a) Newton's corpuscular theory proposed that light was made of small particles, while Huygens' theory suggested that light was a wave. Newton also stated that light travelled faster in more optically dense media, whereas Huygens suggested the opposite – that the light waves should slow down. However, both theories suggested that they could explain refraction and Snell's law.	Mod 7 The Nature of Light PH12–14 Band 3 • Identifies Newton's corpuscular theory and Huygens' light-wave theory. AND • States ONE similarity between the two theories. AND • States ONE difference between the two theories. . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
(b) Huygens' theory of light was more correct than Newton's. This is because when Foucault conducted his experiment, he found that the speed of light travels slower in water than air. This went against Newton's theory of light.	Mod 7 The Nature of Light PH12–14 Band 3 • Identifies that Huygens' model was more correct than Newton's. AND • States a reason proving Huygens' model was correct OR discusses an experiment proving Huygens' model was correct. . . . 2 • Any ONE of the above points. 1

Sample answer	Syllabus content, course outcomes and marking guide
Question 30	
(a) 	Mod 7 The Nature of Light PH12–14 Band 2 • Correctly plots data. AND • Includes line of best fit. . . . . 2 • Any ONE of the above points 1
(b) From the graph, the x-intercept is 0.4×10^{15} Hz. $E = hf$ $= 6.626 \times 10^{-34} \times 0.4 \times 10^{15}$ $= \dfrac{2.6504 \times 10^{-19}}{1.602 \times 10^{-19}}$ $= 1.654$ eV	Mod 7 The Nature of Light PH12–14 Bands 4–6 • Identifies stopping frequency. AND • Uses correct formula. AND • Converts work function into electron voltage . . . . . 3 • Any TWO of the above points. . . . . 2 • Any ONE of the above points 1
(c) $\dfrac{(7.3 \times 10^{-19} - 0.23 \times 10^{-19})}{(1.49 \times 10^{15} - 0.43 \times 10^{15})} = 6.67 \times 10^{-34}$ J s^{-1}	Mod 7 The Nature of Light PH12–14 Band 3 • Uses gradient formula to gain Planck's constant. AND • Answer is within range of 6.6×10^{-34} J s^{-1} . . . . . 2 • Uses gradient formula to gain Planck's constant 1

Sample answer	Syllabus content, course outcomes and marking guide
Question 31	
Particles cannot exceed the speed of light as this is the upper limit of speed in the Universe. This was postulated by Einstein when discussing special relativity. His second postulate states that the speed of light is constant for all observers, which means that it is the upper limit of speed in the Universe. This holds true as recent experiments have not demonstrated that a particle can exceed this speed.	Mod 7 The Nature of Light PH12–14 Bands 2–4 • Explains that the speed of light is the upper limit of speed. AND • Attributes the speed of light being constant to Einstein's postulate. AND • Provides a reasoning for particles never exceeding the speed of light . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
Question 32	
Any one of: • Stand back at least three metres from the apparatus as it produces X-ray radiation. • Handle the tubes with care, as they are made of glass and contain hazardous chemicals such as mercury and sodium. • Do not stare at the light when in operation. • Do not look directly at the Sun, with or without the spectroscope. • any other reasonable safety precaution	Mod 7 The Nature of Light PH12–14 Band 1 • Gives ONE safety procedure for spectroscopy 1

Sample answer		Syllabus content, course outcomes and marking guide
Question 33		
(a)	Rutherford's model of the atom was superior in the beginning; however, it had many limitations, including: • an inability to explain the nucleus; • an uncertainty on how to place the electrons around the dense region that is now known as the nucleus, and; • an uncertainty on why the electrons orbiting the nucleus did not slow down and crash into each other. A couple of years later, a scientist named Niels Bohr created a model of the atom that improved Rutherford's model. Over time, however, Bohr's model of the atom also had limitations, which include: • an inability to predict the spectra of multi-electron atoms, and; • an inability to explain the different intensities of lines or why some lines split into multiple, closely spaced lines. It did not take long before scientists improved Bohr's theory when studying emission line spectroscopy.	Mod 8 From the Universe to the Atom PH12–15 Bands 3–6 • Provides ONE limitation of Rutherford's model about the nucleus. AND • Provides ONE limitation of Rutherford's model about the electrons. AND • Provides ONE limitation of Rutherford's model about the electron orbits. AND • Explains how Bohr's model was superior to Rutherford's model. AND • Provides ONE limitation of Bohr's model about multi-electron atom spectra. AND • Provides ONE limitation of Bohr's model about different spectra-line intensities or why some lines split into multiple, closely split lines . . . . . 6 • Any FIVE of the above points . . . . . 5 • Any FOUR of the above points . . . . . 4 • Any THREE of the above points . . . . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points 1
(b)	Schrödinger's model of the atom was developed mathematically and the equations that he used could explain the probability or the certainty of a quantum event or quantum position in quantum mechanics. This improved the model of the atom from Bohr's model, as Schrödinger identified that the electrons were orbiting the nucleus within probability clouds and not fixed positions within the shell.	Mod 8 From the Universe to the Atom PH12–15 Band 2 • Describes Schrödinger's contribution to quantum mechanics. AND • Describes how the model changed from Bohr's to Schrödinger's . . . . . 2 • Any ONE of the above points 1

