2023

Higher School Certificate

Trial Examination

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 sheets and Periodic Table are provided
- Write your student number and/or name at the top of every page

Total marks – 100

Section I (Pages 2–13)
20 marks
- Attempt Questions 1–20
- Allow about 35 minutes for this part

Section II (Pages 14–32)
80 marks
- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this section

This paper MUST NOT be removed from the examination room

STUDENT NUMBER/NAME:.....

STUDENT NUMBER/NAME.....

Section I
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 and indicate your choice with a cross (X) in the appropriate space on the grid below.

	A	B	C	D
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	A	B	C	D
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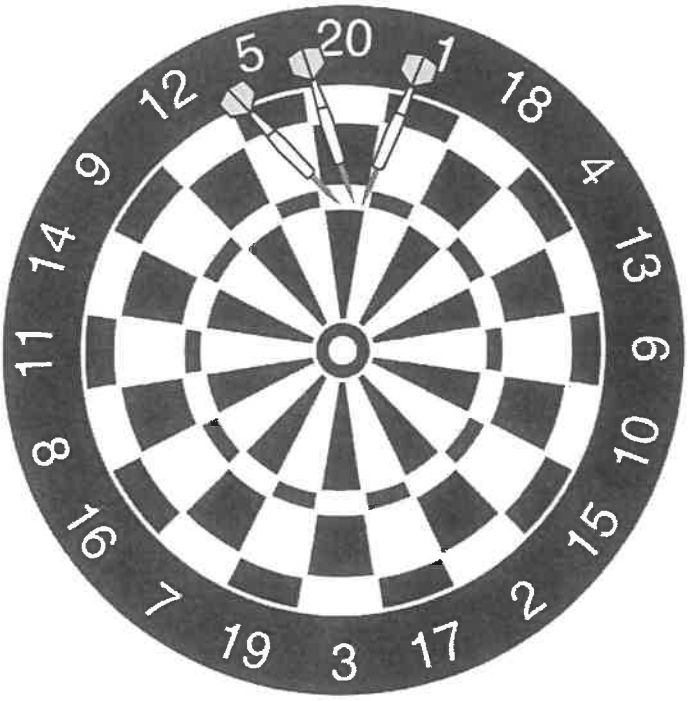
1 Three darts were thrown by a player aiming at the bull's eye centre.



If the object of this game was to hit the bull's eye, which statement about the three throws is correct?

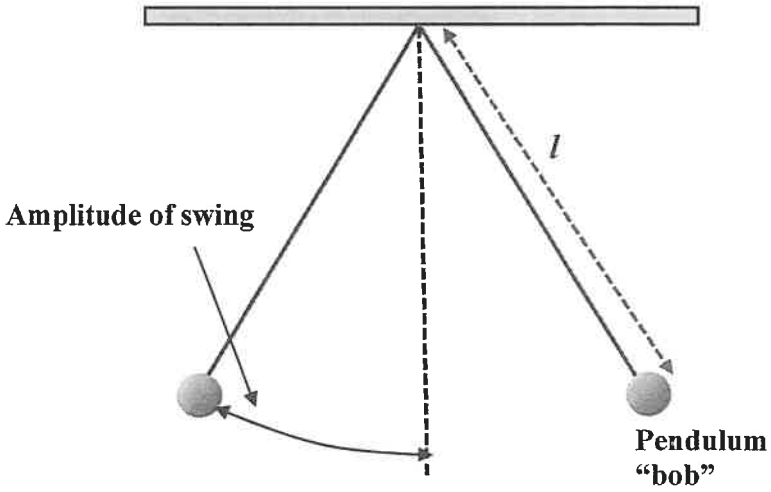
A. The throws were precise but not accurate.

B. The throws were valid but not reliable.

C. The throws were neither valid nor accurate.

D. The throws were reliable but not precise.

2 As part of an investigation, students use a pendulum to indirectly measure the magnitude of Earth's gravitational field at their location.



The students use a constant mass and amplitude of swing, changing only the length of the pendulum and then measuring the time for five oscillations. They obtain four average time readings for four different lengths of the pendulum.

By using the relationship: $T = 2\pi\sqrt{\frac{l}{g}}$

where T = the period of the pendulum swing, and
l = the length of the pendulum measured to the centre of mass of the pendulum bob.

Which identifies the independent, dependent and controlled variables in the students' investigation?

	Independent variable	*Dependent variable*	*Controlled variables*
A.	Mass of the bob	Amplitude of the swing	Pendulum length Period of swing
B.	Period of swing	Mass of the bob	Pendulum length Amplitude of the swing
C.	Pendulum length	Period of swing	Mass of the bob Amplitude of the swing
D.	Pendulum length	Amplitude of the swing	Mass of the bob Period of swing

3 Which of the following is one of Kepler's laws of planetary motion?

A. The laws of physics are the same in all inertial frames of reference.

B. All planets move about the Sun in elliptical orbits, having the Sun at one of the foci.

C. All planets orbit the sun in uniform circular motion, with gravity being the only force acting on them.

D. The force of attraction between planetary objects is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

4 The mass of Mars is approximately 0.1 times the mass of Earth and its diameter is about 0.5 that of Earth.

Which choice gives the best estimate of the surface gravitational field on Mars compared to that of Earth taken as "g"?

A. 0.025 g

B. 0.2 g

C. 0.4 g

D. 2 g

5 Which statement regarding an object in uniform circular motion is correct?

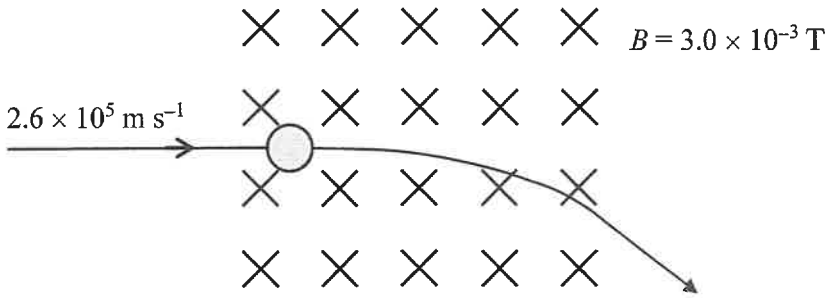
A. The object has a constant speed due to a constant magnitude force acting in a direction parallel to its velocity.

B. The object has a constant velocity due to a constant magnitude force acting in a direction parallel to its speed.

C. The object has a constant speed due to a constant magnitude force acting in a direction perpendicular to its velocity.

D. The object has a constant velocity due to a constant magnitude force acting in a direction perpendicular to its speed.

6 An electron with a velocity of 2.6×10^5 m s^{-1} towards the right is injected into a uniform magnetic field of 3.0×10^{-3} T, directed into the page, as shown in the diagram below. It moves in a vacuum in a curve of radius r.



Which identifies the magnitude of velocity of the electron as it exits the magnetic field?

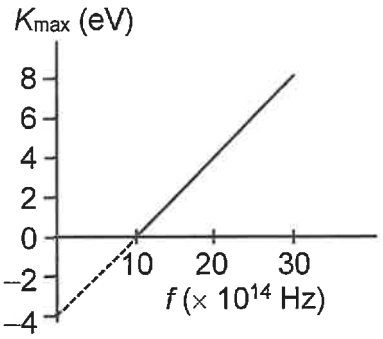
A. Less than 2.6×10^5 m s^{-1}

B. 2.6×10^5 m s^{-1}

C. Greater than 2.6×10^5 m s^{-1}

D. Unable to be found without more data

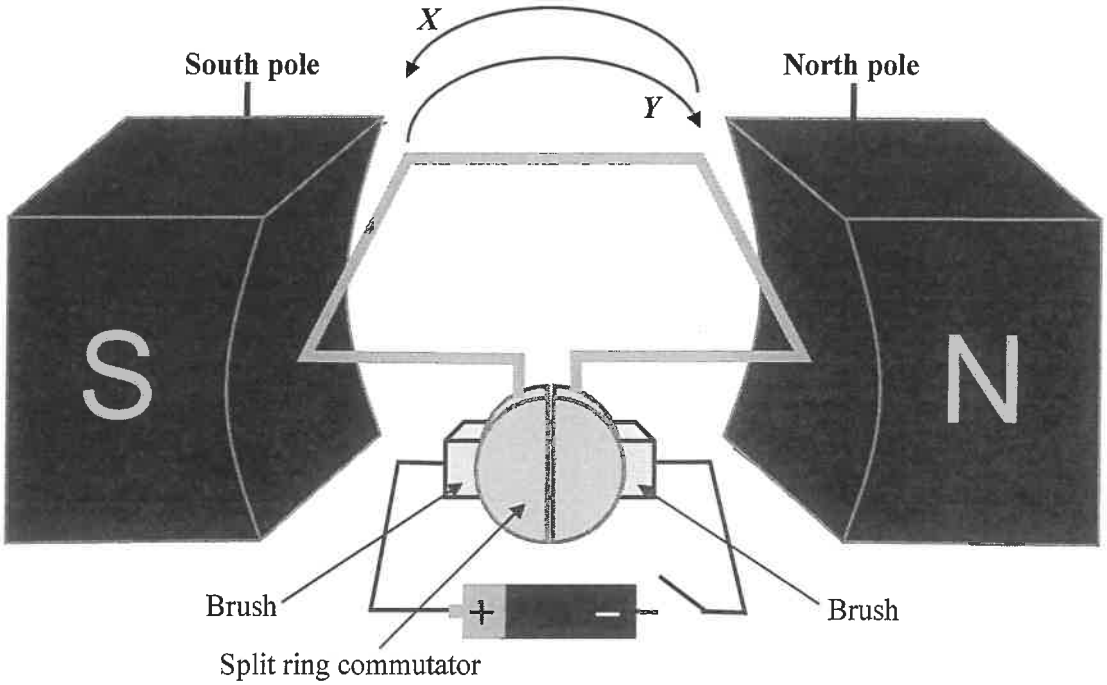
7 The graph shows the maximum kinetic energy of photoelectrons emitted for a range of frequencies of monochromatic light falling on a particular metal.



