VC

Parramatta High School

2023 **TRIAL EXAMINATION**

Physics

General Instructions

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

Total marks 100

Section I -20 marks (pages 2-9)

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

Section II -80 marks (pages 11-25)

- Attempt Questions 21–33
- Allow about 2 hours and 25 minutes for this part

This paper MUST NOT be removed from the examination room.

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.

1. Which of the following needs to be considered when discussing special relativity?

   (A) Two inertial systems.

   (B) A single inertial system.

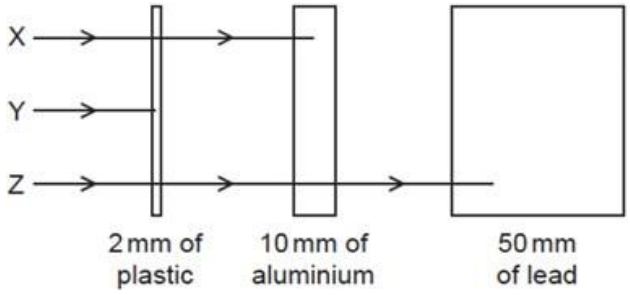
   (C) Two non-inertial systems.

   (D) A single non-inertial system.

2. Which row in the table identifies the change in the total mass of the particles and describes the process of nuclear fusion involved?

	Change in the total mass of particles	*Process*
(A)	Decreases	A large nucleus split into two smaller nuclei
(B)	Increases	A large nucleus split into two smaller nuclei
(C)	Decreases	Two small nuclei combine to form a large nucleus
(D)	Increases	Two small nuclei combine to form a large nucleus

3. The diagram shows the path of three different type of radiation, X, Y and Z

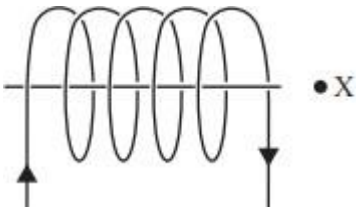


Which row in the table correctly identifies X, Y and Z?

	X	*Y*	*Z*
(A)	α-particles	β-particles	γ- rays
(B)	β-particles	α-particles	γ- rays

(C)	β-particles	γ- rays	α-particles
(D)	γ- rays	α-particles	β-particles

4. The diagram below shows a solenoid.



Which one of the following best describes the direction of the magnetic field of the coil at point X?

