CSSA

CATHOLIC SECONDARY SCHOOLS ASSOCIATION OF NSW

Centre Number

Student Number

DO NOT REMOVE PAPER FROM EXAM ROOM

2020

TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

Physics

Morning Session
Tuesday, 25 August 2020

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using black pen
- Draw diagrams using pencil
- Use Multiple-Choice Answer Sheet provided
- NESA-approved calculators may be used
- Data, formulae sheets and periodic table are provided SEPARATELY
- Write your Centre Number and Student Number on the top of this page

Total marks - 100

Section I Pages 2-13

20 marks

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

Section II Pages 14-29

80 marks

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

Section I

20 marks
Attempt Questions 1-20
Allow about 35 minutes for this part

Use the Multiple-Choice Answer Sheet for Questions 1-20.

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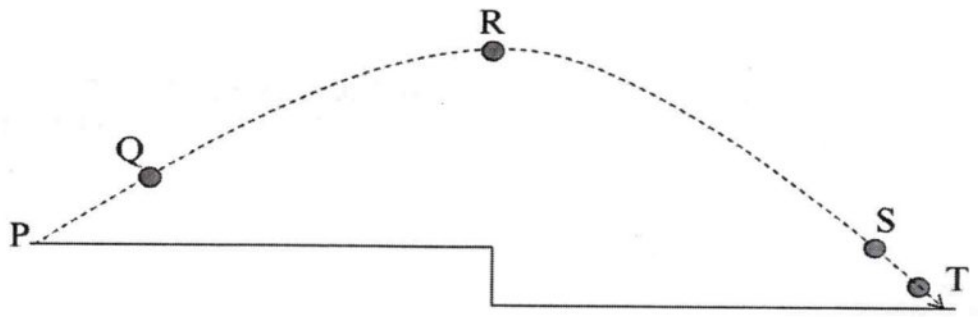
1 A ball undergoes projectile motion from point P to T as shown.



Ignoring air resistance, which statement below correctly describes the motion of the ball?

(A) The ball has no acceleration at point R.

(B) The ball has the greatest acceleration at point T.

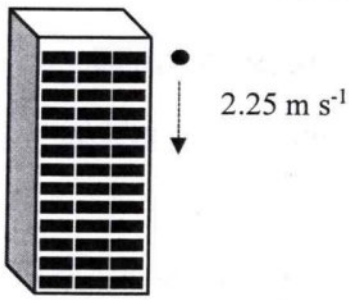
(C) The ball has the maximum acceleration at point R.

(D) The ball has the same acceleration at all the points marked.

2 A student throws a ball vertically downwards from the roof of a building.

The ball leaves her hand at 2.25 m s^{-1}.

If the ball takes 1.80 seconds to hit the ground, how high is the building?



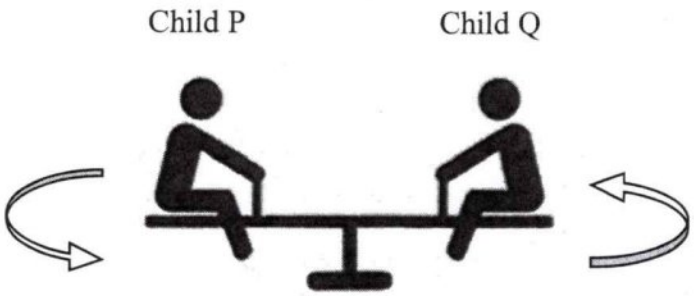
(A) 16 m

(B) 20 m

(C) 25 m

(D) 30 m

3 Two children sit on opposite ends of a small roundabout that is rotating horizontally.
They are both sitting 2.5 metres from the axis of rotation.
Child P has a mass of 36 kg and child Q has a mass of 45 kg.



Which statements correctly show the values for the centripetal acceleration and force experienced by each child?

	Centripetal acceleration	Centripetal force
(A)	P < Q	P < Q
(B)	P = Q	P < Q
(C)	P < Q	P = Q
(D)	P > Q	P > Q

4 Which list only contains fundamental particles from the Standard Model?

(A) Higgs boson, baryon, photon, neutron

(B) Up quark, electron neutrino, proton, tau

(C) Gluon, tau, z boson, strange quark, muon

(D) Proton, neutron, electron, electron neutrino

5 A small satellite with mass of 500 kg is orbiting the Earth at an altitude of 800 km. What is the magnitude of the satellite's centripetal acceleration?

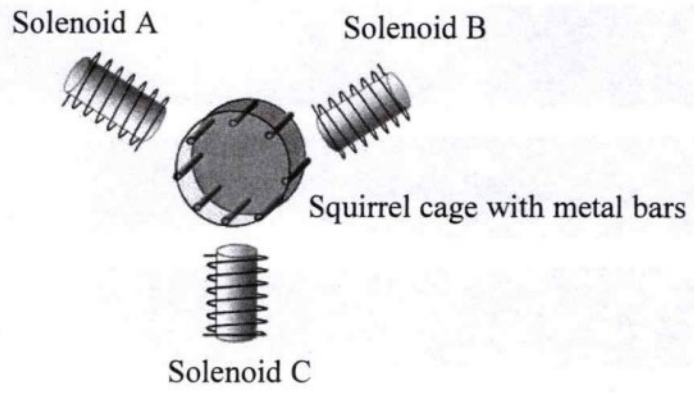
(A) $3.6\ m\ s^{-2}$

(B) $6.8\ m\ s^{-2}$

(C) $7.8\ m\ s^{-2}$

(D) $9.8\ m\ s^{-2}$

6 A student performed an experiment where a squirrel cage was surrounded by three solenoids.



The currents in the solenoids are varied so that they create a north magnetic pole first in A, then then in B and then in C, in a clockwise rotating cycle. Which statement correctly describes what happens in the squirrel cage?