Sample answer	Syllabus content, course outcomes and marking guide
Question 34	
Students can discuss any one of: • Thomson's plum pudding model of the atom using cathode ray tubes • Thomson's charge-to-mass ratio experiment • Millikan's oil drop experiment *For example:* Robert Millikan created an oil drop experiment to measure the charge of the electron. Millikan's apparatus comprised two metal electric plates within a container of water. Millikan sprayed oil drops within the container of water and applied a potential difference between the two plates to suspend the oil between them. This meant that the oil drop was balanced between the electrostatic and gravitational forces, and from this Millikan used $q_E = mg$ to determine that the charge on a drop was a multiple of 1.6×10^{-19} C.	Mod 8 From the Universe to the Atom PH12–15 Band 3 • States experimental evidence to support the existence of the electron. AND • Provides supporting evidence for how the electron was discovered. AND • Names the correct scientists or models. . . 3 • Any TWO of the above points . . . . . 2 • Any ONE of the above points. 1
Question 35	
Fission:  Fusion: 	Mod 8 From the Universe to the Atom PH12–15 Band 1 • Gives correct drawing for fission. AND • Gives correct drawing for fusion . . . . . 2 • Any ONE of the above points. 1
Question 36	
$\lambda = \dfrac{\ln(2)}{t_{\frac{1}{2}}}$ $t_{\frac{1}{2}} = \dfrac{\ln(2)}{\lambda}$ $= 4.1 \times 10^{8}$ s	Mod 8 From the Universe to the Atom PH12–15 Band 3 • Gives correct formula for half-life. AND • Gives correct answer with units . . . . . 2 • Any ONE of the above points. 1
Question 37	
(a) Emission spectra are the production of bright lines against a dark background by the excitation of a low density gas. Absorption spectra are produced by stars and show dark lines against a continuous background spectrum.	Mod 8 From the Universe to the Atom PH12–15 Band 2 • States the difference between emission spectra and absorption spectra. AND • Provides some relevant information about either emission spectra OR absorption spectra. . . . . 2 • Provides some relevant information about either emission spectra OR absorption spectra. 1

Sample answer	Syllabus content, course outcomes and marking guide
(b) *Any two of:* • temperature (K) • luminosity (Sun = 1) • absolute magnitude	Mod 8 From the Universe to the Atom PH12–15 Band 3 • Names TWO correct factors . . . . . 2 • Names ONE correct factor. 1
Question 38	
(a) When using spectroscopy on common elements such as hydrogen and helium in space, scientists discovered that the spectral lines of these elements were shifted towards the red end of the spectrum. This means that the objects being studied are moving or accelerating away from each other.	Mod 8 From the Universe to the Atom PH12–15 Band 3 • Explains spectral lines shifting on the light spectrum. AND • States that the objects are moving or accelerating away from each other . . . . . 2 • Any ONE of the above points 1
(b) Edwin Hubble (He discovered that redshift was useful to support the Big Bang Theory, as it identifies that the Universe is expanding.)	Mod 8 From the Universe to the Atom PH12–15 Bands 2–4 • Names correct scientist 1
Question 39	
(a) $E = mc^2$ $= 5.6 \times 10^9 \times (3.0 \times 10^8)^2$ $= 5.04 \times 10^{26}$ J	Mod 8 From the Universe to the Atom PH12–15 Band 3 • Gives correct equation AND/OR manipulation. AND • Gives correct answer . . . . . 2 • Gives some relevant information. 1
(b)	Mod 8 From the Universe to the Atom PH12–15 Band 3 • Correctly places TWO terms . . . . . 2 • Correctly places ONE term 1

	Stage of stellar evolution
1.	**protostar**
2.	main sequence star
3.	**red giant**
4.	white dwarf