ROSE BAY SECONDARY COLLEGE

Student ID: _____

2024

HIGHER SCHOOL CERTIFICATE
TRIAL EXAMINATION

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 sheet and periodic table are provided
- Draw diagrams using pencil
- A protractor and ruler are required
- Write your Student ID at the top of this page, the top of page 13 and the multiple choice answer sheet

Total marks:
100

Section I — 20 marks (pages 2-11)

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

Section II — 80 marks (pages 13-31)

- Attempt Questions 21–35
- Allow about 2 hours and 25 minutes for this section

Section I

20 marks

Part A – 20 marks

Attempt Questions 1–20

Allow about 35 minutes for this part

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1. Which of the following statements about the speed of light is correct?

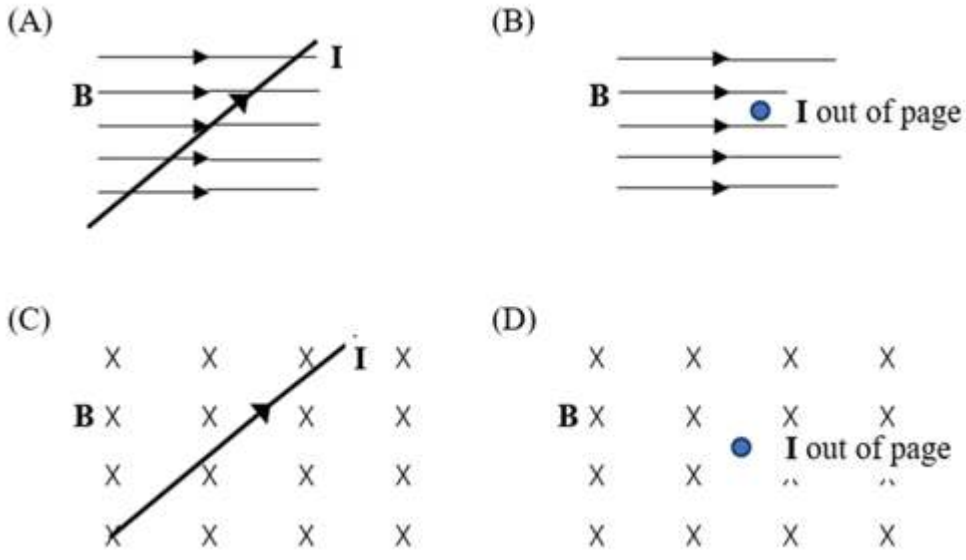
A. The speed of light in a vacuum is independent of the speed of the light source and the observer.

B. The speed of light in a vacuum decreases if the light source moves towards the observer.

C. The speed of light in a vacuum increases if the light source moves away from the observer.

D. The speed of light in a vacuum increases if the observer moves towards the light source.

2. Under which set of conditions will **no** force be exerted on the conducting wire?



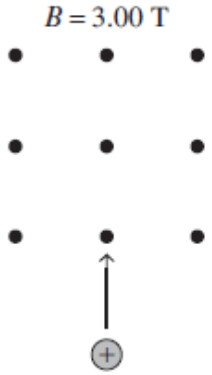
3. During a game of paintball, player X shoots a paintball, which has a velocity of 80 m s^{-1}, horizontally from a height of 10 m towards player Y, who is positioned 25 m away.
What is the horizontal velocity of the paintball just before impact?

A. 8.0 m s^{-1}
B. 8.2 m s^{-1}
C. 80 m s^{-1}
D. 800 m s^{-1}

4. Which of the following describes Einstein's mass–energy equivalence relationship most accurately?

A. Mass and energy are independent quantities.
B. The rest mass of an object is determined by its inertial frame of reference.
C. Mass and energy are identical.
D. Mass is a form of energy.

5. The diagram shows a proton being fired with a velocity of 1200 m s^{-1} into a uniform magnetic field of 3.00 T. The magnetic field is directed out of the page.



What is the acceleration of the proton as it enters the field?

A. 5.78×10^{-16} m s^{-2} to the right
B. 5.78×10^{-16} m s^{-2} to the left
C. 3.45×10^{11} m s^{-2} to the right
D. 3.45×10^{11} m s^{-2} to the left

6. A plutonium-239 isotope is struck by a neutron; it absorbs the neutron and undergoes nuclear fission according to the following equation.

$$^{1}_{0}n + {}^{239}_{94}\text{Pu} \rightarrow {}^{144}_{56}\text{Ba} + {}^{93}_{38}\text{Sr} + 3\,{}^{1}_{0}n + \text{energy}$$

The combined mass of the plutonium-239 isotope's nucleus and the absorbed neutron is 3.99×10^{-25} kg. During the reaction, a mass of 3.07×10^{-28} kg is lost.

How much energy does the reaction release?

A. 4.42×10^{-30} eV

B. 1.72×10^{8} eV

C. 2.76×10^{-11} eV

D. 3.99×10^{-25} eV

7. The Moon is located 3.84×10^{8} m from Earth and has a mass of 7.35×10^{22} kg. Earth has a mass of 6.0×10^{24} kg.

If a 1.00 kg object is located midway between Earth and the Moon, what is the object's acceleration due to gravity?

A. 1.07×10^{-2} m s^{-2} towards Earth

B. 1.07×10^{-2} m s^{-2} towards the Moon

C. 1.08×10^{-2} m s^{-2} towards Earth

D. 1.08×10^{-2} m s^{-2} towards the Moon

8. Which law can be used to predict the direction of induced current in a circuit?

A. Oersted's law

B. Faraday's law

C. Lenz's law

D. Newton's Third law

9. Which row of the table correctly compares the nucleosynthesis reactions that occur in main sequence stars?

	Proton–proton chain	Carbon–nitrogen–oxygen (CNO) cycle
A.	relatively slow and occurs in cooler main sequence stars	relatively fast and occurs in more massive, hotter main sequence stars
B.	relatively slow and occurs in more massive, hotter main sequence stars	relatively fast and occurs in cooler main sequence stars
C.	relatively fast and occurs in cooler main sequence stars	relatively slow and occurs in cooler main sequence stars
D.	relatively fast and occurs in cooler main sequence stars	

10. Newton's law of gravitation can be applied to the Earth-Moon system. Which of the following statements is **not** correct?