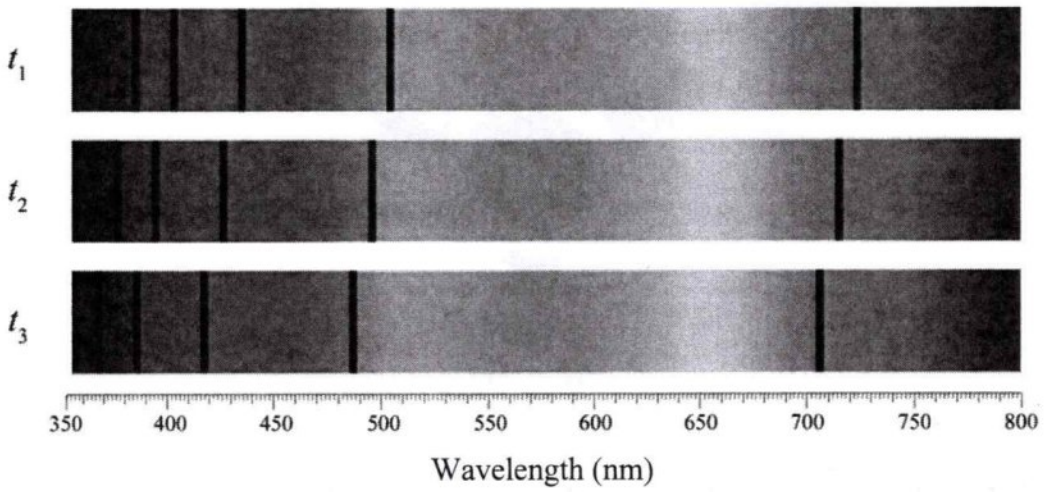
(A) Current is induced in the metal bars of the squirrel cage and will cause it to rotate in a clockwise direction.

(B) Current is induced in the metal bars of the squirrel cage and will cause it to rotate in an anticlockwise direction.

(C) The metal bars in the squirrel cage will become permanent magnets causing the squirrel cage to rotate in a clockwise direction.

(D) The metal bars in the squirrel cage will become permanent magnets causing the squirrel cage to rotate in an anticlockwise direction.

7 Three simplified absorption spectra from a distant star are shown below.



The spectra are recorded sequentially in time.

Which physics principle would be used to conclude that the star is moving relative to an Earth observer?

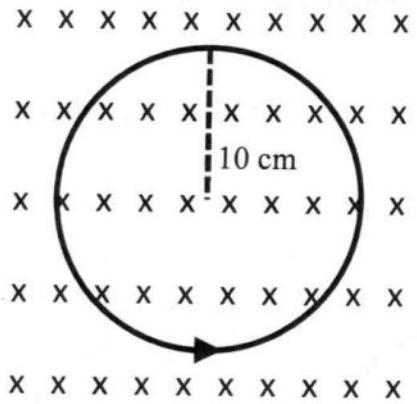
(A) Malus' law

(B) Wien's law

(C) Doppler effect

(D) Photoelectric effect

8 A charged particle with a mass of 6.692×10^{-27} kg and charge of 1.6×10^{-16} C follows a circular path of radius 10 cm, inside a uniform magnetic field of strength 0.10 T. Calculate the speed of the charged particle.



(A) 1.2×10^{6} m s^{-1}

(B) 2.4×10^{6} m s^{-1}

(C) 2.4×10^{8} m s^{-1}

(D) 2.4×10^{10} m s^{-1}

9 A transformer has a primary input power of 500 W and is 70 % efficient. If the secondary voltage of the transformer is 70 V. What is the current flowing in the secondary coil?