Which alternative predicts the graph details that would likely change if a different metal is used?

	Slope of line	x axis intercept	y axis intercept
A.	No	No	Yes
B.	Yes	Yes	Yes
C.	No	Yes	No
D.	No	Yes	Yes

8 The diagram below shows a small DC electric motor, powered by a battery that is connected via a split-ring commutator.



Which of the following statements best describes the motion of the coil when the switch is closed?

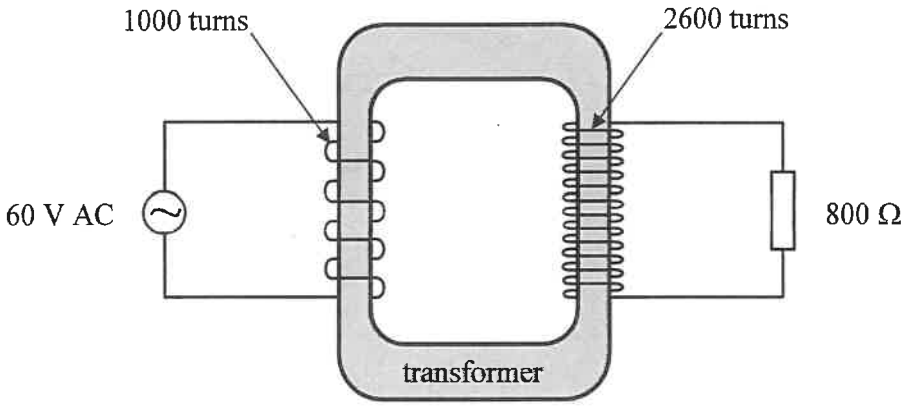
A. The coil will remain stationary.

B. The coil will rotate in direction *X*, as shown in the diagram.

C. The coil will rotate in direction *Y*, as shown in the diagram.

D. The coil will oscillate alternately in directions *X* and *Y*.

9 A 60 V AC generator and an ideal transformer are used to supply power. The diagram below shows a generator and transformer supplying current to a resistor of 800 Ω.



What current will flow through the load resistor?

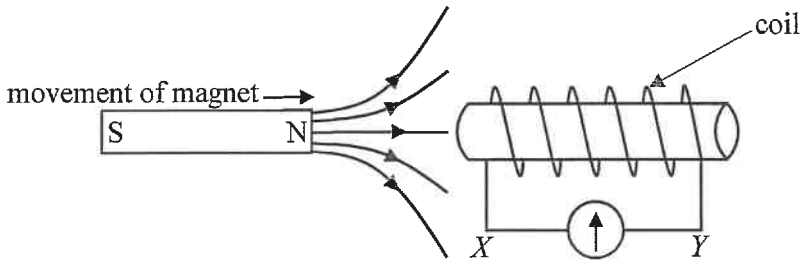
A. 0.075 A

B. 0.120 A

C. 0.195 A

D. 5.128 A

10 A magnet approaches a coil at a constant rate. During the time interval Δt, the magnetic flux in the coil changes by 0.05 Wb and the average induced EMF in the coil is 0.6 V.



Which of the following statements about this situation is correct?

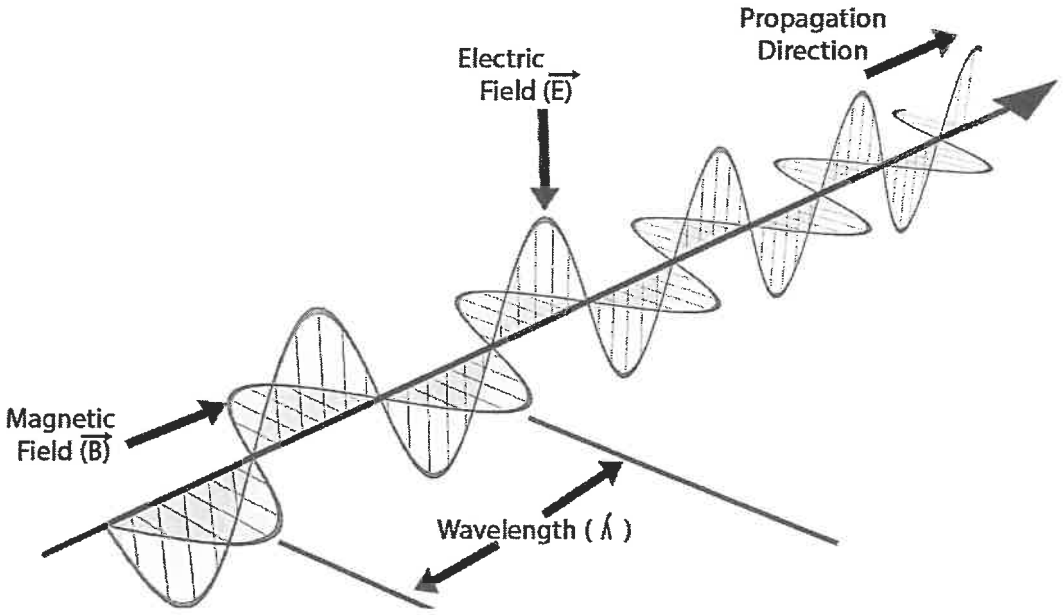
A. The time interval Δt is 0.08 s and induced current flows through the meter from X to Y.

B. The time interval Δt is 0.08 s and induced current flows through the meter from Y to X.

C. The time interval Δt is 12 s and induced current flows through the meter from X to Y.

D. The time interval Δt is 12 s and induced current flows through the meter from Y to X.

11 The diagram shows an electromagnetic wave.



Three physics students make different statements about the energy of the electromagnetic waves.

Student 1: The energy of the waves increases with increasing amplitude.
Student 2: The energy of the waves increases with increasing frequency.
Student 3: The energy the waves increases with decreasing wavelength.

Which students are making a correct statement?

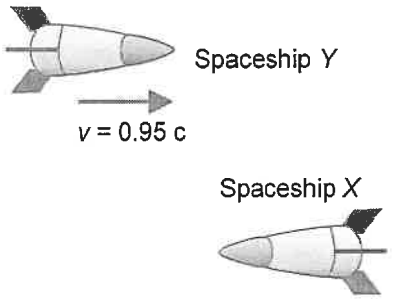
A. Only student 1

B. Only student 2

C. Both students 1 and 2

D. Students 1, 2 and 3

12 An astronaut in Spaceship *X*, watching Spaceship *Y* fly past at a relative speed of 0.95 c, measures its length to be 150 m.



Which one of the following is closest to the proper length of Spaceship *Y*?

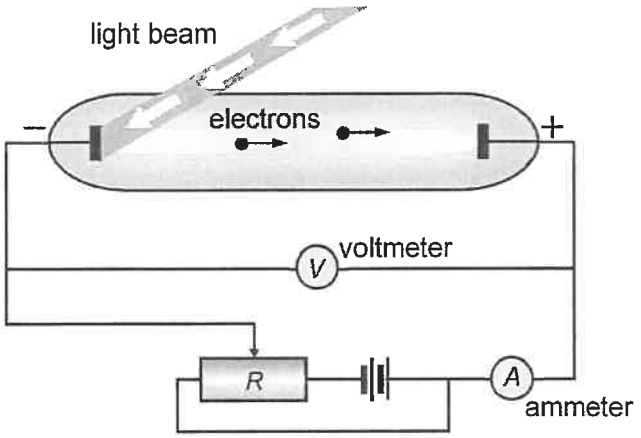
A. 50 m

B. 150 m

C. 450 m

D. 900 m

13 The diagram shows a circuit used to study the photoelectric effect.



Which is essential to the measurement of the maximum kinetic energy of the emitted photoelectrons?