A. The orbital time of the Moon about the Earth is independent of the mass of the Moon.

B. The value of G at the surface of the Moon is the same as the surface of the Earth.

C. The gravitational force between the Earth and the Moon is proportional to the mass of the Moon.

D. The gravitational force between the Earth and the Moon is proportional to the square of the separation of the Earth and the Moon.

11. Calculate the energy released from an electron-positron annihilation.

A. 1.6×10^{-13} J

B. 8.2×10^{-14} J

C. 4.1×10^{-14} J

D. 2.7×10^{-22} J

12. A spaceship on Earth has a length *L*. This spaceship has a speed of 2.2×10^8 m s^{-1} as it passes another planet.

Which row in the table describes the length of the spaceship as measured by the pilot in the spaceship and an observer on the planet?

	Length measured by pilot in the spaceship	**Length measured by observer on the planet**
A.	*L*	less than *L*
B.	*L*	*L*
C.	*L*	greater than *L*
D.	greater than *L*	*L*

13. A person with a viral infection has their body temperature rise from 37 °C (310 K) to 40 °C. What is the change in the peak wavelength of electromagnetic radiation emitted?

A. Increase by 8.96×10^{-8} m

B. Decrease by 8.96×10^{-8} m

C. Increase by 9.66×10^{-4} m

D. Decrease by 9.66×10^{-4} m

14. A satellite is currently in a low Earth orbit of 850 km and must be brought down to a lower orbit of 650 km. In order to be stable in the lower orbit, the speed of the satellite would need to:

A. increase by 105 m s^{-1}

B. decrease by 105 m s^{-1}

C. increase by 3115 m s^{-1}

D. decrease by 3115 m s^{-1}

15. For a charged particle in an electric field, which of the following statements is **NOT** true for work done on the charge?

A. The work done on a charged particle is directly proportional to the strength of the electric field.

B. Doubling the charge of the particle has no impact on the work done on the charged particle.

C. The work done on the charged particle is dependent on the potential difference between the plates producing the electric field.

D. The work done on the charged particle is calculated using the magnitude of the displacement from the starting point.

16. The gravitational force between two objects is *F* when the objects are separated by distance *r*. The distance between the objects is decreased by one third, and the mass of ONE of the objects is increased by a factor of 4.
What is the representative force (*F*1) between the objects?

A. $F1=\frac{1}{36}F$

B. $F1=\frac{1}{3}F$

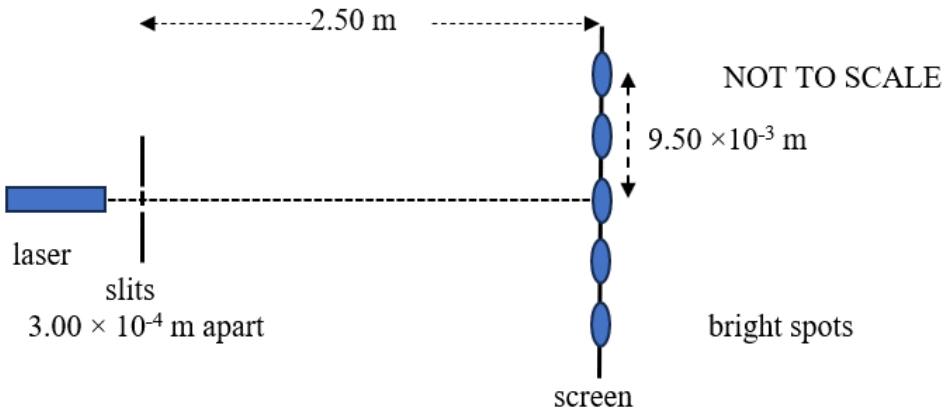
C. $F1=12F$

D. $F1=9F$

17. Laser light of unknown wavelength was passed through a pair of slits separated by 3.00×10^{-4} m.

This produced an interference pattern on a screen 2.50 m from the slits.

The distance between the central bright spot in the interference pattern and another bright spot is 9.50×10^{-3} m as shown in the diagram below.



The laser wavelength is closest to:

A. 1.14×10^{-6} m

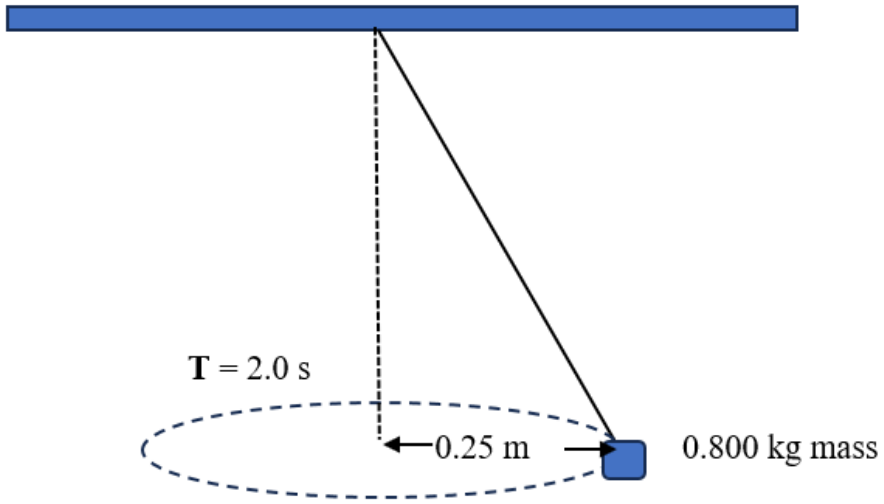
B. 5.70×10^{-7} m

C. 5.70×10^{-4} m

D. 1.14×10^{-9} m

18. A 0.800 kg mass is swinging in a horizontal circle on the end of a conical pendulum as shown.

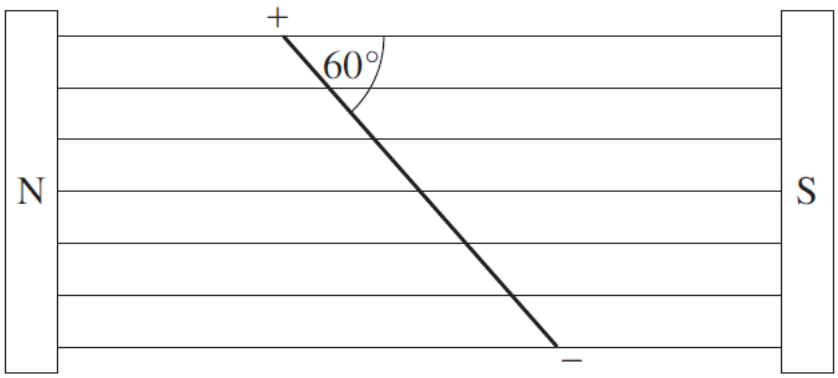
The radius of the circle **r** is 0.25 m and the period **T** is 2.0 s.