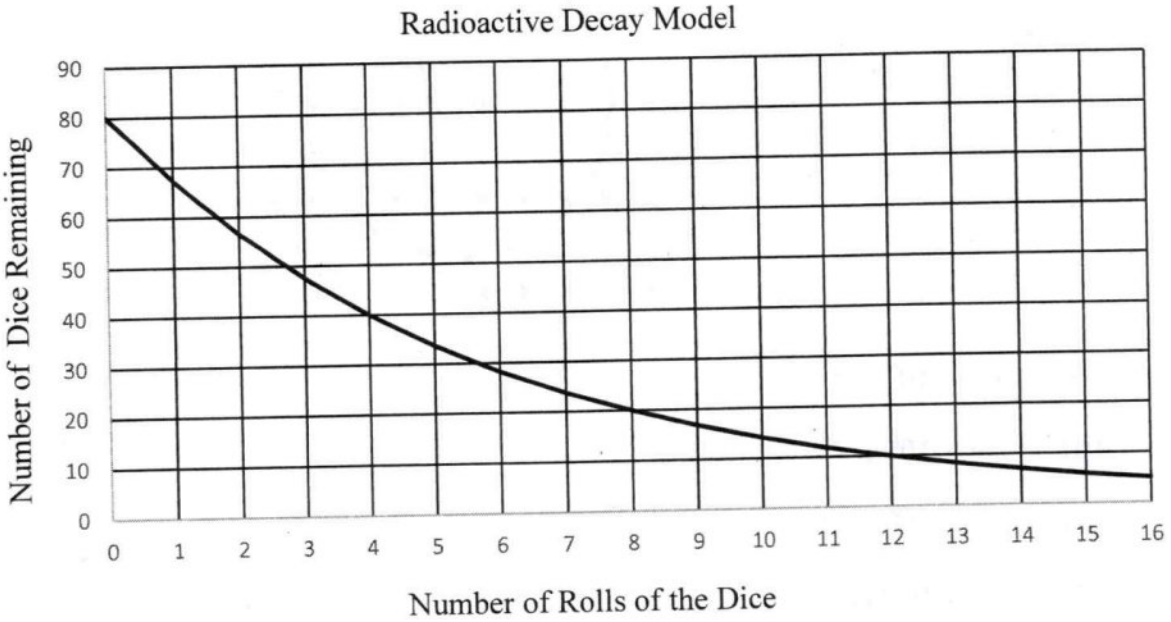
(A) 2.1 A

(B) 5.0 A

(C) 7.1 A

(D) 10.2 A

10 Students performed an experiment to model radioactive decay.
80 dice were rolled and the dice that showed a six were removed.
The procedure was repeated multiple times, with the sixes removed after each throw.
The graph shows the results of the student's experiment.



Identify the half-life of the radioactive decay that the student modelled.

(A) 1 roll

(B) 2 rolls

(C) 4 rolls

(D) 8 rolls

11 Two parallel conductors have their separation distance halved and both their currents halved.
What effect will this have on the magnitude of force between the conductors?

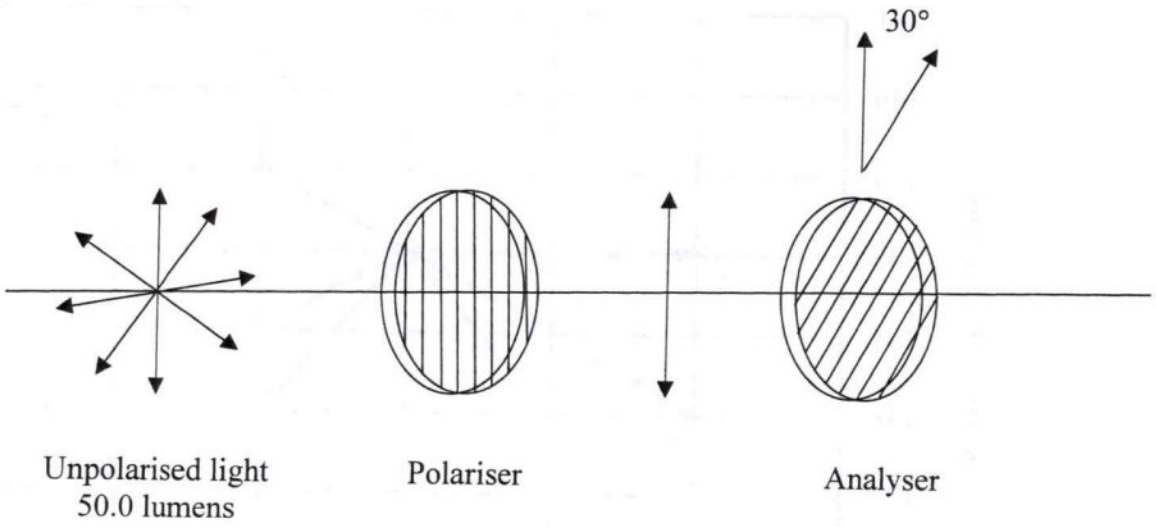
(A) The magnitude will be halved.

(B) The magnitude will be doubled.

(C) The magnitude will be 8 times larger.

(D) The magnitude will be 1/8 times smaller.

12 An unpolarised light with intensity of 50.0 lumens passes through a polariser and then an analyser as shown. The analyser is rotated by an angle of 30 degrees to the polariser. Calculate the intensity of the light after it passes through the analyser.



(A) 18.8 lumens

(B) 21.6 lumens

(C) 37.5 lumens

(D) 43.3 lumens

13 When comparing gamma and ultraviolet radiation, which statement is correct?

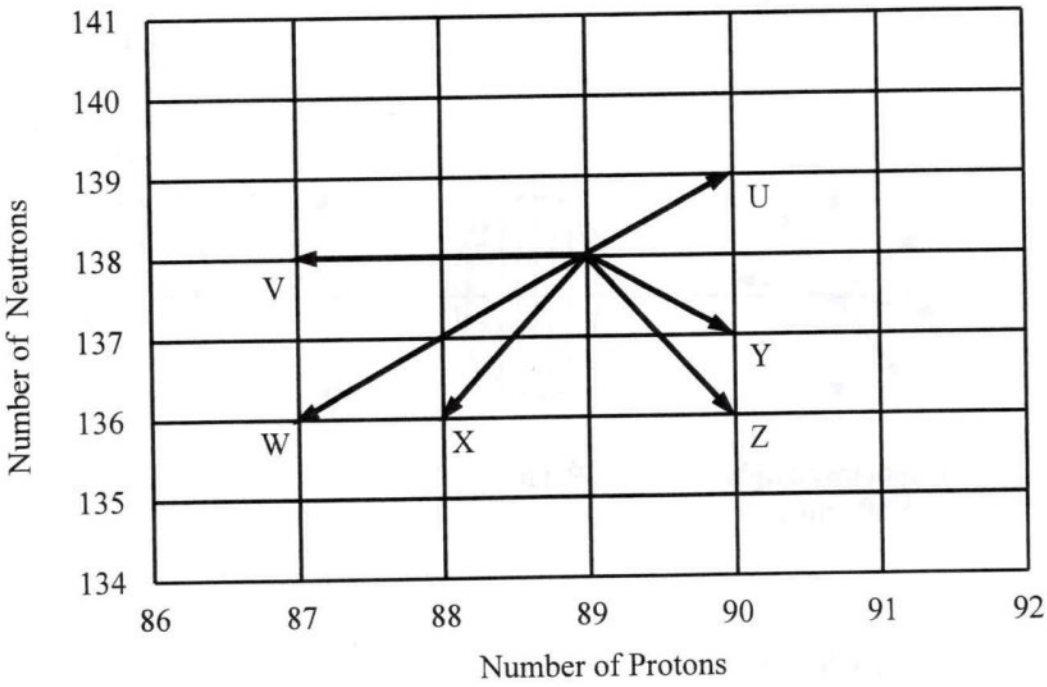
(A) Gamma radiation has a higher wavelength.