A. The level of brightness of the light source

B. The wavelength that passes through the filter

C. The reading on the voltmeter when the current is at a minimum value

D. The reading on the ammeter when the voltage is at a maximum value

14 Which one of the following statements correctly compares incandescent and laser light?

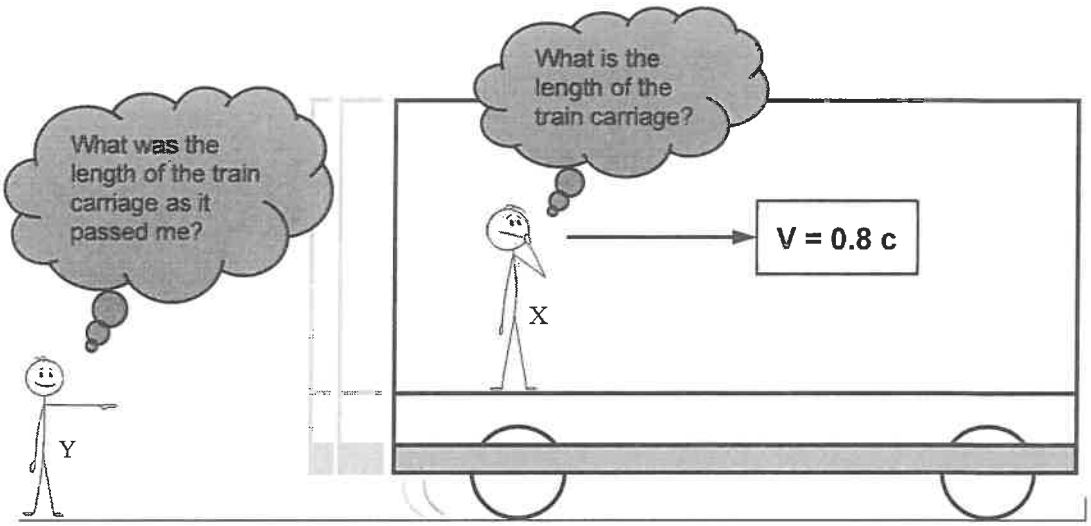
A. Laser light has a very wide spectrum; incandescent light has a very narrow spectrum.

B. Laser light has a very narrow spectrum; incandescent light has a very wide spectrum.

C. Both laser light and incandescent light have a very narrow spectrum.

D. Both laser light and incandescent light have a very wide spectrum.

15 Scientist *X* is on a train travelling at 0.8 c. The train passes scientist *Y* who is standing on the platform at a train station. They each measure a different length for the train and also measure a different length for the platform.



Which one of the following statements is correct?

A. Scientist *X* measures a proper length for the train because she is stationary with respect to the train.

B. Scientist *Y* measures a proper length for the train because he is stationary in his reference frame.

C. Scientist *Y* measures a proper length for both the platform and the train because he is standing still.

D. Scientist *X* measures a proper length for the platform because she passes the start and the end of the platform over the course of her journey.

16 Which identifies evidence for the Big Bang Theory?

A. The expansion of the universe and Hertzsprung-Russell diagrams

B. Kepler's laws of planetary motion and Hubble's law

C. The evolution of stars and the amount of hydrogen in the universe

D. Hubble's law and the cosmic background radiation

17 Which was the most important limitation of the Rutherford model of the atom?

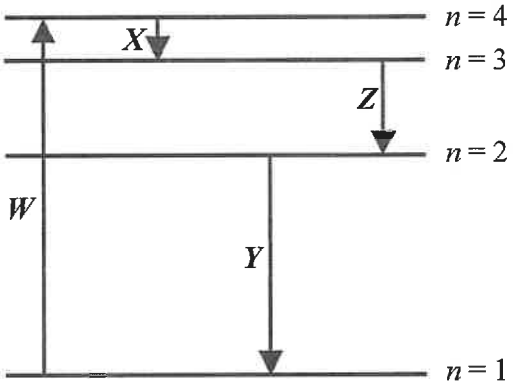
A. It proposed that electrons orbited the nucleus in stable circular orbits.

B. It did not specify the composition of the nucleus.

C. The model was only correct for the hydrogen atom.

D. It was only able to explain the hydrogen spectral lines.

18 The diagram shows energy levels for the electrons in an atom of a particular element. The arrows labelled *W*, *X*, *Y* and *Z* indicate transitions between various energy levels.



Which transition results in the emission of a photon with the most energy?

A. *W*

B. *X*

C. *Y*

D. *Z*

19 A fossil was carbon dated and found to contain 1/32 of the carbon-14 present when it was part of a living organism.

Given the half-life of carbon-14 is 5 730 years, about how old is this fossil?

A. 22 920 years old

B. 28 650 years old

C. 40 100 years old

D. 735 000 years old

20 What are mesons?

A. Subatomic particles composed of one quark and one antiquark

B. Elementary particles that are classified as leptons

C. Elementary particles exchanged between quarks

D. Subatomic particles composed of three quarks

Section II

80 marks
Attempt Questions 21–33
Allow about 2 hours and 25 minutes for this section

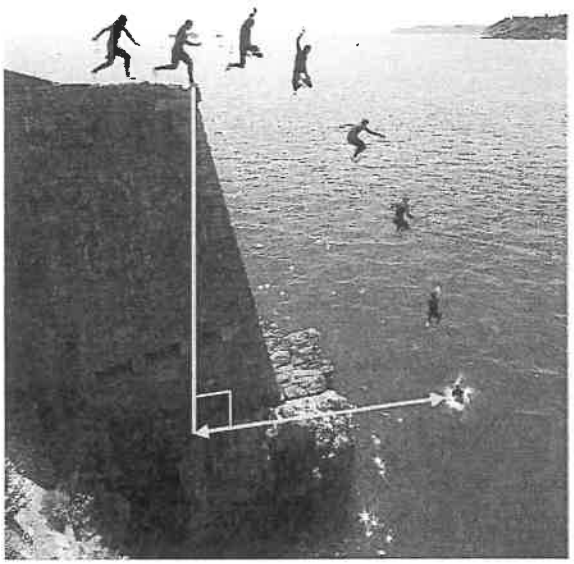
Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.

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 (5 marks)

The stroboscopic photo shows a person running at 4.0 m s^{-1} and jumping off a 19.6 m high cliff to land in the water.



Question 21 continues on the next page

Question 21 (continued) **Marks**

(a) If the take-off from the top of the cliff is horizontal, calculate how long will it take for the person to land in the water? **1**

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(b) Calculate the velocity of the person as they enter the water? **4**

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End of Question 21

Question 22 (8 marks) **Marks**

The Ionospheric Connection Explorer (ICON) space weather satellite, constructed to study Earth's ionosphere, was launched in October 2019. ICON studies the link between space weather and Earth's weather at an altitude of 600 km above Earth's surface. Assume that ICON's orbit is circular. The radius of Earth is 6.37×10^6 m and its mass is 6.0×10^{24} kg.

(a) Calculate the orbital period of the ICON satellite. **2**

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(b) Explain how this satellite can stay in orbit for a long period without the use of engines. **3**

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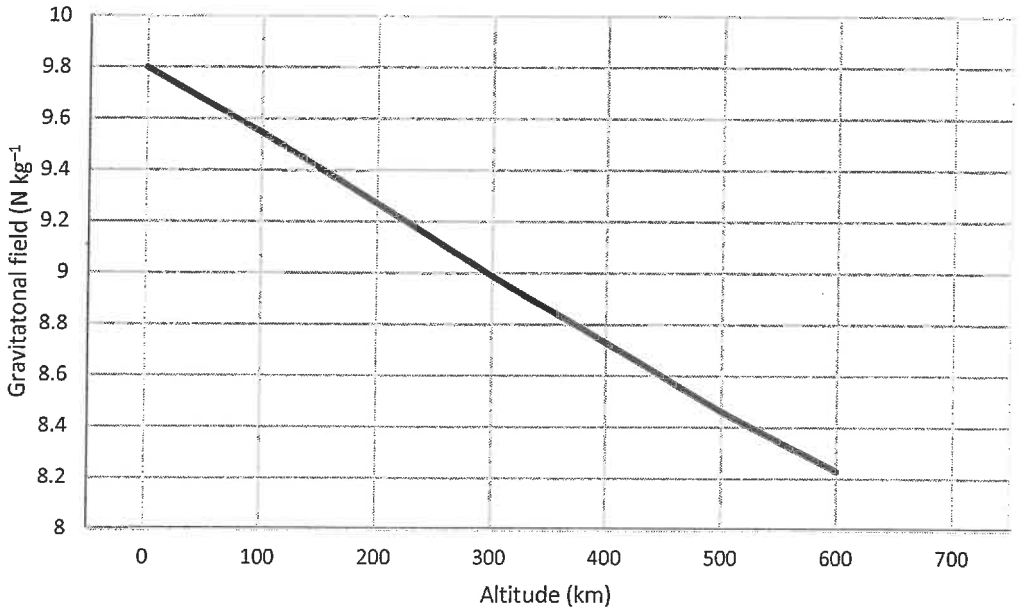
Question 22 continues on the next page

Question 22 (continued) **Marks**

(c) The graph shows how the strength of Earth's gravitational field changes with altitude above the Earth's surface up to 600 km. **3**



Determine the change in gravitational potential energy of the ICON satellite as it travels from Earth's surface to its orbital altitude of 600 km above Earth's surface. The mass of the ICON satellite is 288 kg.

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End of Question 22

STUDENT NUMBER/NAME.....

Question 23 (7 marks) **Marks**

In this course, you investigated the relationship between centripetal force, mass, speed and/or radius for objects in circular motion 7

Describe the investigation including hypothesis, method, classification of variables, results and your conclusion.