Which row of the table shows the correct kinetic energy and the correct amount of work done on the mass during one full revolution?

	Kinetic Energy (J)	**Work Done (J)**
A.	0.79	zero
B.	0.25	0.63
C.	0.50	1.58
D.	0.25	zero

19. A straight current-carrying conductor that has a length of 5.0 cm is suspended in a uniform magnetic field of 1.0 T at an angle of 60° to the field, as shown in the diagram.



If the current passing through the conductor is 2 A, what is the magnitude of the force acting on the conductor?

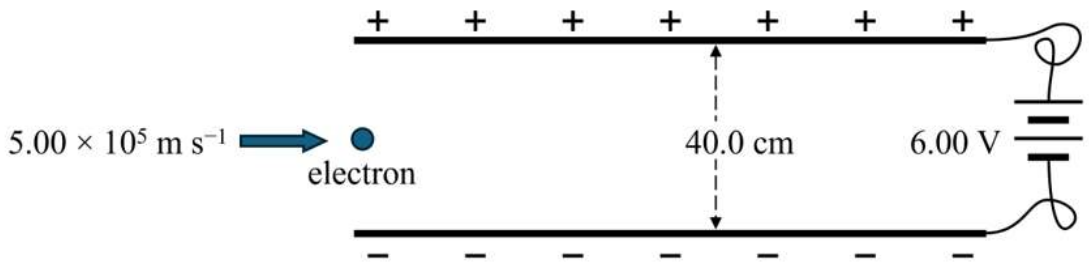
A 0.087 N into the page

B 0.087 N out of the page

C 8.7 N into the page

D 8.7 N out of the page

20. An electron enters a uniform electric field created by a pair of parallel plates.
The plates are 40.0 cm apart and have a potential difference of 6.00 V between them, as shown in the diagram below.



The electron enters the electric field at 5.00×10^5 m s^{-1}, in a direction parallel to the plates. Assuming the electron enters the field exactly halfway between the plates, what is its speed when it collides with one of the plates?

A 1.14×10^6 m s^{-1}

B 5.00×10^5 m s^{-1}

C 1.52×10^6 m s^{-1}

D 1.03×10^6 m s^{-1}

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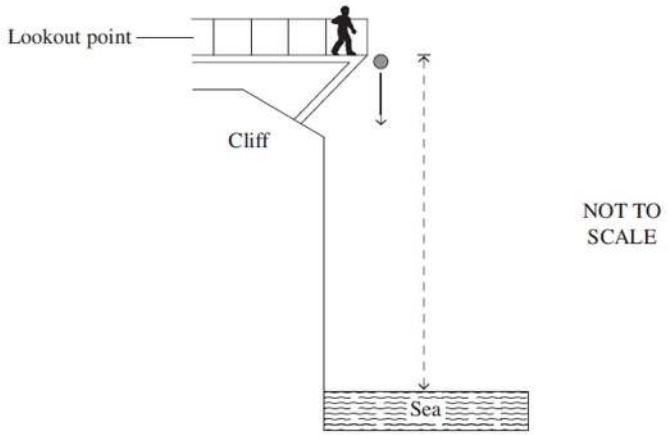
Question 21 (5 marks)

A popular tourist site has a lookout point at the top of a cliff overlooking the sea.

(a) A visitor accidentally rolls a ball off the lookout point, as shown in the diagram. It takes 3.5 seconds for the ball to land in the sea below.



Calculate the vertical distance that the ball travels before it lands in the sea.

2

(a) $u = 0$

$a = 9.8 \text{ m s}^{-2}$

$t = 3.5 \text{ s}$

$s = ?$

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

$$= 0 + \frac{1}{2} \times 9.8 \times 3.5^2$$

$$= 60 \text{ m}$$

Mod 5 Advanced Mechanics (PH12–6, 12–12)	Bands 2–3
• Provides the correct solution using the required variables AND the correct formula. 2	
• Provides some relevant working 1	

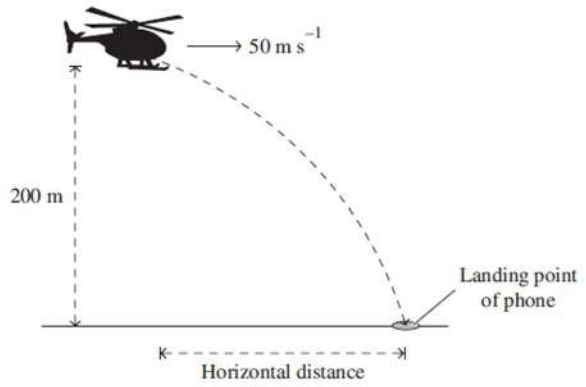
3

(b) The tourist site also offers helicopter sightseeing tours.

A passenger in one of the helicopters drops their phone while trying to take a photo of the scenery. When the phone is dropped, the helicopter is 200 m above the ground and travelling at a horizontal speed of 50.0 m s^{-1}.

Calculate the horizontal distance that the phone travels before it lands on the ground.

(b) The scenario can be illustrated as follows.