(B) Gamma radiation travels faster in a vacuum.

(C) Gamma radiation has less power to ionise molecular bonds.

(D) Gamma radiation produces photoelectrons with higher maximum kinetic energy.

14 An Actinium-227 isotope can naturally undergo either alpha, or beta-minus decay.
Which arrows on the diagram would best represent an alpha and beta-minus decay respectively?



(A) W and Y

(B) W and Z

(C) X and Z

(D) Y and X

15 In a particle accelerator a proton has a momentum of 5.1×10^{-19} kg m s^{-1}. Calculate the proton's wavelength.

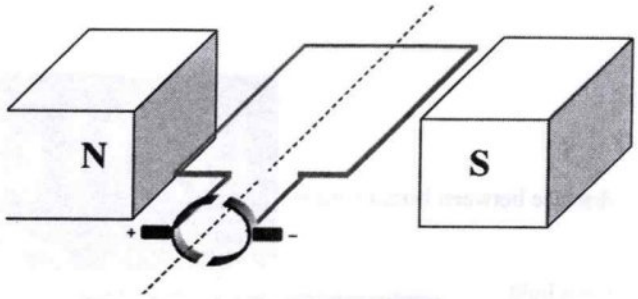
(A) 1.3×10^{-18} m

(B) 1.3×10^{-15} m

(C) 4.0×10^{-10} m

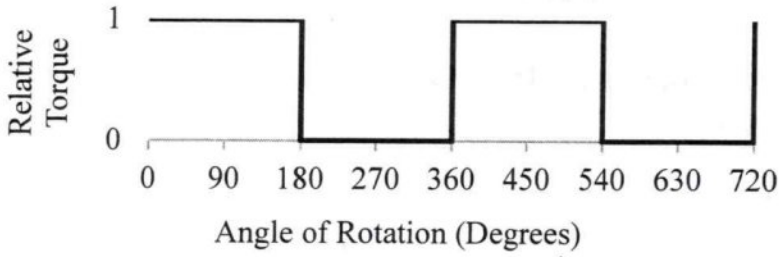
(D) 4.0×10^{-7} m

16 The diagram shows a simple D.C. motor.

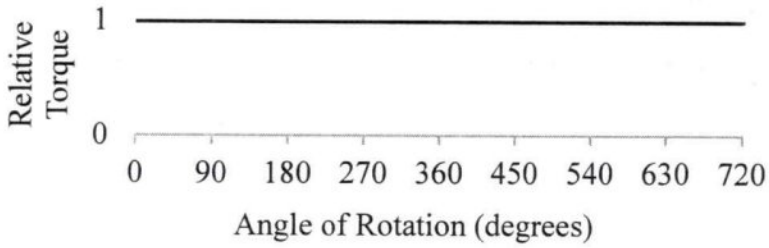


Which of the following graphs correctly shows the change in torque on the coil, as the motor rotates through two revolutions?

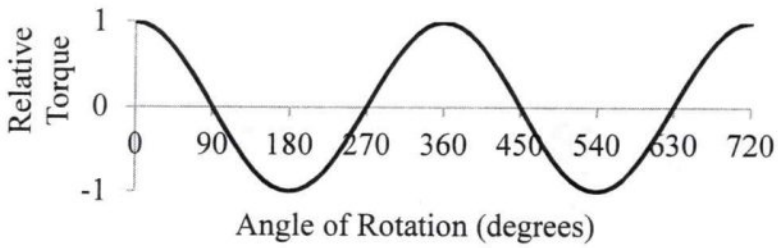
(A)



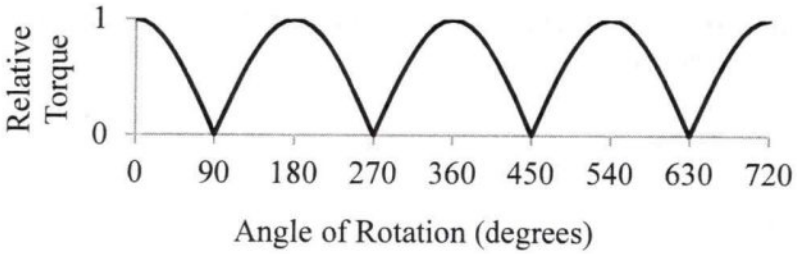
(B)



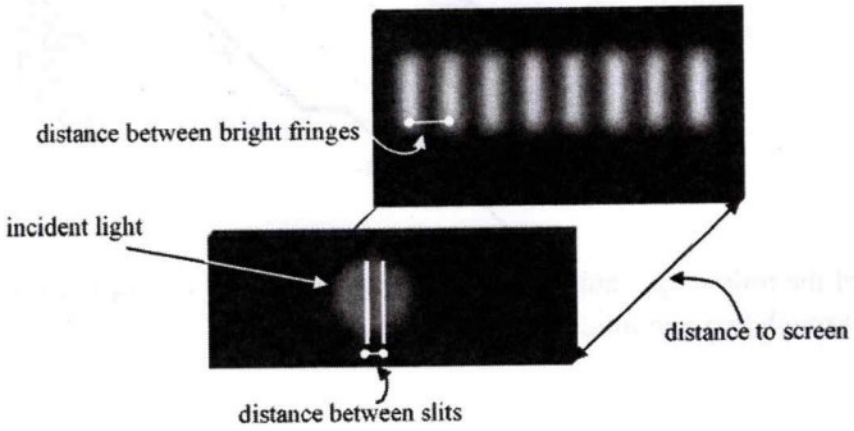
(C)



(D)



17 The diagram below shows the set-up for an investigation of double-slit diffraction.



Which of the following changes would increase the distance between the bright fringes appearing on the screen?