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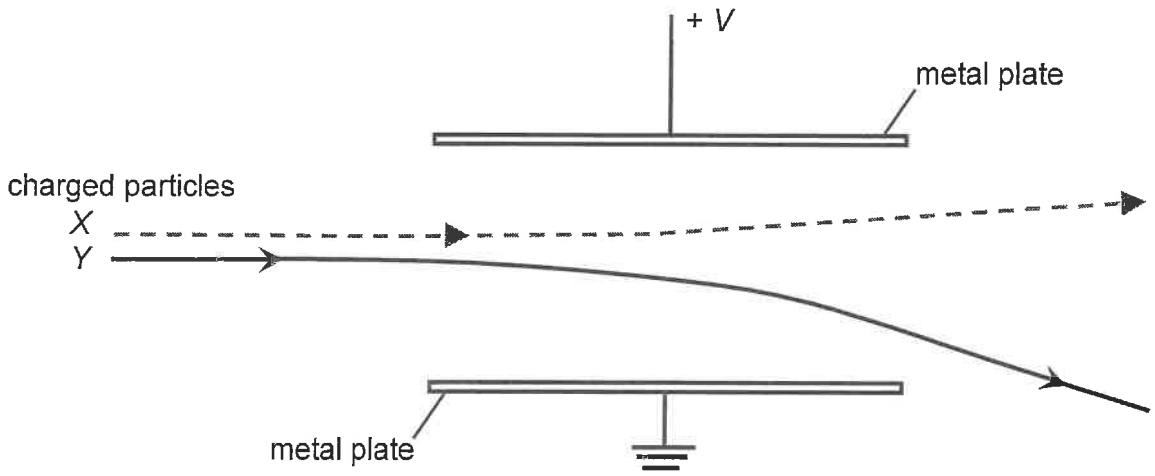
Question 24 (4 marks) **Marks**

Two charged particles (*X* and *Y*) are fired horizontally, at different times, into the electric field between two oppositely charged parallel horizontal plates, as shown in the diagram below. **4**



Analyse the motion of the particles and compare properties of the charged particles. Justify your answer.

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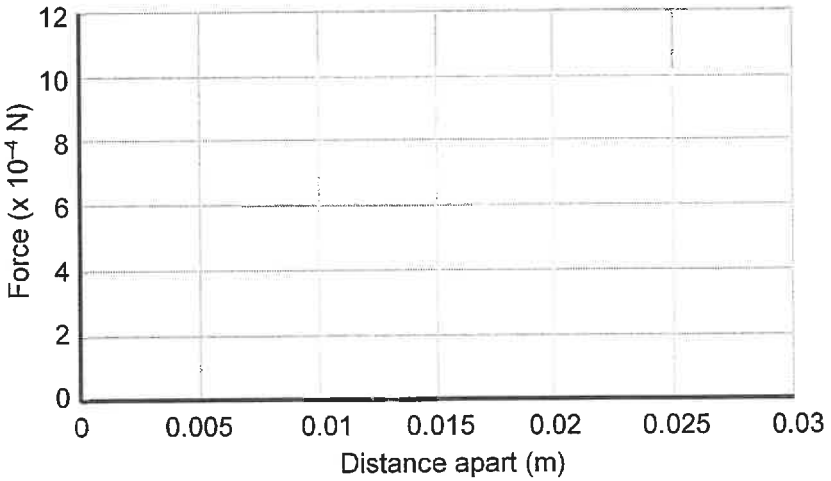
Question 25 (8 marks) **Marks**

Students investigated the relationship between force on two 60 cm long parallel current carrying conductors and distance between the conductors. The results are shown in the table.

Force between wires (N)	*Distance between wires (m)*	
1.13×10^{-3}	0.005	
5.68×10^{-4}	0.010	
3.76×10^{-4}	0.015	
2.82×10^{-4}	0.020	
2.26×10^{-4}	0.025	

(a) Plot a graph of the force between the wires against the distance between them. **2**



(b) Identify why it is inappropriate to draw a conclusion from this graph. **1**

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Question 25 continues on the next page

Question 25 (continued) **Marks**

(c) Predict the relationship between force and distance and add appropriate data to test this relationship to the third column of the table on page 20. **2**

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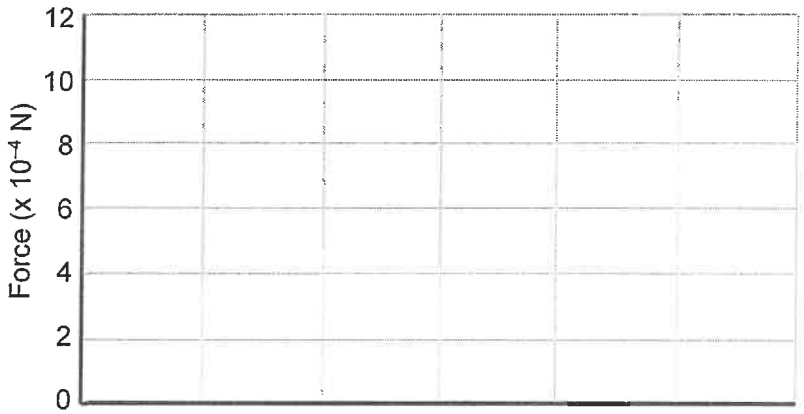
(d) Plot your new data on the grid provided. **2**



(e) Evaluate the choice you made to complete the last column of the table. Justify your answer. **1**

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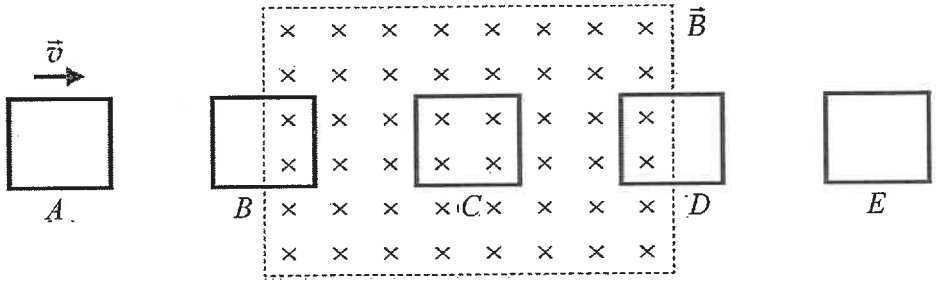
End of Question 25

STUDENT NUMBER/NAME.....

Question 26 (5 marks) **Marks**

A square coil of wire of 10 turns with a cross-sectional area of 1.6×10^{-3} m^2 passes at a constant speed into, through and out of a magnetic field of magnitude 2.0×10^{-2} T. The coil takes 0.40 s to go from position *A* to position *B*. The distance between each coil position equals the length of coil side.



(a) Calculate the emf induced in this coil as it enters the field. **2**

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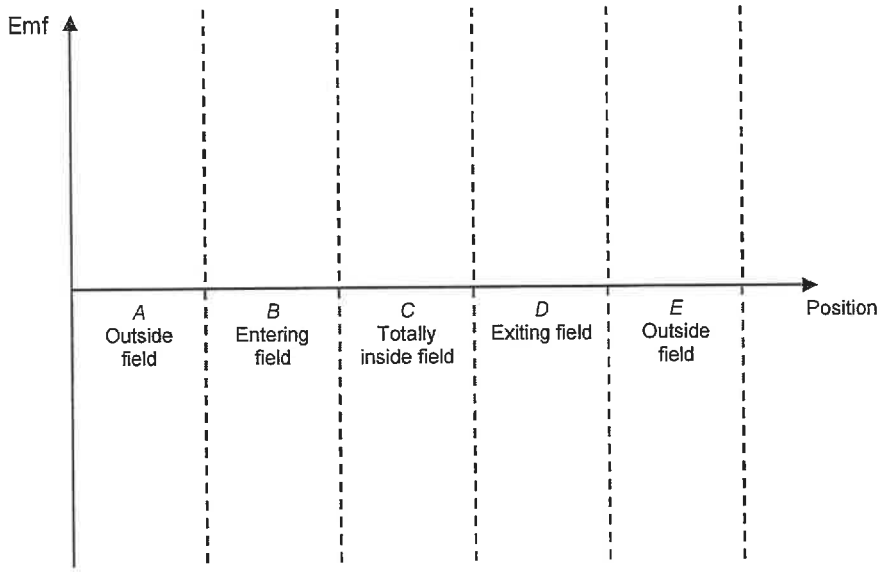
(b) Complete the diagram below to show how the magnitude and direction of the induced emf in the coil as it moves through the 5 labelled positions. **3**

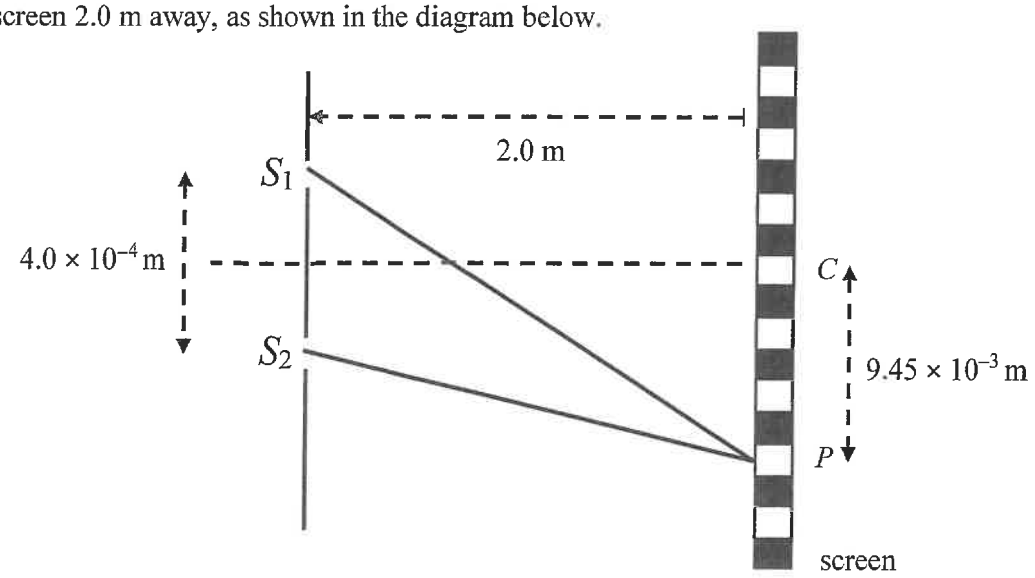
You do not need to include values on the axes.