$a_y = 9.8 \text{ m s}^{-2}$
$a_x = 0 \text{ m s}^{-1}$
$u = 50 \text{ m}^{-1}$

The angle of projection is 0° because the phone was dropped from the helicopter. Therefore:

$u_x = u\cos\theta$
$= 50\cos(0)$
$= 50 \text{ m s}^{-1}$
$u_y = u\sin\theta$
$= 50\sin(0)$
$= 0 \text{ m s}^{-1}$

Calculating the phone's time of flight gives:

$$s_y = u_y t + \frac{1}{2}a_y t^2$$
$$-200 = 0 + \frac{1}{2}(-9.8)\times t^2$$
$$t^2 = \frac{-200}{-4.9}$$
$$t = \sqrt{40.81\ldots}$$
$$= 6.38\ldots \text{ seconds}$$

Therefore, calculating the horizontal distance that the phone travels gives:

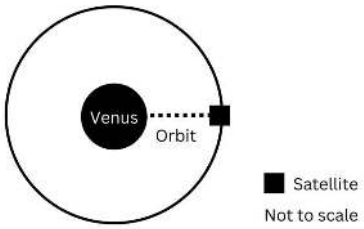
$s_x = u_x t$
$= 50.0 \times 6.38\ldots$
$= 319 \text{ m}$

Note: Responses are not required to include diagrams to obtain full marks.

Mod 5 Advanced Mechanics (PH12–6, 12–12)	Bands 3–4
• Provides the correct solution.	3
• Calculates the phone's time of flight.	2
• Provides some relevant working	1

Question 22 (5 marks)

On May 4, 1989, the objective of the Magellan mission to Venus was to place a satellite in orbit to image the entire surface of the planet.



Mass of Venus is 4.867 x 10^{24} kg

Mass of satellite is 3445 kg

Orbital radius = 6.346 x 10^{6} m

(a) Determine the orbital period of the satellite around Venus. Assume a circular orbit.

Question 22(a)

Criteria	Marks
• Correctly calculates the force of gravity between the satellite and Venus	2
• Provides some relevant information	1

2

Sample response/solution:

$$T^2 = \frac{4\pi^2 r^3}{GM} = \frac{4\pi^2 (6.346 \times 10^6)^3}{6.67 \times 10^{-11} \times 4.867 \times 10^{24}}$$

$$T = 5574.89\ s$$

Therefore, the orbital period around Venus s 92.9 minutes.

(b) How much additional work would need to be done for the satellite to escape the planet, Venus? Use relevant equations and calculations to support your answer. **3**

Question 22(b)

Criteria	Marks
• Explains the energy changes as the satellite manoeuvres with relevant calculations	3
• Describes the energy changes as the satellite manoeuvres AND/OR includes relevant calculations	2
• Provides some relevant information	1

Sample response/solution:

For a satellite to escape to infinity, the total mechanical energy of the satellite must be zero.

$$U + K = -\frac{GMm}{2r} = -\frac{6.67 \times 10^{-11} \times 4.867 \times 10^{24} \times 3445}{2 \times 6.346 \times 10^{6}} = -8.81 \times 10^{10}\text{J}$$

Therefore, the amount of required work done by the rocket boosters attached the satellite would equal to 8.81 x 10^{13} J to increase the total energy to zero.

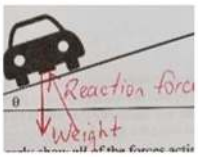
Question 23 (5 marks)

A race car is moving around a banked circular track that has a radius of 90.0 m and an angle of banking of θ degrees, as shown in the diagram.

The car has a constant speed.

(a) On the diagram, clearly show all of the forces acting on the car using labelled arrows. **2**

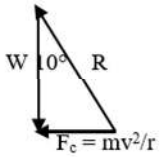
Marking Criteria	Marks
• Forces acting identified with correct labels and arrows	2
• One force identified correctly with arrow and label	1



(b) If the angle of banking is 10°, find the speed necessary so that no sideways force need be exerted between the tyres and the track. **3**

Marking Criteria	Marks
• Correct calculations made to show correct answer given	3
• Some appropriate steps towards correct answer made but with an error	2
• A correct step (diagram or calculation) shown	1

Find the car's speed when angle of banking is 10°:
Assume net force equals centripetal force
Use: reaction force + weight force = centripetal force:

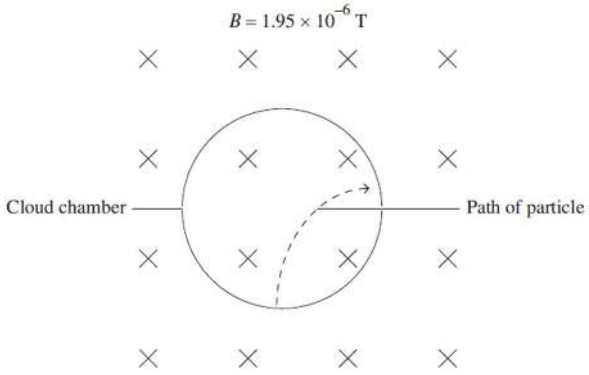


So: $\tan 10° = [mv^2/r]/mg$

$$v = \sqrt{gr\tan 10°}$$
$$= \sqrt{9.8 \times 90.0 \times \tan 10°}$$
$$= 12.5 \text{ m s}^{-1}$$

Question 24 (4 marks)

A particle in an accelerator reaches a velocity of 2.50×10^4 m s^{-1} before entering a Wilson cloud chamber. The cloud chamber is in a uniform magnetic field of 1.95×10^{-6} T. The path of the particle in the cloud chamber is illustrated in the diagram.



(a) State whether the particle is positively or negatively charged. **1**

(a) negatively charged *(as B is into the page and the particle arcs to the right)*

Mod 6 Electromagnetism (PH12–4, 12–5, 12–13)	Bands 2–3
• States that the particle is negatively charged. 1	

(b) The radius of the particle's path is 5.0 cm. **3**

Show that the mass-to-charge ratio of the particle is 2.6×10^{11} C kg^{-1}.

(b) $\dfrac{mv^2}{r} = qvB$

$r = \dfrac{mv}{qB}$

$\dfrac{q}{m} = \dfrac{v}{rB}$

$= \dfrac{2.50 \times 10^4}{0.050 \times 1.95 \times 10^{-6}}$

$= 2.6 \times 10^{11}$ C kg^{-1}

Mod 6 Electromagnetism (PH12–4, 12–5, 12–13)	Bands 4–5
• Substitutes into the relevant formula correctly 3	
• Attempts to substitute into the relevant formula 2	
• Identifies the relevant formula. 1	

Question 25 (7 marks)

A space organisation is planning to send an astronaut to a distant planet, P. The spacecraft will travel at a speed of 0.8c and the journey is expected to take 15 years, as measured by observers on Earth.