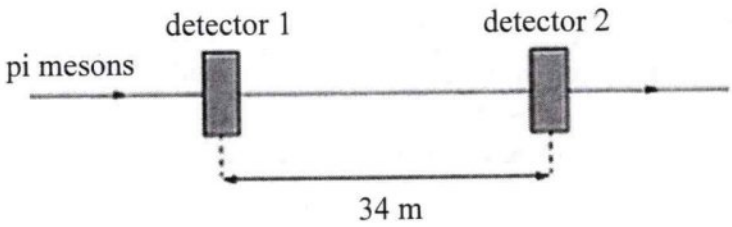
(A) Moving the screen closer to the double slits.

(B) Increase the wavelength of the incident light.

(C) Increasing the width of the slits, while keeping their separation distance the same.

(D) Increasing the separation distance between the slits, while keeping their width the same.

18 Two detectors are measured to be 34 m apart by an observer in a laboratory. A beam of pi mesons travels in a straight line at a speed of 0.95 c past the two detectors, as shown in the figure below.



What time difference would the observer measure in their reference frame for the pi meson to travel between the two detectors?

(A) 6.0×10^{-8} s

(B) 1.2×10^{-7} s

(C) 1.9×10^{-7} s

(D) 3.8×10^{-7} s

19 How would the spectra of the first stars that were formed after the Big Bang vary from recently formed stars, like the Sun?

(A) There would be no variation.

(B) They would not contain element lines heavier than lithium.

(C) They will contain many fewer lines, as the atoms will have no electrons.

(D) They would contain many more absorption lines, as they will be much hotter.

20 Two relativistc spacecraft travel away from each other, each at a speed of 0.6 c.
What value would each spacecraft measure the others's speed?

(A) Less than 0.6 c

(B) 0.6 c

(C) Greater than 0.6 c, but less than c

(D) 1.2 c

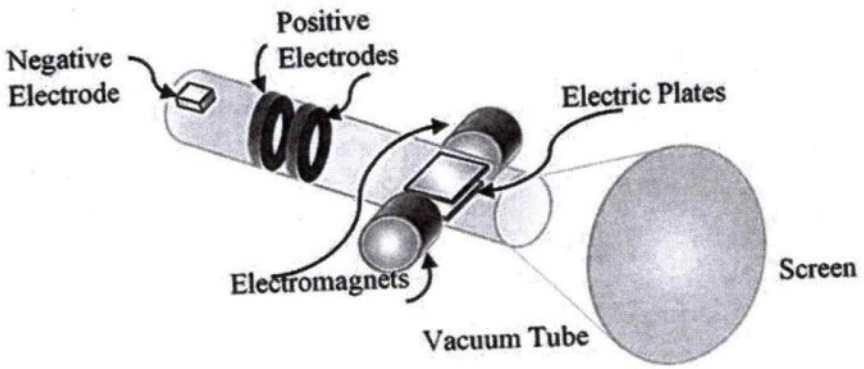
Section II

80 marks
Attempt Questions 21-35
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 on page 30. If you use this space, clearly indicate which question you are answering.

Question 21 (3 marks)

The diagram shows an experiment that was used to discover more about the properties of electrons.



Outline the physics of this experiment and what it revealed about the electron. **3**

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Question 22 (5 marks)

Kepler 186f, an exoplanet that orbits the red dwarf star Kepler 186, was discovered in 2014.

The planet has been proposed as an alternate place for human habitation.

The following data provides a comparsion of the Earth and Sun, to the exoplanet Kepler 186f and its star Kepler 186.

Mass of Sun 2.0×10^{30} kg = 1 solar mass	Mass of star Kepler 186 0.54 solar mass
Orbital radius of Earth 1.5×10^{8} km = 1 astronomical unit	Orbital radius of exoplanet Kepler 186f 0.41 astronomical units
	Mass of the exoplanet Kepler 186f 1.4 Earth's mass
Earth days in a year = 365	Radius of the exoplanet Kepler 186f 1.2 Earth's radius

(a) Calculate the orbital period for Kepler 186f, to the nearest day. **3**

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(b) Show by calculation if the gravity of Kepler 186f would be suitable for human life. **2**

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Question 23 (8 marks)

The International Space Station (ISS), with its crew of six astronauts, orbits the Earth at an altitude of 400 km. The ISS has been constructed utilising multiple space missions and now has a total mass of 420,000 kg.

(a) Calculate the amount of energy required to raise the total mass of the ISS to its 400 km altitude from the Earth's surface. **3**

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(b) Calculate the kinetic energy and the total energy of the ISS as it orbits the Earth. **3**

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(c) Explain why the total energy of the ISS is less than its kinetic energy. **2**

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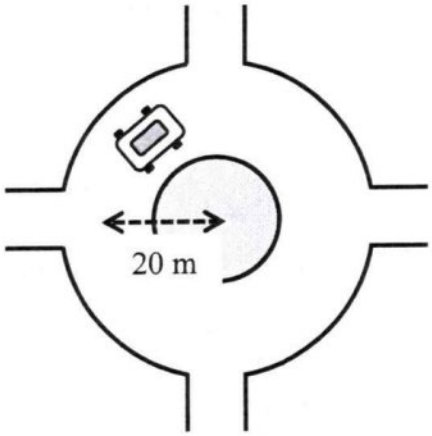
Question 24 (4 marks)

A student, sitting in a passenger seat of a car, was balancing a flat tray with a 50 g marble placed on the centre of the tray. As the car travelled around a roundabout of radius 20 metres at 30 km/h, the student angled the tray to stop the marble rolling off.