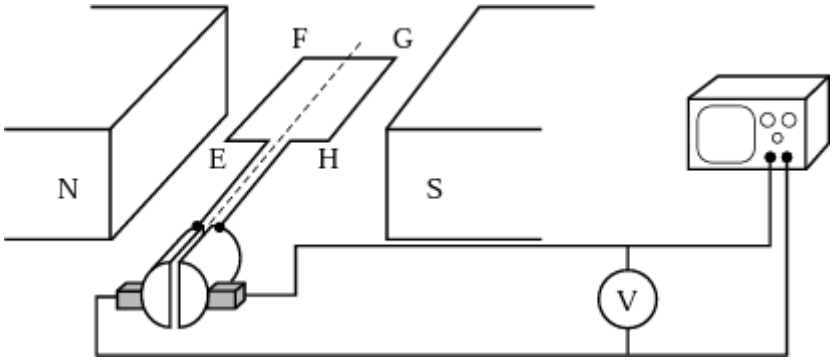
(A) left

(B) right

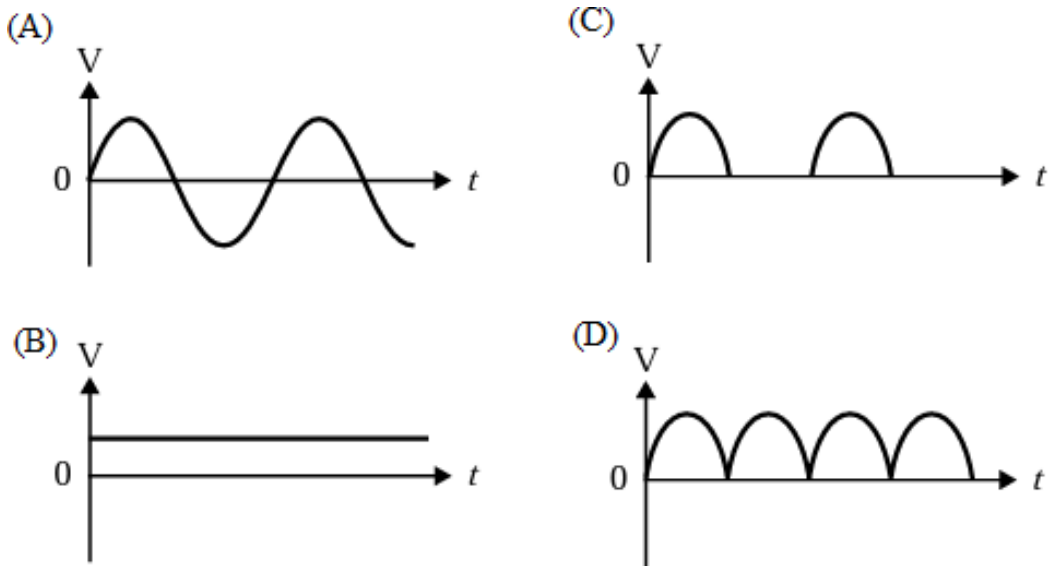
(C) up

(D) out of the page

5. The diagram shows a generator attached to an oscilloscope, at t = 0 the coil is horizontal.



Which one of the following graphs best shows the voltage output as viewed on the oscilloscope as the coil rotates steadily?



6. Which of the following explains the reduced power loss when the voltage is increased in the power transmission cable?

   (A) The resistance of the cable decreases.

   (B) The current increases, increasing the flow of charge.

   (C) The current decreases, reducing thermal energy losses.

   (D) The resistance of the cable increases, reducing the current.

7. A warrior spins a slingshot in a horizontal circle above his head at a constant speed. The sling is 1.5 m long, and the stone has a mass of 50 g. The tension in the string is 3.3 N.

   When he releases the sling, what will be the stone's speed?

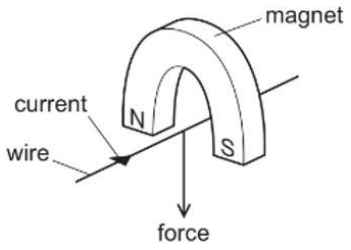
   (A) 5 m/s

   (B) 10 m/s

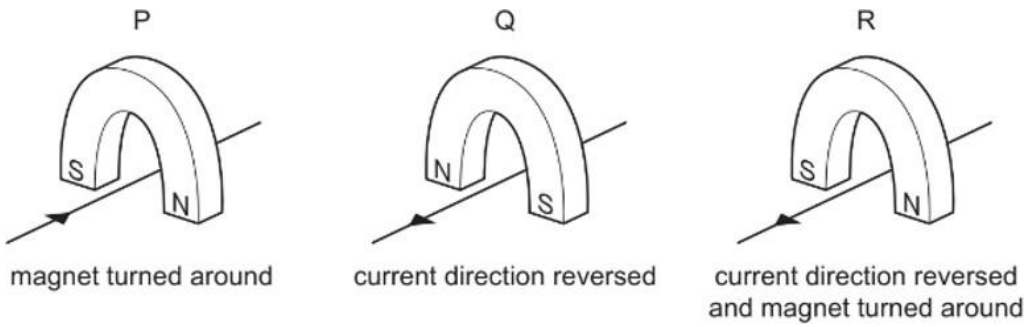
   (C) 25 m/s

   (D) 30 m/s

8. A wire is placed between the poles of a horseshoe magnet. There is a current in the wire in the direction shown, and this causes a force to act on the wire.



   Three other arrangements, P, Q and R, of the wire and magnet are set up as shown.



Which arrangement(s) will cause a force in the same direction as the original arrangement?