STUDENT NUMBER/NAME.....

Question 27 (5 marks) **Marks**

In an experiment similar to that done by Thomas Young, a laser light is incident on two slits, *S*1 and *S*2, that are 4.0×10^{-4} m apart. A pattern of light and dark is observed on a screen 2.0 m away, as shown in the diagram below.



(a) Explain the formation of the bright band at point *P*. **3**

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(b) If the distance from the central bright fringe at point *C* to the bright fringe at point *P* is 9.45×10^{-3} m, calculate the wavelength of the laser light. Show your working. **2**

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STUDENT NUMBER/NAME.....

Question 28 (8 marks) **Marks**

(a) In 1864, James Maxwell developed equations to describe the interaction of electric and magnetic fields and suggested that light was an electromagnetic wave. **6**

Outline why his work was challenged by physicists of his day and explain the eventual solution in Einstein's Theory of Special Relativity.

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(b) Describe experimental evidence supporting Einstein's Theory of Special Relativity. **2**

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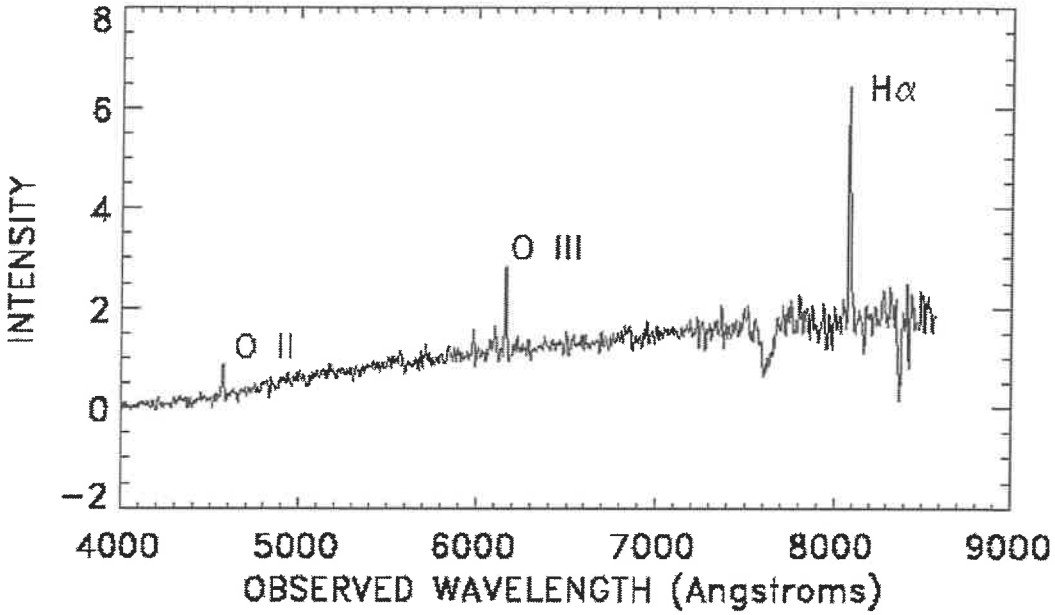
Question 29 (8 marks)

Light from a galaxy in the Hubble Deep Field and was recorded with a spectrograph on one of the Keck Observatory's 10 metre telescopes on Mauna Kea, Hawaii.



The three peaks are emission lines from glowing gas in the galaxy. H alpha is the red Balmer line of neutral hydrogen, O III comes from doubly ionized oxygen, and O II from singly ionised oxygen. The observed wavelengths in the graph have been "red shifted".

(a) What is meant by the "red shift" of the wavelengths of the light from the galaxy and why does it happen? **2**

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Question 29 continues on the next page

Question 29 (continued) **Marks**

(b) What is the significance of Hubble's work using the observed "red shift" of galaxies? **2**

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(c) For each of the emission lines the wavelength at rest is given in Angstroms. **4**

Measure its observed wavelength as accurately as you can, enter it in the table (in Angstroms units) and use the information below to determine the speed of the galaxy based on its small average red shift.

Redshift = (observed wavelength / rest wavelength) – 1
For small red shifts, velocity = average red shift × speed of light

Line	*Rest wavelength*	*Observed wavelength*	*Red shift*
H_α	6562.8 angstroms		
O III	5006.8 angstroms		
O II	3727 angstroms		

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End of Question 29

STUDENT NUMBER/NAME.....

Question 30 (8 marks) **Marks**

Outline the various cathode ray experiments done in the 1800's and assess their evidence supporting the existence and properties of the electron. **8**

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Question 31 (4 marks) **Marks**

Draw a well-labelled diagram to show an experiment involving the polarisation of light to demonstrate the wave nature of light. **4**

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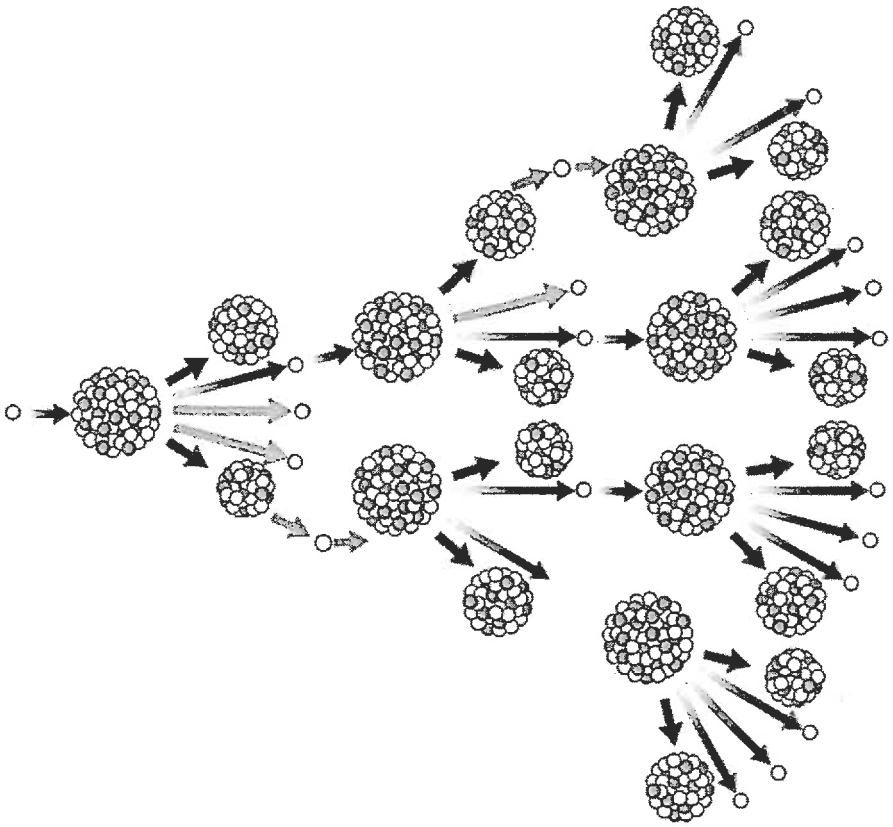
Question 32 (6 marks) **Marks**

The unlabelled diagram shows an important atomic reaction.



Explain what is happening in this reaction and the source of the energy produced. **6**

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Question 33 (4 marks) **Marks**

The Standard Model identifies bosons as responsible for all the force interactions we observe. **4**

Outline the role of bosons in our universe.

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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.

NSW INDEPENDENT TRIAL EXAMS – 2023
PHYSICS – TRIAL HSC EXAMINATION
MARKING GUIDELINES

Section I

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

Section II

Question 21(a)

Criteria	Marks
• Calculates time correctly	1

Sample answer:

Using vertical component: $s = ut + \frac{1}{2}at^2$

$19.6 = 0 + 4.9t^2$

$t = 2.0$ s

Question 21(b)

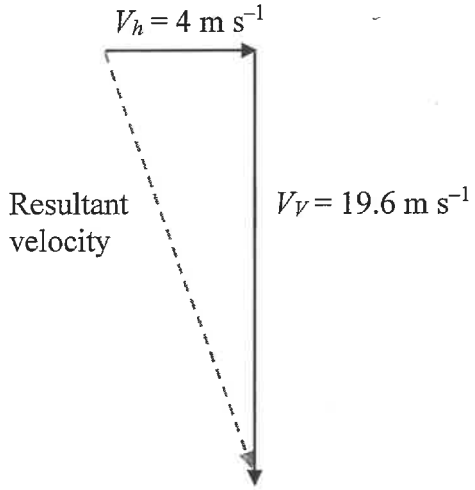
Criteria	Marks
• Calculates speed and direction correctly	4
• Calculates speed and direction with ONE error in calculations	3
• Calculates speed correctly	2
• Calculates vertical speed on hitting water	1

Sample answer:

For vertical component: $v = u + at$ = at, since $u = 0$

Vertical velocity on hitting the water = $9.8 \times 2 = 19.6$ m s^{-1}

Vector velocity diagram:



Resultant velocity: $v = \sqrt{(19.6^2 + 4^2)}$

$= 20$ m s^{-1} at $\tan^{-1}(19.6/4)$

$= 20$ m s^{-1} at 78° down from the horizontal

Question 22(a)

Criteria	Marks
• Calculates orbital period correctly	2
• Calculates orbital period with error in radius substitution	1

Sample answer:

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

$$T = \sqrt{\frac{R^3 4\pi^2}{GM}} = \sqrt{\frac{(6.37 \times 10^6 + 600\,000)^3 \times 4\pi^2}{6.67 \times 10^{-11} \times 6 \times 10^{24}}}$$

$= 5.8\ 10^3$ s

Question 22(b)

Criteria	Marks
• Explains the relationship between gravitational centripetal force and other variables involved in circular motion, the negligible friction and eventual change of orbit	3
• Explains TWO of the following: the relationship between gravitational centripetal force and other variables involved in circular motion, the negligible friction, eventual change of orbit	2
• Explains ONE of the following: the relationship between gravitational centripetal force and other variables involved in circular motion, the negligible friction, eventual change of orbit	1

Sample answer: Moving in circular orbit requires a centripetal force, provided by gravity, acting at 90° to its instantaneous velocity. The force required is related to its mass, radius of orbit and orbital speed – $F = mv^2/r$.