(a) What is the angle that the student needed to hold the tray to keep the marble in the centre of the tray, while travelling in the roundabout? Assume no friction acts on the marble. **3**

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(b) If the marble's mass was doubled to 100 g, what angle would the student now require? Justify your answer. **1**

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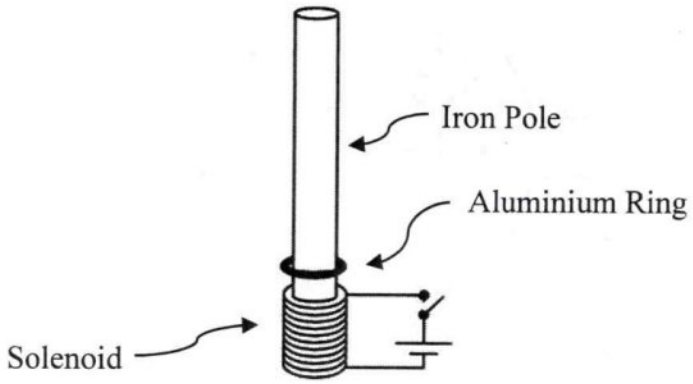
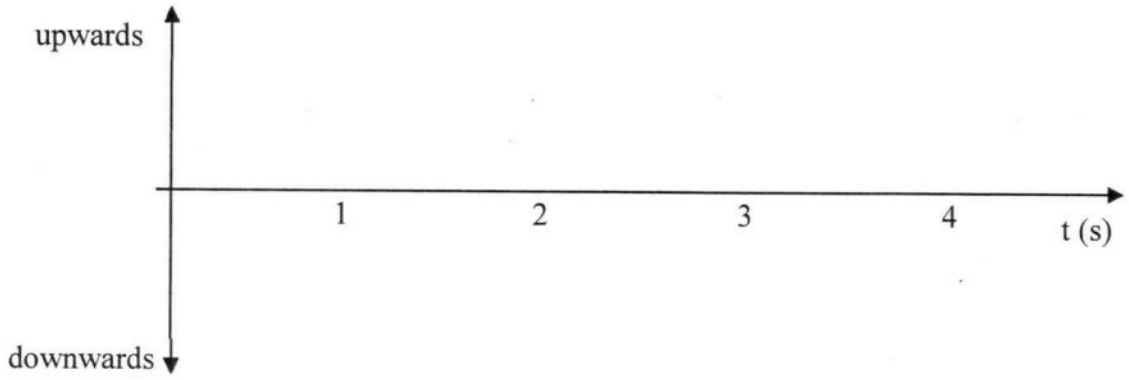
Question 25 (5 marks)

An aluminim ring is free to move up and down an iron pole (as shown).
Wound around the bottom of the pole is a high voltage solenoid.
At time t = 0 s, the ring is resting on the solenoid.
At time t = 1 s, a D.C. voltage is switched on by closing the switch shown.
At time t = 3 s, the D.C. voltage is switched off by opening the switch.



(a) Sketch a velocity versus time graph for the motion of the alumium ring for the first 4 s. **2**



(b) Using the appropriate physics, explain the motion of the aluminium ring, if the switch is closed and remains closed. **3**

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Question 26 (5 marks)

When a uranium-235 nucleus absorbs a slow-moving neutron, a possible outcome is the production of a strontium-90 and xenon-136 nucleus. The nuclear reaction also results in the release of a number of neutrons.

(a) Complete the nuclear equation to represent this fission. State how many neutrons must be released as part of this process. **2**

$^{235}_{92}U + {}^{1}_{0}n \rightarrow$

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(b) Use the information in the table below to calculate the amount of energy released from a single Uranium-235 atom undergoing the fission reaction described above. **3**

Particle	Mass (x 10^{-27} kg)
neutron	1.675
U-235	390.989
Sr-90	149.301
Xe-136	225.687

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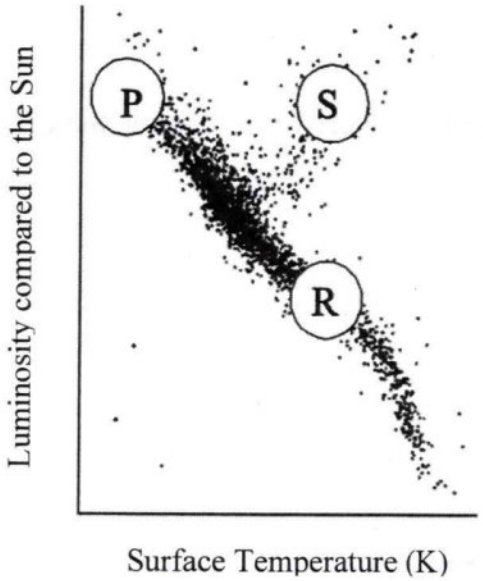
Question 27 (4 marks)

Three stars are positioned on the Hertzsprung Russell Diagram as shown.