(a) Determine the distance to P in metres, as measured by observers on Earth.

Criteria	Marks
• Correctly calculates distance to P	2
• Provides some relevant information	1

Sample response/solution:

$d = v \times t = 0.8 \times 15 = 12$ light years

$12 \times 3 \times 10^8 \times 365 \times 24 \times 60 \times 60 = 1.14 \times 10^{17}$ m

2

(b) Use time dilation to show that the astronaut will be observed to age only 9 years while travelling.

Criteria	Marks
• Correctly calculates t_0	2
• Provides some relevant information	1

2

Sample response/solution:

$$t = \frac{t_0}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$t_0 = 15 \times 0.6 = 9\ years$$

(c) The astronaut is NOT expected to experience time dilation within their frame of reference.

Explain why the astronaut will still expect to age only 9 years on the journey. Use calculations to support your answer.

Criteria	Marks
• Correctly explains aging of astronaut within their frame AND uses correct calculations to support answer	3
• Correctly explains aging of astronaut within their frame AND attempts calculations to support answer OR • Performs correct calculations	2
• Provides some relevant information	1

3

Sample response/solution:

In the astronaut's frame of reference, the distance to P is contracted:

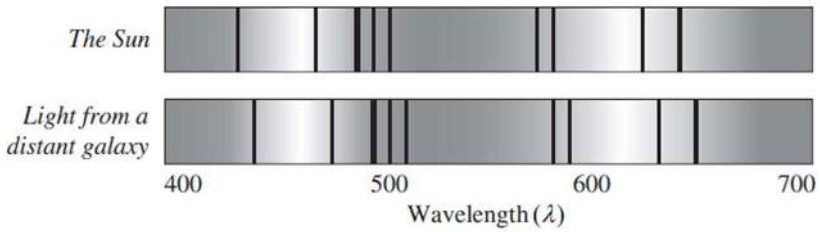
$$l = l_0\sqrt{1 - \frac{v^2}{c^2}} = 12 \times 0.6 = 7.2\ ly$$

Based on this distance, the journey time measured by the astronaut is:

$$t = \frac{d}{v} = \frac{7.2}{0.8} = 9\ years$$

Question 26 (4 marks)

The spectra of the Sun and the light from a distant galaxy are shown.



Explain how the spectra support Hubble's law and the Big Bang theory.

Hubble's law states that the further a galaxy is from Earth's galaxy, the faster it is moving away from Earth. Hubble plotted velocity against distance and obtained a linear graph, indicating that the universe is expanding. This can be seen in the red shift of the spectra. Comparing the spectrum of the Sun to the spectrum of light from a distant galaxy shows that the Sun and light from the distant galaxy have the same spectral lines; however, in the spectrum of light from the distant galaxy, these lines have shifted towards the red end. This indicates a longer wavelength and thus a greater distance from Earth, thereby providing evidence that the universe is expanding. This subsequently supports the Big Bang theory, which proposes that all matter and energy in the universe was originally contained to a single extremely hot and dense point before rapidly expanding. **4**

Mod 8 From the Universe to the Atom (PH12–5, 12–6, 12–7, 12–15)	Bands 4–5

- States Hubble's law.
  AND
- Identifies the red shift in the spectra.
  AND
- Explains how the spectra support Hubble's law.
  AND
- Explains how the spectra support the Big Bang theory. 4

- Any THREE of the above points. 3

- Any TWO of the above points. 2

- Provides some relevant information 1

Question 27 (6 marks)

A physicist conducted an experiment using a transformer. The results of the experiment are recorded in the table.

	Primary coil	*Secondary coil*
Voltage (V)	120	?
Current (mA)	3.0	30
Number of turns	?	5

(a) Assuming that the transformer was 100% efficient, determine the secondary voltage and the number of turns in the primary coil.

(a) $V_p I_p = V_s I_s$

$$V_s = \frac{V_p I_p}{I_s}$$

$$= \frac{120 \times 3.0}{30}$$

$$= 12 \text{ V}$$

$$\frac{V_p}{V_s} = \frac{N_p}{N_s}$$

$$N_p = \frac{V_p N_s}{V_s}$$

$$= \frac{120 \times 5}{12}$$

$$= 50 \text{ turns}$$

3

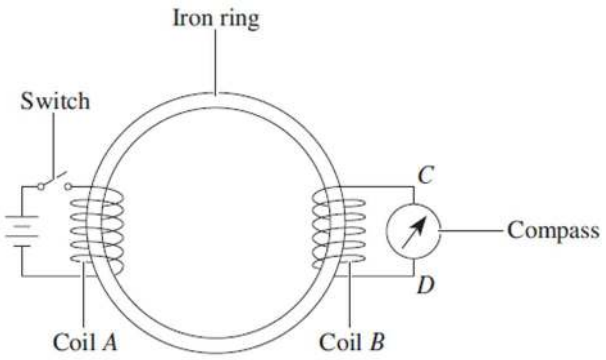
Mod 6 Electromagnetism (PH12–4, 12–5, 12–13)
Working Scientifically Skills (PH12–6) Bands 3–4

- Calculates V_s.
  AND
- Determines N_p 3

- Calculates V_s.
  OR
- Determines N_p using ratios 2

- Provides some relevant working 1

(b) Faraday's iron ring experiment used two coils and a soft iron ring, as shown in the diagram.



3

A compass was placed above the wire *CD* to detect any changes in the magnetic field produced. Faraday observed that the compass needle did not deflect when the switch was left open or closed, but it did deflect momentarily when the switch was initially opened or closed.

Explain Faraday's observations.

(b) *For example:*

Faraday's law states that a change in magnetic flux will induce an electromotive force (emf), which will in turn induce a current.

When the switch is left open, there is no magnetic field; when it is left closed, there is a constant magnetic field. Therefore, coil *B* does not experience a change in flux, so the compass needle does not deflect.