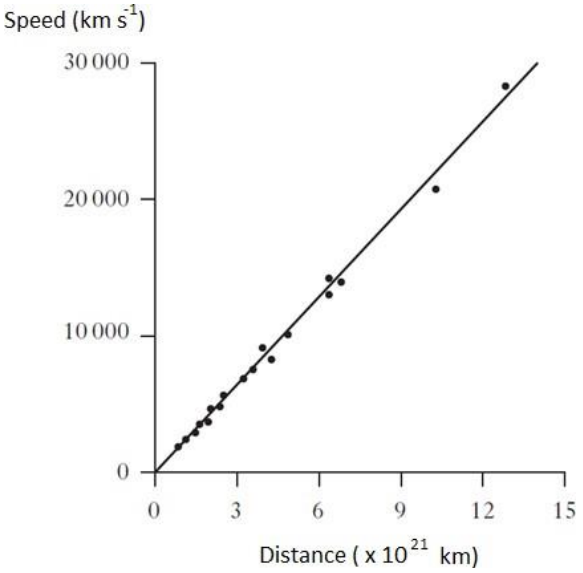
(A) P only

(B) R only

(C) P, Q and R

(D) P and Q only

9. Galaxies at different distances from the Earth have been found to have different speeds. The graph shows the recessional velocities for some distant galaxies.



Which of the following statement is correct?

(A) The unit for Hubble's constant is s^{-2}.

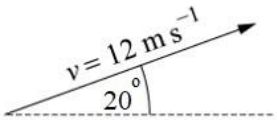
(B) The area under the line is the value of Hubble's constant.

(C) The gradient of the line gives the value of Hubble's constant.

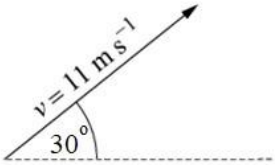
(D) The speed of distant galaxies varies inversely with their distance from the Earth.

10. Which diagram would result in the furthest horizontal distance travelled?

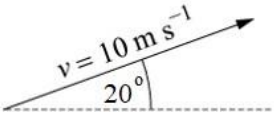
(A)



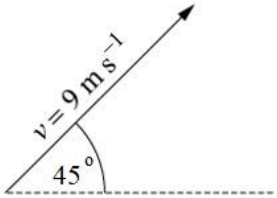
(B)



(C)



(D)



11. Which of the following is Lenz's Law?

(A) The total electric charge of an isolated system remains constant regardless of changes within the system.

(B) The magnetic flux around current-carrying wire changes in proportion to the rate of change of the current.

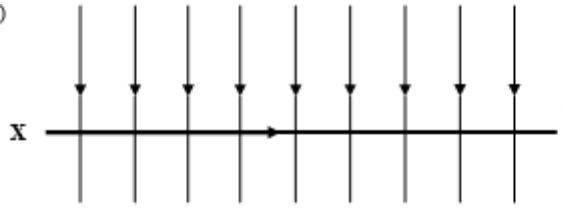
(C) The direction of an induced electric current always opposes the change in the circuit or magnetic field that produces it.

(D) The ratio of the sines of the angles of incidence and refraction of a wave is constant when the wave passes between two given media.

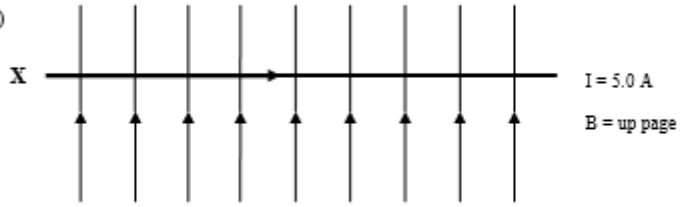
12. Two long, straight parallel conductors, X and Y, each have a current of 5.0 amps flowing in the same direction, as shown. They are 5.0 cm apart.

In which one of the following situations could conductor X experience the same force per length as when it is parallel to conductor Y?