(a) State the evolutionary stages of stars P, R and S. **1**

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(b) Compare the nucleosynthesis reactions that are occurring in the three stars. Include the reactants and products of the reactions. **3**

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Question 28 (3 marks)

Outline the important features of Edwin Schrödinger's model of the the atom and contrast one feature from earlier models. **3**

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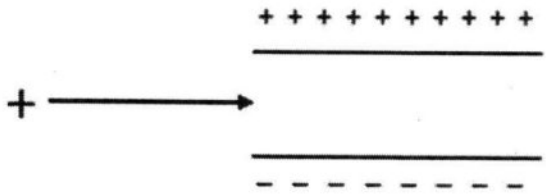
Question 29 (6 marks)

A particle of mass 0.01 g and charge +3 μC enters a uniform electric field as shown.
The voltage between the metal plates is 1000 V, and the plates are 5 cm apart.
The particle enters the field midway between the plates with a velocity of 50 m s^{-1}, perpendicular to the field.



(a) Calculate the horizontal distance travelled by the particle before it reaches one of the electric plates. **3**

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(b) Calculate the velocity of the particle when it reaches the same plate. **3**

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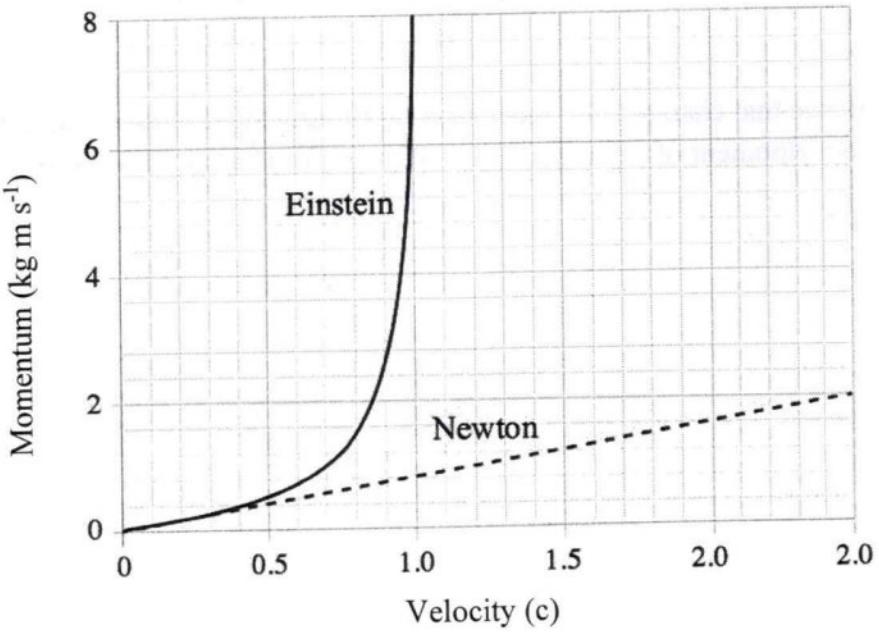
Question 30 (6 marks)

The graph below shows the relationship between the velocity of an object and its momentum as explained by Newton's laws of motion and Einstein's theory of special relativity.



(a) Justify the claim that the gradient of the line labelled Newton is equivalent to mass. **2**

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(b) Account for the differences in the shape of the two lines using Newton's classical mechanics and Einstein's theory of special relativity. **4**

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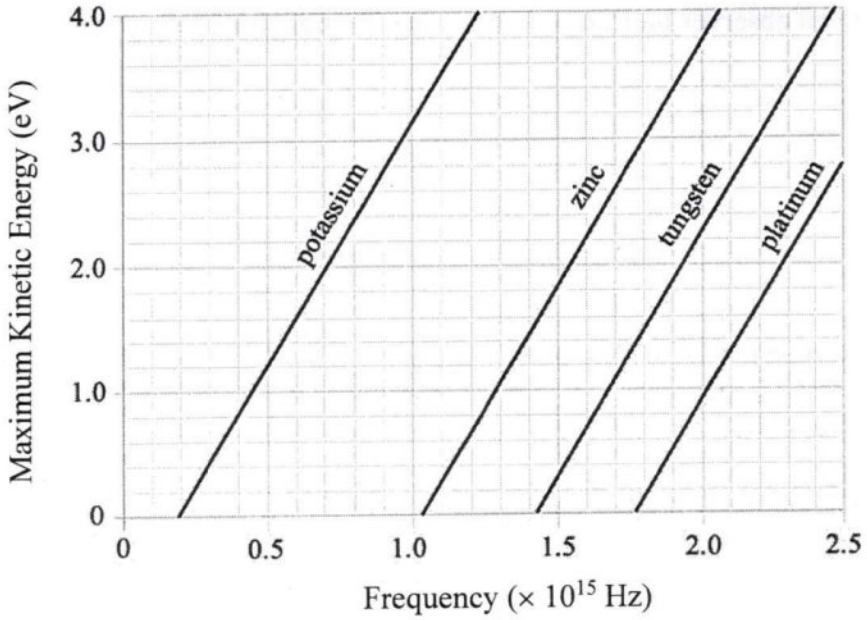
Question 31 (7 marks)

Thomas Young provided the first real experimental evidence for the wave nature of light in 1803 by demonstrating diffraction and interference for a beam of visible light. We now accept light as having either wave or particle properties, depending on the experiment conducted to measure those properties. **7**

Describe the evidence that changed our understanding of light since Young's discovery and explain how it led to the development of wave-particle duality as a model for all forms of electromagnetic radiation.

Question 32 (5 marks)

The graph below shows how the relationship between the frequency of incident light and the maximum kinetic energy of emitted photoelectrons varies for different metals.