When the switch is initially opened or closed, the magnetic field produced by coil *A* rapidly changes, causing coil *B* to experience a change in magnetic flux. This induces a current in coil *B*, which in turn causes the compass needle to deflect.

Mod 6 Electromagnetism (PH12–4, 12–5, 12–7, 12–13) Working Scientifically Skills (PH12–6)	Bands 5–6
• Explains what happens in coil *B* when the switch is initially opened or closed. AND • Explains why the needle deflects when the switch is initially opened or closed. AND • Explains what happens in coil *B* when the switch is left open or closed 3	
• Outlines what happens in coil *B* when the switch is initially opened or closed. AND • Outlines what happens in coil *B* when the switch is left open or closed..... 2	
• Provides some relevant information 1	

3

Question 28 (3 marks)

Justify how ONE observation from photoelectric effect investigations was inconsistent with the wave model of light.

Criteria	Marks
• Justifies how an observation from photoelectric effect investigations was inconsistent with the wave model of light	3
• Identifies a relevant investigation and a relevant observation	2
• Provides some relevant information	1

Sample response/solution:
In some investigations, light of different intensities was directed at metals to eject photoelectrons. The wave model predicts that, since more intense light had more total energy, it would create higher maximum kinetic energy electrons. However, intensity of light had no effect on the maximum kinetic energy.

Question 29 (3 marks)

The Balmer series is observed when electrons in hydrogen transition to the second atomic shell ($n = 2$). Determine the lowest frequency of light observed in the Balmer series.

3

Criteria	Marks
• Correctly calculates lowest observed frequency	3
• Shows some working to determine lowest observed frequency	2
• Provides some relevant information	1

Sample response/solution:
Lowest frequency will occur with lowest change in energy, therefore:

$\frac{1}{\lambda} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$ with n_i=3

$\lambda = 6.56 \times 10^{-7}$ m

$f = \frac{c}{\lambda} = \frac{3\times10^8}{6.56\times10^{-7}} = 4.57 \times 10^{14}$ Hz

Question 30 (8 marks)

The analysis of spectra produced by discharge tubes can be used to identify the gas or gases in the tube. In a similar way, the spectra from stars can be used to identify the chemical composition of those stars as well as several other features of the star.

8

Compare and contrast the spectra produced from discharge tubes and those produced by stars and outline what features of a star can be revealed by the analysis of stellar spectra.

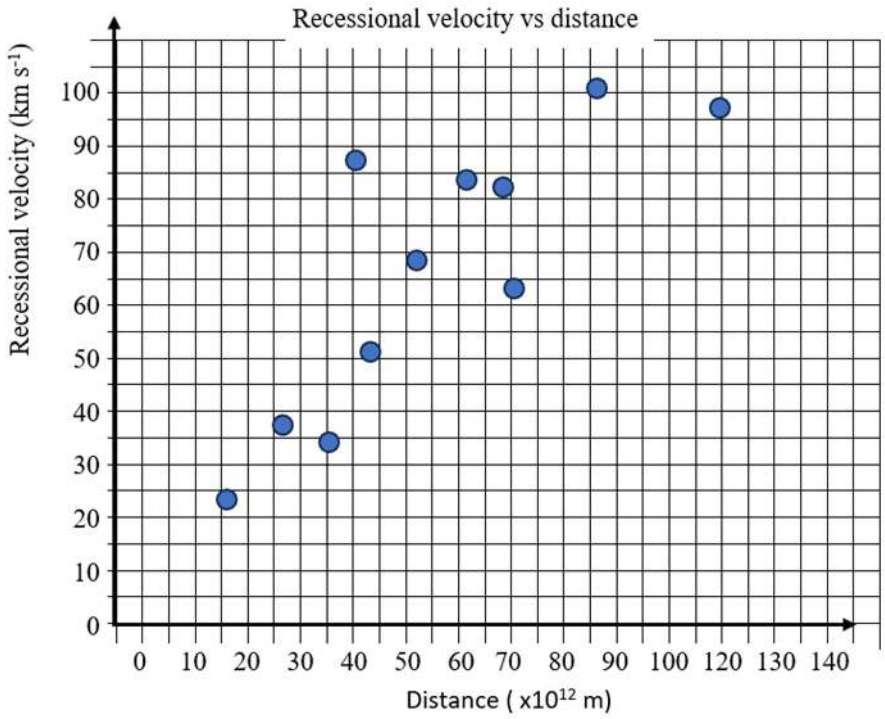
Marking Criteria	Marks
• The comparison and contrast of the two spectra is thorough and detailed • How key features of stars can be revealed is outlined • Response is clear, thorough and logical using appropriate physics language and refers to physics concepts throughout	**8**
• The comparison and contrast of the two spectra is thorough and detailed • How key features of stars can be revealed is outlined	**6-7**
• The comparison and contrast of the two spectra is made • How most key features of stars can be revealed is outlined	**4-5**
• Response addresses several relevant aspects of the question	**2-3**
• Response includes at least one relevant reference	**1**

Discharge tubes produce emission spectra from the low pressure gas in the tube that has been excited by a strong electric field. Electrons in the gas molecules/atoms are elevated to higher energy levels and then fall back, emitting light at characteristic wavelengths due to the difference in the electron energy level: $\Delta E = hf$.
In the outer layers of stars, a similar process occurs however the electrons are boosted to higher energy levels by absorbing photons of specific wavelengths and therefore energies. When this light is re-emitted when the excited electrons fall back, it is emitted in all directions so to an observer on Earth, these wavelengths are not as intense as the background light coming from the core, and we observe an absorption spectrum.
The translational velocity of a star is shown by a red (receding) or blue (approaching) shift in the lines of the spectrum. Chemical composition is determined by observing the lines characteristic to certain elements. Rotational velocity is measured by observing the broadening of the spectral lines as one side of the star is approaching, the other receding from the observer causing simultaneous red and blue shifting. The density of the star is determined by similar observations of the distinction of the spectral lines – very fine lines indicate low pressure/density of the atmosphere pointing to a giant star. Broader lines indicate a denser atmosphere indicating dwarf or denser, main sequence stars.