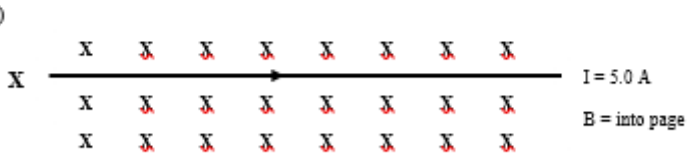
(A)



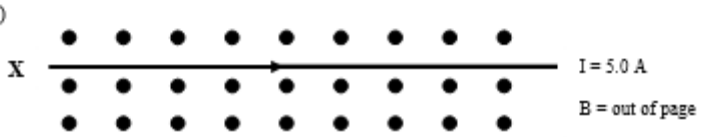
(B)



(C)



(D)



13. The orbit of the International Space Station (ISS) around the Earth is modelled as circular, with an orbital period is 92 mins at a particular time.

How high above Earth's surface is the ISS at that instant in time?

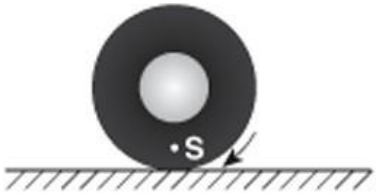
(A) 388.8 km

(B) 441.1 km

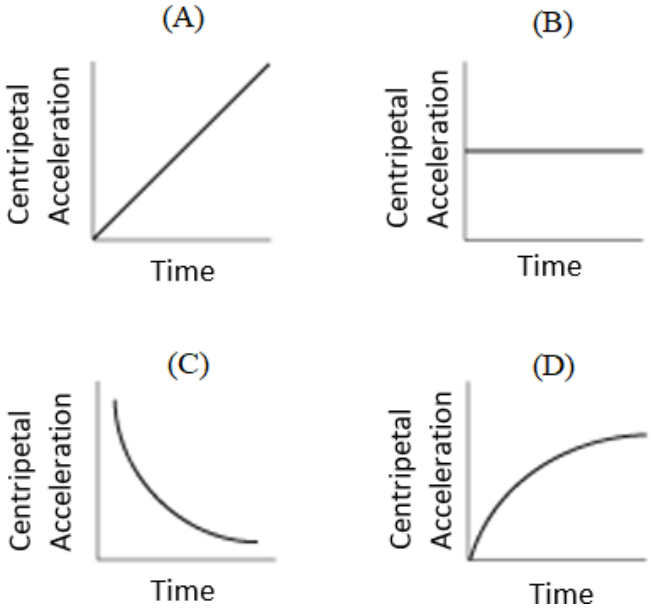
(C) 5928.9 km

(D) 6759.8 km

14. In the diagram below, S is a point on a car tire rotating at a constant rate.



Which of the following graphs best represents the magnitude of the centripetal acceleration of point S as a function of time during one complete revolution of the tyre?



15. In which of the following situations would you expect the smallest escape velocity?

(A) Launching from a 10km high mountain on Earth.

(B) Launching from the bottom of a deep vertical mine shaft.

(C) Launching from a planet with half the radius of Earth, but with the same mass.

(D) Launching from a planet with twice the radius of Earth, but with the same mass.

16. A π meson has a lifetime of approximately $2{\cdot}6 \times 10^{-8}$ s when at rest. A π meson moves with a speed of $0{\cdot}99c$ towards the surface of Earth.

What is the mean lifetime of the π meson as measured by an observer on the Earth?

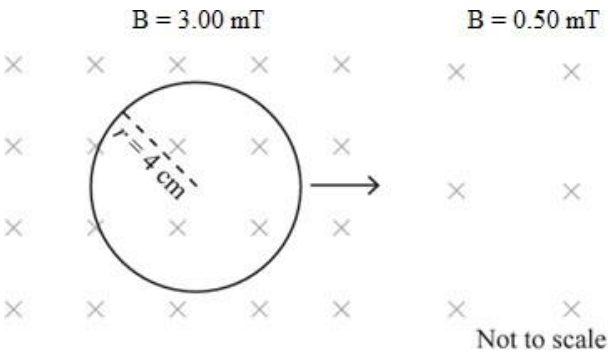
(A) 3.67×10^{-9} s

(B) 2.60×10^{-8} s

(C) 1.87×10^{-7} s

(D) 2.60×10^{-7} s

17. The diagram shows a current-carrying loop moving from one magnetic field to another magnetic field in 0.300 seconds.



What is the magnitude of the EMF produced in the current-carrying loop?