As there is almost negligible friction to slow the speed, the satellite stays in orbit for a long period, but eventually atmospheric drag will slow its speed and cause a change in the orbit.

Question 22(c)

Criteria	Marks
• Relates change in U to work done and calculates work correctly from area under graph	3
• Relates change in U to work done and calculates work incorrectly from area under graph	2
• Relates change in U to work done	1

Sample answer:

Change in U = work done = Fs = (force per kg × mass) × distance
= (force per kilogram × distance) × mass
= area under the graph × mass

(Note that it is only the area of the triangle required, not the total area down to the x-axis)

Work done = $0.5 \times 600\,000 \times (9.8 - 8.22) \times 288$
= 1.37×10^8 J

Question 23

Criteria	Marks
• Provides hypothesis, details of all variables, method, analysis used for conclusion	**5–7**
• Provides THREE of the following: hypothesis, details of all variables, method, analysis used for conclusion	**3–4**
• Provides TWO of the following: hypothesis, details of all variables, method, analysis used for conclusion	**1–2**

Sample answer:

Hypothesis

The radius of an object in circular motion is proportional to the square of orbital speed of the stopper for a constant centripetal force, according to the equation $F_c = mv^2/r$.

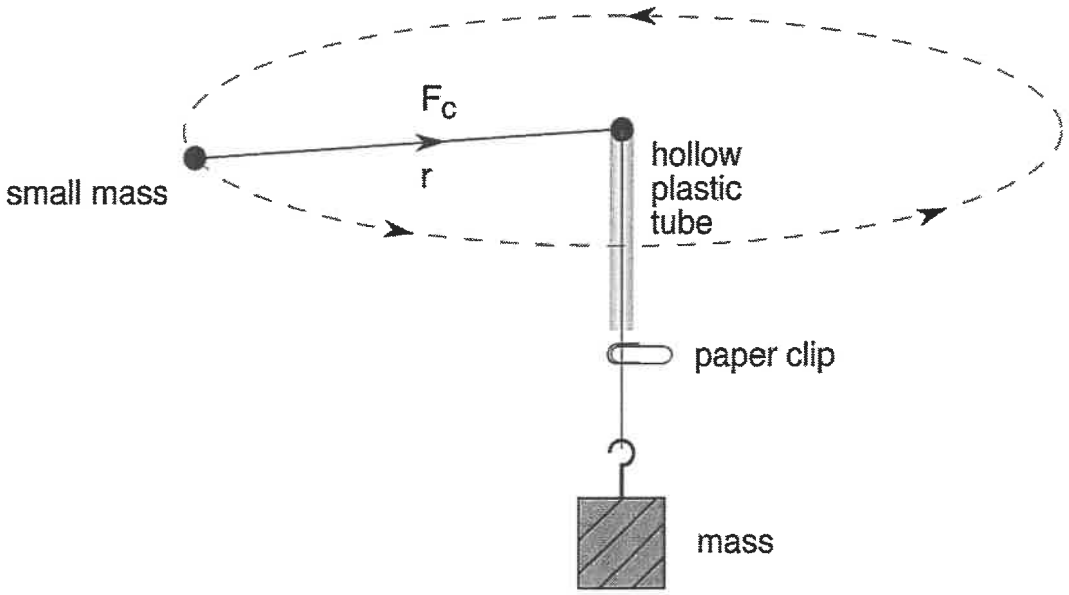
Method

Controlled variables were the centripetal force F_c provided by constant mass hanging on the end of the string below a vertical hollow plastic tube and the mass m of the object in circular motion, as shown in the diagram.

Independent variable was the radius of the motion.

Dependent variable was the speed of the small mass in horizontal circular motion.

(Diagram not essential.)



The method involved attaching a paper clip on the string below the tube allowing rotation at the various selected radii and rotating the small mass at different speeds until the paper clip reached the base of the plastic tube and timing 5 rotations. (Keep a safe distance from other people.)

The times were entered for each radius and the average time for each radius used to calculate the orbital speed.

Analysis

A graph of radius against orbital speed squared was drawn. A straight line graph would verify that the radius of an object in circular motion is proportional to its orbital speed squared.

Question 24

Criteria	Marks
• Identifies the effect on path of charges to the nature of the charge, entry speed, mass and size of charge	4
• Identifies the effect on path of charges to THREE of the following: the nature of the charge, entry speed, mass and size of charge	3
• Identifies the effect on path of charges to TWO of the following: the nature of the charge, entry speed, mass and size of charge	2
• Identifies the effect on path of charges to ONE of the following: the nature of the charge, entry speed, mass and size of charge	1

Sample answer: The particles differ in charge because they have been deflected in opposite directions by the electric field; Particle X is negative moving in a direction opposite to the electric field, while particle Y is positive moving in the field direction.

The force on each particle is vertical and there is no horizontal force. Therefore, their horizontal velocities do not change. Their motion is parabolic, similar to projectile motion.

The difference in the deflection could be accounted for by charge X entering the electric field at a faster speed and spending less time being deflected by the field.

If the entry speeds are the same, they are in the electric field for equal times and the paths are different because their vertical acceleration could be different due to X having a greater mass.

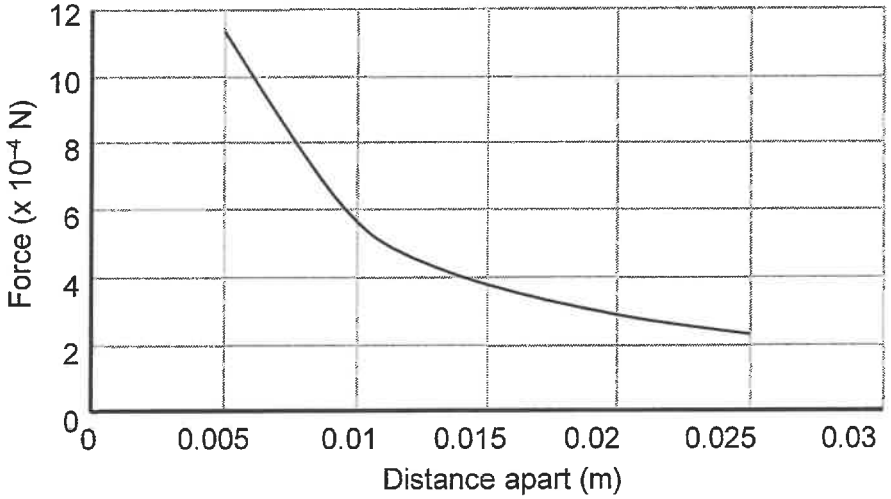
For each charge, the vertical force $F = qE$ and the acceleration = qE/m.

If the electric field and mass is identical for each, then difference in their parabolic path could be due to the charge q on Y being greater or a combination of differences in speed, mass and charge.

Question 25(a)

Criteria	Marks
• Plots all points correctly and draws a smooth curve	2
• Plots FOUR points correctly and draws a smooth curve OR • Plots all points correctly and draws a line	1

Sample answer:



Question 25(b)

Criteria	Marks
• Identifies need for a straight-line graph	1

Sample answer: A conclusion cannot be made from a curved graph because we do not know the mathematical relationship it shows. The next step is to plot a different version of these variables in the hope of obtaining a straight-line graph from which a conclusion can be drawn.

Question 25(c)

Criteria	Marks
• Provides a possible relationship and enters FOUR suitable data values to table	2
• Provides a possible relationship OR enters FOUR suitable data values to table	1

Sample answer: The relationship is that force is inversely proportional to the distance between conductors.