Question 31 (8 marks)

In a universe similar to ours, cosmologists on a planet plotted the recessional velocity of several galaxies against their distance.

The results are shown on the graph below.



(a) Discuss how these results are evidence for the belief that this universe is expanding.

Marking Criteria	Marks
• Evidence clearly and logically linked to expanding universe	2
• Some link made to the expanding nature of the universe	1

In whichever direction observations were made, distant galaxies were observed to have a redshift and therefore are moving away from us. The more distant the galaxy, the faster their recessional velocity. The geometrical conclusion to this is that the universe must be expanding in such a way that to any observer, the observer seems to be the centre of the universe.

2

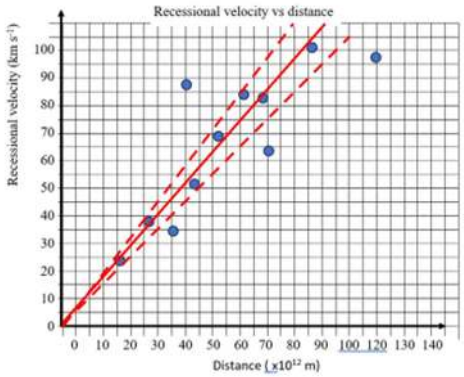
Question 31 continues on page 25.

3

(b) Calculate the equivalent of the Hubble constant for this universe.

Express your answer in units of s^{-1}. You may use the formula $v = H_oD$.

Marking Criteria	Marks
• Line of best fit drawn appropriately • Gradient of line calculated with unit conversions made correctly • Correct calculation made	3
• As above but with error or omission made	2
• One correct step shown toward calculation	1



To find the Hubble constant (equivalent) use $v = H_oD$
So that $H_o = v/D$, the gradient of the line of best fit.

Using the point $(82.5 \times 10^{12}, 100)$:
Gradient = $100 \text{ km s}^{-1}/(82.5 \times 10^{12} \text{ m})$
= $(100 \times 10^3 \text{ m s}^{-1})/(82.5 \times 10^{12} \text{ m})$
= $1.2 \times 10^{-9} \text{ s}^{-1}$.

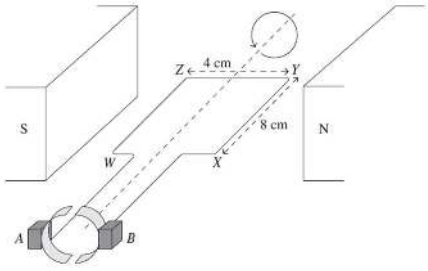
(c) Outline how Hubble was able to measure the recessional velocity of distant galaxies. **3**

Marking Criteria	Marks
• Outline of method is comprehensive and explanatory	3
• Several relevant aspects of the method used are stated	2
• One relevant aspect of the method used is stated	1

Hubble analysed the spectral lines of the galaxies and measured their redshift, i.e. the lengthening of the wavelengths of the lines due to relative motion away from the observer. By then applying the Doppler equation but for light, the recessional velocity of the source of the light – i.e. the stars and nebulae in the galaxy, was calculated.

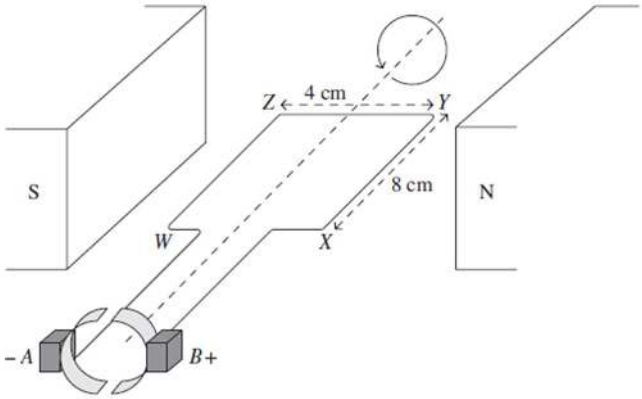
Question 32 (7 marks)

A simple DC motor is shown in the diagram.



(a) On the diagram, label terminals *A* and *B* with their charges (+ or –).

(a)



Mod 6 Electromagnetism (PH12–4, 12–5, 12–13) Bands 2–3

- Labels terminal *A* as negative and terminal *B* as positive 1

(b) One component of the motor ensures that the direction of the torque remains constant. With reference to the diagram, identify this component and explain why it is essential that the component maintains the direction of the torque.

(b) The commutator (split-ring) reverses the direction of the current every half rotation. If the current is not reversed every half rotation, the forces on *WZ* and *XY* will remain in a constant direction, resulting in a torque that reverses. **1**

Mod 6 Electromagnetism (PH12–4, 12–5, 12–13) Bands 3–4

- Identifies the commutator.
  AND
- Explains how the commutator maintains the constant torque.
  AND
- Refers to the diagram 3

3

- Identifies the commutator.
  AND
- Explains how the commutator maintains the constant torque 2

- Identifies the commutator.
  OR
- Provides some relevant information 1

(c) The magnets produce a magnetic field of 0.65 T. The magnetic field is at right angles to side *XY*, and a current of 12 A flows through loop *WXYZ*.

The loop rotates from the position shown in the diagram on page 26 (position I), to a position where the plane of the loop makes an angle of 60° from the horizontal (position II), and then to a position where the plane of the loop makes an angle of 90° from the horizontal (position III).

Determine the magnitude of the torque and the direction of rotation at positions I, II and III.

(c) Position shown in the diagram (position I):

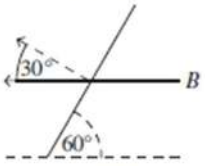
$\tau = nIAB\sin\theta$

$= 1\times12\times0.080\times0.040\times0.65\times\sin(90°)$

$= 0.025$ N m anticlockwise

Position where the plane of the loop makes an angle of 60° from the horizontal (position II):

View from front



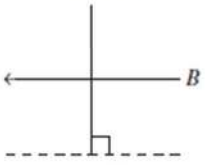
$\therefore \sin(30°)$

$\tau = 1\times12\times0.080\times0.040\times0.65\times\sin(30°)$

$= 0.012$ N m anticlockwise

Position where the plane of the loop makes an angle of 90° from the horizontal (position III):

View from front



$\therefore \sin(0°)$

$\tau = 1\times12\times0.080\times0.040\times\sin(0°)$

$= 0$ N m anticlockwise

Note: Responses are not required to include diagrams to obtain full marks.