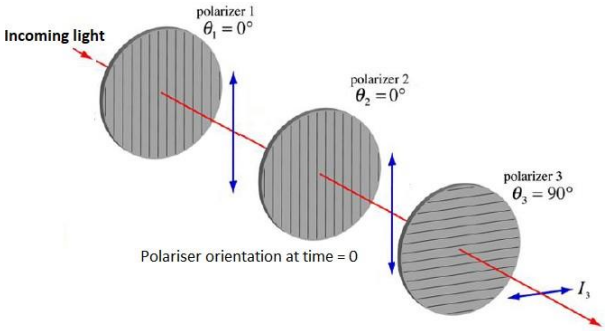
(A) 4.19×10^{-5} V

(B) 8.38×10^{-6} V

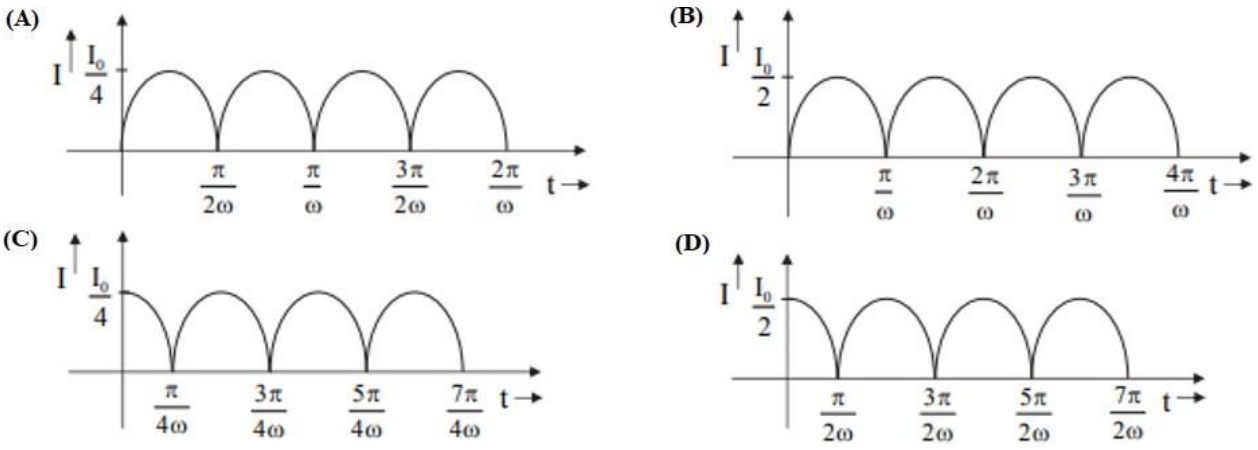
(C) 5.03×10^{-5} V

(D) 4.12×10^{-1} V

18. A polaroid shape rotating with constant angular velocity ω about an axis along the direction of propagation of light and passing through its centre, is kept between two cross polariser. I_0 is the intensity of light after passing through the first polariser. The polaroid sheet is perfectly lined to the first polariser at time t = 0.



Which graph shows the relationship between the intensity of light emerging from the last polariser with time?