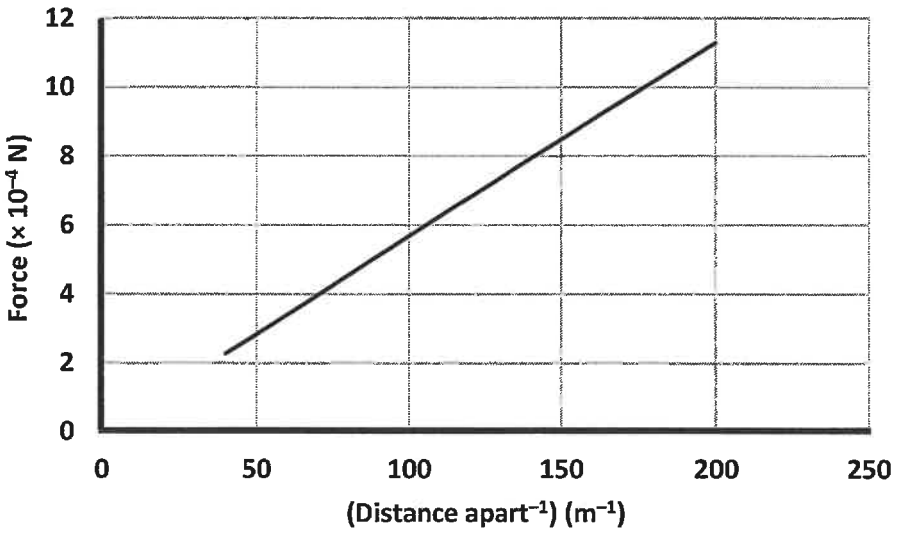
Force between the wires (N)	*Distance between the wires (m)*	*(Distance between wires)$^{-1}$ (m^{-1})*
1.13×10^{-3}	0.005	200
5.68×10^{-4}	0.010	100
3.76×10^{-4}	0.015	66.7
2.82×10^{-4}	0.020	50
2.26×10^{-4}	0.025	40

Question 25 continues on the next page

Question 25(d)

Criteria	Marks
• Plots values and labels *x*-axis	2
• Plots values	1

Sample answer: (Note: answers will vary if students did not choose the inverse distance relationship for the data in the third column of data.)



Question 25(e)

Criteria	Marks
• Provides evaluation based on their graph	1

Sample answer: The choice was valid in that the aim was to find the connection between the variables which gave a direct relationship. The straight-line graph shows that this was the right choice.

(Note: Answer will vary if second graph is not a straight-line graph and should state that their choice was invalid).

Question 26(a)

Criteria	Marks
• Calculates induced emf correctly	2
• Substitutes into equation omitting N or using incorrect time	1

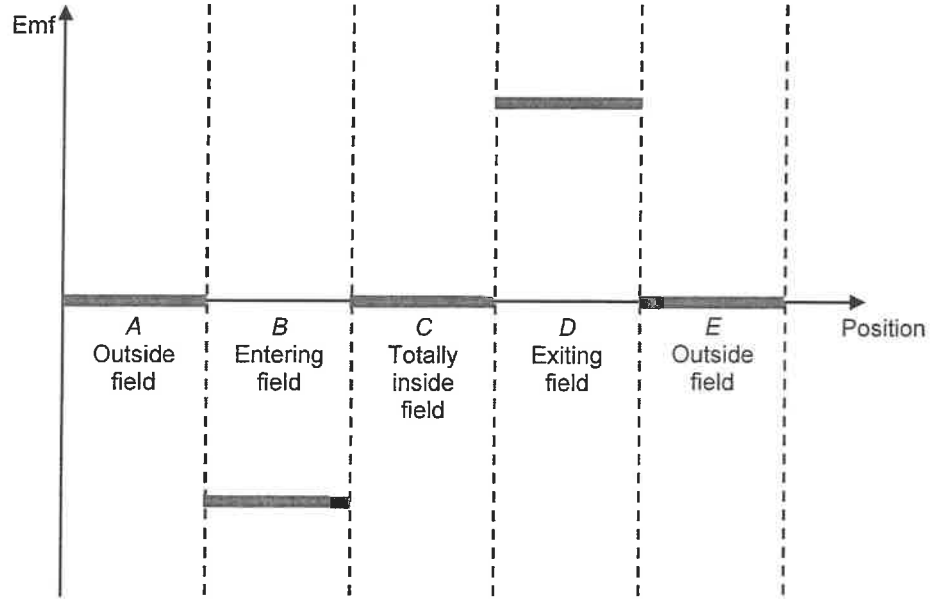
Sample answer: From the data given the coil takes 0.2 s entering the magnetic field.

$$\text{Magnitude of } \varepsilon = N\frac{\Delta\Phi}{\Delta t} = 10 \times (2.0 \times 10^{-2} \times 1.6 \times 10^{-3}) / 0.2 = 1.6 \times 10^{-3} \text{ V}$$

Question 26(b)

Criteria	Marks
• Provides graph with constant emf for B and D in opposite directions and zero at A, C and E	3
• Provides graph with constant emf for B and D with Band D reversed and zero at A, C and E	2
• Provides graph with sloping lines for emf of B and D in opposite directions	1

Sample answer:



Question 27(a)

Criteria	Marks
• Identifies diffraction at slits, formation of coherent circular wavefronts and constructive interference due to paths differing by 3 wavelengths exactly	**3**
• Describes TWO of the following: the interference of coherent circular wavefronts, constructive interference, paths difference of 3 wavelengths exactly	**2**
• Identifies ONE of the following: the interference of coherent circular wavefronts, constructive interference, paths difference of 3 wavelengths exactly	**1**

Sample answer: Diffraction at each slit produces circular wave fronts that are coherent (in phase) and monochromatic. The bright band in question is the third bright band from the centre resulting from the constructive interference of the waves from S_1 and S_2 which have a path difference of three wavelengths.

Question 27(b)

Criteria	Marks
• Calculates wavelength correctly	**2**
• Substitutes correctly	**1**

Sample answer:

$m\lambda = d \sin\theta = dx/L$

$3\lambda = 4.0 \times 10^{-4} \times 9.45 \times 10^{-3} / 2.0$

$\lambda = 6.3 \times 10^{-7}$ m = 630 nm

Question 28(a)

Criteria	Marks
• Clearly outlines the problem due to the speed of light and its measurement relative to the aether, Einstein's postulates and consequent space-time continuum	**5–6**
• Outlines the problem due to the speed of light and its measurement relative to the aether, Einstein's postulates and consequent space-time continuum	**3–4**
• Identifies TWO of the following: the problem due to the speed of light, its measurement relative to the aether, Einstein's postulates, consequent space-time continuum	**2**
• Identifies ONE of the following: the problem due to the speed of light, its measurement relative to the aether, Einstein's postulates, consequent space-time continuum	**1**

Sample answer: James Maxwell had presented his theory on electromagnetism in the form of mathematical equations describing the interaction of electric and magnetic fields resulting in the propagation of the fields as an electromagnetic wave with a speed identical to the speed of light. He therefore reasoned that light was an electromagnetic wave.

The problem was that waves were thought to need a medium through which they moved. The medium for light waves was called the aether, although experiments to demonstrate the predicted effect of the aether on the motion of light had all been failures, including that done by Michelson and Morley. The experiment was thought to be a failure as it did not show any effect of the aether on the speed of light moving in perpendicular directions. As well, the role of aether could be shown to violate the Galileo's principle of relativity that all uniform motion could not be detected without an outside frame of reference.

Einstein's solution was to reject the existence of the aether and he stated two Postulates.

Postulate 1: The speed of light in a vacuum is an absolute constant.

Postulate 2: All inertial frames of reference are equivalent and the principle of relativity holds.

Einstein argues that as a consequence of the speed of light being an absolute, length and time are relative quantities depending on the motion of the observer.

Question 28(b)

Criteria	Marks
• Describes an experimental measurement indicating time dilations or length contraction occurring	**2**
• Identifies an experiment	**1**

Sample answer: Muons are unstable particles formed in Earth's atmosphere and travel at velocities near the speed of light towards Earth's surface. The majority of muons should decay before reaching the surface based on their extremely short half-life, but the number of muons measured at the Earth's surface showed that this was not happening This is explained by the increase in their half-life time due to time dilation when measured by a stationary observer on Earth.

Question 29(a)

Criteria	Marks
• Explains what the term "red shift" describes AND the cause	2
• Explains what the term "red shift" describes OR the cause	1

Sample answer: A galaxy's "red shift" is a measure of how far the wavelengths of the component peaks in its spectrum have shifted towards the red end of the spectrum of white light. Due to the movement of a light source away from the observer, the frequency of the arrival of each wavelength of the wave is decreased. As the speed of light is constant, the wavelength is increased.

Question 29(b)

Criteria	Marks
• Explains how the law provided evidence for expansion of the Universe	2
• States that the law provided evidence for expansion of the Universe	1

Sample answer: Hubble's showed that a galaxy's velocity away from an observer is directly proportional to its distance from the observer. The red shift of a galaxy is used to determine its velocity and then Hubble's law is used to find the distance to the galaxy. Application of the relationship to distant galaxies provided the evidence for the expansion of the Universe, with the distant galaxies moving away at a faster rate.