Mod 6 Electromagnetism (PH 12–4, 12–5, 12–13)	Bands 4–5
• Determines the magnitude of the torque in all THREE positions. AND • Determines the direction of rotation in all THREE positions	3
• Determines the magnitude of the torque in TWO positions. AND • Determines the direction of rotation in TWO positions	2
• Provides some relevant working	1

3

Question 33 (4 marks)

(a) The work function for zinc is 4.31 eV.

In an investigation of the photoelectric effect, the stopping voltage for the electrons ejected from a zinc cathode was found to be 2.20 V.

Calculate the frequency of the incident light.

Marking Criteria	Marks
• Correct answer with correct method provided	2
• Calculation attempted but error or omission made	1

$K_{max} = hf - \Phi$
$K_{max} = 2.20 \times (1.6 \times 10^{-19})\ J = 3.5 \times 10^{-19}\ J$
$\Phi = 4.31 \times (1.6 \times 10^{-19})\ J = 6.90 \times 10^{-19}\ J$
$hf = K_{max} + \Phi$
$f = (K_{max} + \Phi)/h$
$= 1.57 \times 10^{15}$ Hz

2

(b) Explain why different metals have different work function values. **2**

Marking Criteria	Marks
• Explanation of work function is clear and thorough • Reasons for different values for different metals clearly stated	2
• Work function is correctly identified	1

The work function for any particular element/metal is the energy expended by an electron to just escape from the metal with no residual kinetic energy. This is similar to ionisation energy and is associated with the activity of the metal. A low work function value indicates a very reactive metal where electrons are easily lost. Gold, an unreactive metal, has a high work function.

Question 34 (4 marks)

Compare the magnitude of the forces on a proton moving through a magnetic field of 1.50×10^{-5} T perpendicular to the field at 4.00×10^{5} m s^{-1} to the force it experiences due to an electric field produced between two parallel plates, 0.30 m apart with a potential difference of 200 V between them. **4**

Marking Criteria	Marks
• Correct steps taken with correct working to obtain correct answer • A comparison is made	4
• As above but with an error • A comparison is attempted	3
• Several appropriate steps towards a correct answer provided	2
• A correct step provided	1

For magnetic force use: $F_B = qvB\sin\theta$
$= (1.6 \times 10^{-19}) \times (400 \times 10^{3}) \times (1.5 \times 10^{-5}) \times \sin 90°$
$= 9.6 \times 10^{-19}$ N

Compared to electric field force: $F_E = qE$ where $E = V/d$
$= (1.6 \times 10^{-19}) \times (200/0.300)$
$= 1.1 \times 10^{-16}$ N

The force due to the electric field is around 100 times (2 orders of magnitude) greater than that due to the magnetic field.

Question 35 (7 marks)

A ball bearing launcher was used in the laboratory to analyse the motion of projectiles.

(a) Outline a first-hand investigation that would enable sufficient measurements to be taken so that the launch speed of the ball bearings could be calculated.

Include any equations that would be used and show how these equations would yield the launch speed.

Marking Criteria	Marks
• A complete outline of an appropriate FHI is provided • A complete set of relevant equations is identified • A method shown for the use of the equations	4
• As above but with an omission	3
• Several correct steps for an appropriate FHI provided OR • Appropriate equations selected	2
• A correct aspect of the investigation or relevant equation is provided in context	1

1.The ball bearing launcher was arranged so that it launched ball bearings horizontally off the end of a desk top h metres above the floor.
2. The horizontal range, x, of the ball bearings launched was measured and repeated several times and the average value taken.
3. The time of flight was calculated using the formula $s_y = u_y t + \frac{1}{2} a t^2$ where $u_y = 0$, $s_y = h$ and $a = g$ **4**
4. The launch speed u_x can now be found using $x = u_x \times t$

(b) Show that, regardless of the value of gravitational acceleration "g", a launch angle of 45° will always give the maximum range for a projectile over level ground. **3**

Marking Criteria	Marks
• Full explanation with correct working shown	**3**
• Partial explanation provided	**2**
• A correct aspect/fact provided	**1**

The range of any projectile over horizontal ground is given by $x = u_x \times t$
u_x is given by: $u_x = u\cos\theta$ where θ is the launch angle.
The time of flight, t, is given by: $v_y = -u_y + a_y t$ where $u_y = u\sin\theta$ and $v_y = -u_y$ due to the symmetry of the trajectory.

So: $2u\sin\theta = gt$ where $g = a_y$

$t = (2u\sin\theta)/g$

Then: $x = u_x t$

$= (u\cos\theta \times 2u\sin\theta)/g$

$= u^2\sin 2\theta/g$

As sin has a maximum value of 1 when $2\theta = 90°$, θ must be 45° irrespective of the launch speed or the value of g.

End of examination

Section II extra writing space

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

Section II extra writing space

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

STUDENT ID _____

2024 Physics Trial HSC Examination

Section I Answer Sheet

20 marks

Attempt Questions 1–20

Allow about 35 minutes for this section

Select the alternative A, B, C, or D that best answers the question. Fill in the response circle completely.

1	A ○	B ○	C ○	D ○
2	A ○	B ○	C ○	D ○
3	A ○	B ○	C ○	D ○
4	A ○	B ○	C ○	D ○
5	A ○	B ○	C ○	D ○
6	A ○	B ○	C ○	D ○
7	A ○	B ○	C ○	D ○
8	A ○	B ○	C ○	D ○
9	A ○	B ○	C ○	D ○
10	A ○	B ○	C ○	D ○
11	A ○	B ○	C ○	D ○
12	A ○	B ○	C ○	D ○
13	A ○	B ○	C ○	D ○
14	A ○	B ○	C ○	D ○
15	A ○	B ○	C ○	D ○
16	A ○	B ○	C ○	D ○
17	A ○	B ○	C ○	D ○
18	A ○	B ○	C ○	D ○
19	A ○	B ○	C ○	D ○
20	A ○	B ○	C ○	D ○