(a) Explain the relationship of maximum kinetic energy and frequency as shown on the graph. **3**

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(b) Explain why the line for each of the metals shown on the graph has the same gradient. **2**

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Question 33 (3 marks)

Light takes 4.3 years to reach the Earth from the nearby star Alpha Centauri.

(a) A space probe is to be sent from the Earth to Alpha Centauri to arrive 5.0 years later, according to an observer on Earth. At what speed would the space probe need to travel? **1**

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(b) Calculate the time taken for this journey in years measured by a clock inside the space probe. **2**

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Question 34 (7 marks)

An experiment is performed to measure the charge of the electron. A potential difference of 2041.7 V is applied between two horizontal parallel metal plates which are 20.0 mm apart. As a result, an oil droplet with mass of 5.0×10^{-15} kg is suspended stationary in the field.

(a) Calculate the charge of this oil droplet. **3**

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(b) The experiment was repeated 7 times and the results are shown in the table below. **2**

Trial number	Charge on the oil droplet ($\times 10^{-19}$ C)
1	19.2
2	12.8
3	9.6
4	6.4
5	38.4
6	16.0
7	28.8

What value for the charge on an electron would these results produce?
Justify your answer.

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(c) Electrons are classified as leptons in the Standard Model of matter. Name two other lepton particles. **2**

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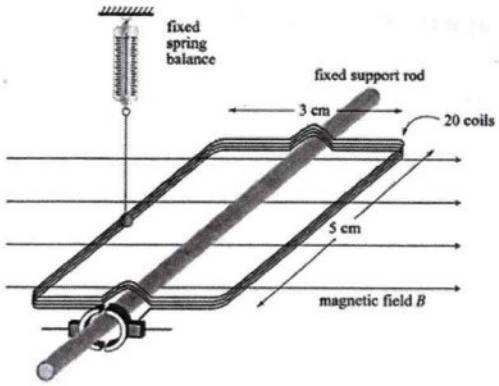
Question 35 (9 marks)

A simple D.C. motor is placed in a magnetic field (B). The rectangular coil has sides 3 cm and 5 cm with 20 turns. A spring balance is attached to one side of the winding to measure the force required to prevent the motor from rotating. The current in the winding is increased and the force on the spring balance recorded.

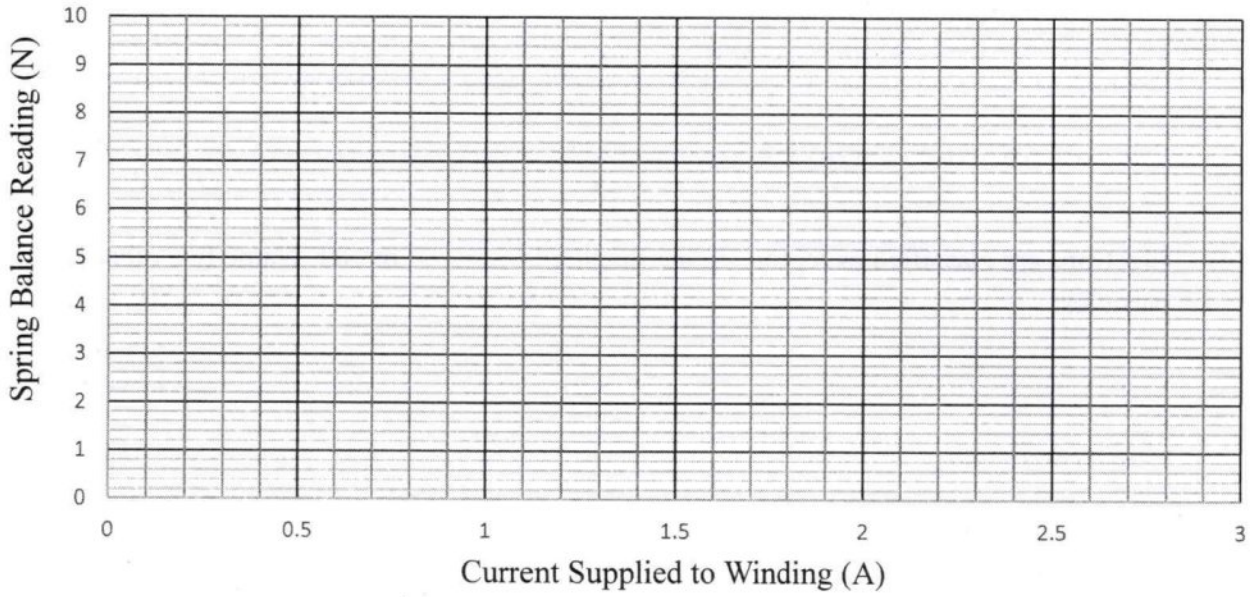


The results are shown in the table.

Current Supplied to Winding (A)	Spring Balance reading (N)
0.0	0
0.5	1.8
1.0	3.3
1.5	5.3
2.0	6.3
2.5	8.5

(a) Indicate the direction the current is flowing on the diagram above. **1**

(b) Graph the results and include a line of best fit. **3**



Question 35 continued

(c) How can the reading on the spring balance be used to determine the torque produced by the motor? **1**

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(d) Use the line of best fit to determine the strength of the magnetic field in this DC motor. **2**

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(e) A student completing this experiment notices that when the motor is running it stays cool, but when the spring balance prevents the motor from turning it gets hot. Explain why this is the case. **2**

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Section II extra writing space

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EXAMINERS

Tony Walsh (Convenor)	Freeman Catholic College, Bonnyrigg Heights
Janet Pemberton (Convenor)	Roseville College, Roseville
Jonathon Saurine	All Saints Grammar School, Belmore
Alex Conolly	Santa Sabina College, Strathfield
Lily Okati	Christian Brothers' High School Lewisham

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