Question 29(c)

Criteria	Marks
• Lists THREE observed suitable wavelengths, calculates each red shift, calculates average red shift and velocity of galaxy	4
• Determines correctly THREE of the following: observed wavelengths, red shifts, average red shift, velocity	3
• Determines correctly TWO of the following: observed wavelengths, redshifts, average red shift, velocity	2
• Determines correctly ONE of the following: observed wavelengths, red shifts, average red shift, velocity	1

Sample answer:

Line	*Rest wavelength*	*Observed wavelength*	*Red shift*
$H\alpha$	6562.8 Angstroms	8100 Angstroms	0.234
O III	5006.8 Angstroms	6150 Angstroms	0.228
O II	3727 Angstroms	4550 Angstroms	0.221

Average red shift of galaxy = 0.228
Velocity = $0.288 \times 3 \times 10^8 = 6.8 \times 10^7$

Question 30

Criteria	Marks
• Outlines clearly the evidence from THREE different types of cathode ray experiments and the work of Thomson	**7–8**
• Outlines clearly the evidence from THREE different types of cathode ray experiments OR • Outlines clearly the evidence from TWO different types of cathode ray experiments and the work of Thomson	**5–6**
• Outlines clearly the evidence from TWO different types of cathode ray experiments OR • Outlines clearly the evidence from ONE type of cathode ray experiment and the work of Thomson	**4**
• Outlines the evidence from TWO different types of cathode ray experiments OR • Outlines the evidence from ONE type of cathode ray experiment and the work of Thomson	**3**
• Outlines clearly the evidence from ONE type of cathode ray experiment OR • Outlines clearly the evidence from the work of Thomson	**2**
• Outlines the evidence from ONE type of cathode ray experiment OR • Outlines the evidence from the work of Thomson	**1**

Sample answer: The discovery of vacuum pumps led to scientists experimenting with passing electric currents across gases at different pressures in glass tubes with an anode at one end and a cathode at the other. As the pressure was reduced, the residual gas glowed until at the lowest pressure there was no glow but a green fluorescence at the anode end of the tube caused by the energy carried by "rays" from the negatively charges cathode. To determine whether cathode rays were particles or waves and their other properties, a number of other cathode ray tubes were devised.

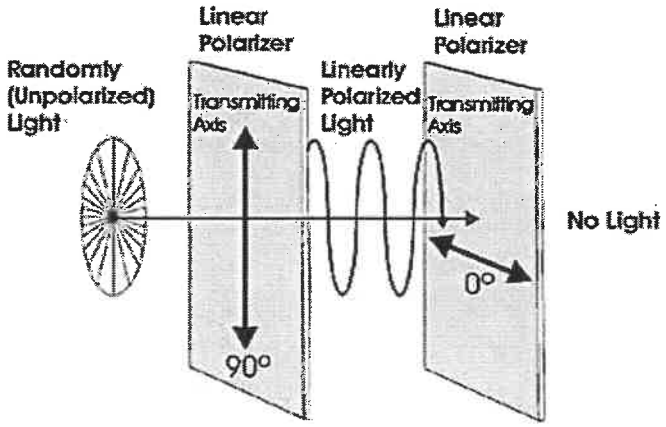
- A Maltese shaped metal cross inside a cathode ray tube resulted in a sharp shadow in the fluorescence at the anode end showing that the rays travelled in straight lines.
- A glass paddle wheel in the path of the cathode rays in the tube rotated when the rays hit the flat paddles of the wheel showing that the rays had momentum.
- Cathode rays were passed through the electric field between parallel positive and negative plates inside the tube causing their deflection toward the positive plate.

The results were evidence for cathode rays to be particles due to their momentum and negatively charged due to their deflection direction – the rays were probably particles not waves. Both waves and particles travel in straight lines unless deflected. There was uncertainty as initial attempts to show the expected deflection of the rays by a magnetic field failed. Their nature as negatively charged particles was confirmed when JJ Thomson demonstrated their deflection when he was able to almost evacuate the cathode ray tube, which prevented ionisation of residual gas interfering with magnetic force on the particles. Thomson was also able to measure the charge to mass ratio of the cathode ray particles.

Question 31

Criteria	Marks
• Provides a clear well-labelled diagram showing polarisation of light waves passing through polarisers with identified axes of transmission and explanatory text involving planes of polarisation of the wave	3–4
• Provides a labelled diagram showing polarisation of light passing through polarisers	2
• Provides a diagram with some relevant labels or information	1

Sample answer: In experiments, no light is able to pass through two polarisers at right angles, as waves in all planes of vibration have been prevented from passing through. This behaviour is not typical of particles, it can only happen to waves which have planes of oscillation along which they move. This phenomenon is shown in the diagram below.



Question 32

Criteria	Marks
• Demonstrates a clear understanding of fission, chain reactions with large energy release, an increase in binding energy due to less mass based on Einstein's equation	5–6
• Demonstrates some understanding of fission, chain reactions with large energy release, an increase in binding energy due to less mass based on Einstein's equation	3–4
• Demonstrates some understanding of fission and TWO of the following: chain reactions with large energy release, an increase in binding energy due to less mass based on Einstein's equation	2
• Demonstrates some understanding of fission and ONE of the following: chain reactions with large energy release, an increase in binding energy due to less mass based on Einstein's equation	1

Sample answer: The diagram represents an uncontrolled nuclear reaction called fission in which an atom bombarded by a neutron divides into two "daughter" atoms releasing energy. In the example, several neutrons are also released and result in other fission reactions, setting up a chain reaction and a possible uncontrolled release of huge amounts of energy if a critical mass of uranium is present.

The source of the energy is the difference in binding energy of the products and reactants. The binding energy of an atom is the energy equivalent of the amount of mass that the atom is less than the mass of its constituents. Einstein's equation relates the amount of energy produced to the loss of mass, $E = mc^2$. A reaction occurs spontaneously if it produces energy and this occurs if the mass of the products is less than the reactants, meaning that the binding energy has increased.

Question 33

Criteria	Marks
• Provides information about the THREE fundamental forces, the role of bosons and the predicted graviton	4
• Provides information about the THREE fundamental forces and the role of bosons	3
• Identifies bosons as force-carrier particles involved in energy exchange	2
• Identifies bosons as force-carrier particles	1

Sample answer: There are four fundamental forces at work in the universe: the strong force, the weak force, the electromagnetic force, and the gravitational force. Apart from the gravitational force, the forces result from the exchange of force-carrier particles called bosons, sub-atomic particles having an integer spin quantum number. Particles of matter transfer discrete amounts of energy by exchanging bosons with each other. Each fundamental force has its own corresponding boson – the strong force is carried by the "gluon", the electromagnetic force is carried by the "photon", and the "W and Z bosons" are responsible for the weak force. Although not yet found, the "graviton" should be the corresponding force-carrying particle of gravity.

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PHYSICS – TRIAL HSC EXAMINATION
MAPPING GRID

Question	Marks	Content module		Syllabus Outcomes (PH)	Targeted performance bands
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1	1	5	Projectile Motion	12-5	4-5
2	1	5	Motion in a Gravitational Field	12-2	2-3
3	1	5	Motion in a Gravitational Field	12-12	2-3
4	1	5	Motion in a Gravitational Field	12-6, 12-12	4-5
5	1	5	Uniform Circular Motion	12-12	3-4
6	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-13	2-3
7	1	7	Light: Quantum Model	12-6, 12-14	3-4
8	1	6	Applications of the Motor Effect	12-6, 12-13	2-3
9	1	6	Electromagnetic Induction	12-6, 12-13	3-4
10	1	6	Electromagnetic Induction	12-6, 12-13	2-3
11	1	7	Light: Wave Model	12-14	3-4
12	1	7	Light and Special Relativity	12-6, 12-14	5-6
13	1	7	Light: Wave Model Light: Quantum Model	12-14	4-5
14	1	7	Electromagnetic Spectrum	12-14	2-3
15	1	7	Light and Special Relativity	12-14	4-5
16	1	8	Origin of the Elements	12-15	3-4
17	1	8	Structure of the Atom	12-15	3-4
18	1	8	Structure of the Atom	12-15	3-4
19	1	8	Properties of the Nucleus	12-15	4-5
20	1	8	Deep Inside the Atom	12-15	4-5

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MAPPING GRID cont'd

Question	Marks	Content module		Syllabus Outcomes (PH)	Targeted performance bands
Section II					
21(a)	1	5	Motion in a Gravitational Field	12-12	3-4
21(b)	4	5	Motion in a Gravitational Field	12-12	4-5
22(a)	2	5	Motion in a Gravitational Field	12-6, 12-12	4-5
22(b)	3	5	Motion in a Gravitational Field	12-7, 12-12	3-4
22(c)	3	5	Motion in a Gravitational Field	12-5, 12-2	5-6
23	7	5	Uniform Circular Motion	12-2, 12-12	3-6
24	4	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-7, 12-13	3-4
25(a)	2	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-4	2-3
25(b)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-5	3-4
25(c)	2	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-6	4-5
25(d)	2	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-4	2-3
25(e)	1	6	Charged Particles, Conductors and Electric and Magnetic Fields	12-5	4-5
26(a)	2	6	Electromagnetic Induction	12-6, 12-13	4-5
26(b)	3	6	Electromagnetic Induction	12-13	4-5
27(a)	3	7	Light: Wave Model	12-7, 12-14	3-5
27(b)	2	7	Light: Wave Model	12-14	3-4
28(a)	6	7	Light and Special Relativity	12-7, 12-14	3-6
28(b)	2	7	Light and Special Relativity	12-14	3-4
29(a)	2	8	Origins of the Elements	12-15	2-3
29(b)	2	8	Origins of the Elements	12-15	3-4
29(c)	4	8	Origins of the Elements	12-4, 12-6, 12-15	4-5
30	8	8	Structure of the Atom	12-4, 12-7, 12-15	3-5
31	4	7	Light-wave Model	12-7, 12-14	4-5
32	6	8	Properties of the Nucleus	12-7, 12-15	4-6
33	4	8	Deep inside the Atom	12-15	3-4