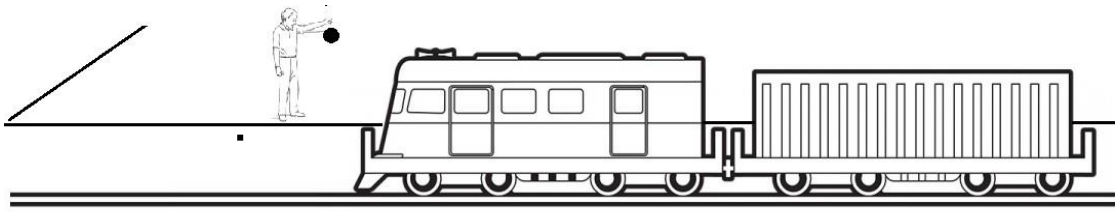
19. The following graph shows $_{69}^{149}Tm$ nuclei undergoing a series of decays to form $_{66}^{141}Dy$.

$$^{149}_{69}\mathrm{Tm} \xrightarrow{\text{Decay 1}} \square \xrightarrow{\text{Decay 2}} \square \xrightarrow{\text{Decay 3}} {}^{141}_{66}\mathrm{Dy}$$

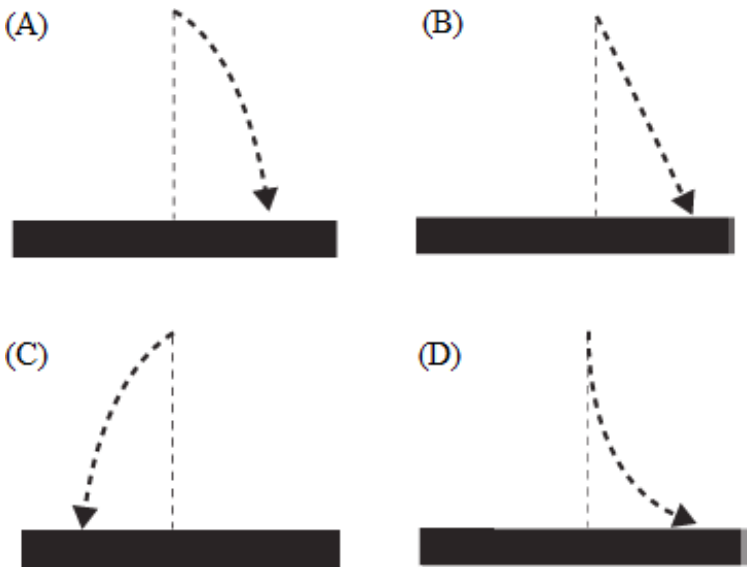
Which of the following row correctly identifies each decay?

	Decay 1	*Decay 2*	*Decay 3*
(A)	α	β^-	α
(B)	β^-	β^+	α
(C)	α	α	β^+
(D)	β^-	β^-	β^+

20. John is standing on a railway station and drops a ball from a height of 1.25 m as shown in the diagram below. Mary is in a train that is passing through the station at a constant speed and observes the falling ball.



Which of the diagrams below best represents the path of the ball as seen by Mary?



3	7	8		

Centre Number

Student Number

2023 **Parramatta High School**

HIGHER SCHOOL CERTIFICATE TRIAL EXAMINATION

Physics

Starting from the left, please write your student number NEATLY in the boxes.

Section I Part A - Multiple Choice

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

Sample: 2 + 4 = (A) 2 (B) 6 (C) 8 (D) 9

A ○ B ● C ○ D ○

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

A ● B ✕ C ○ D ○

If you change your mind and have crossed out what you consider to be the correct answer, then indicate the correct answer by writing the word ***correct*** and drawing an arrow as follows.

Correct

A ✕ B ✕ C ○ D ○

Start Here

1	AO	BO	CO	DO	**11**	AO	BO	CO	DO
2	AO	BO	CO	DO	**12**	AO	BO	CO	DO
3	AO	BO	CO	DO	**13**	AO	BO	CO	DO
4	AO	BO	CO	DO	**14**	AO	BO	CO	DO
5	AO	BO	CO	DO	**15**	AO	BO	CO	DO
6	AO	BO	CO	DO	**16**	AO	BO	CO	DO
7	AO	BO	CO	DO	**17**	AO	BO	CO	DO
8	AO	BO	CO	DO	**18**	AO	BO	CO	DO
9	AO	BO	CO	DO	**19**	AO	BO	CO	DO
10	AO	BO	CO	DO	**20**	AO	BO	CO	DO

Do NOT write anything or make any marks below this line.

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.

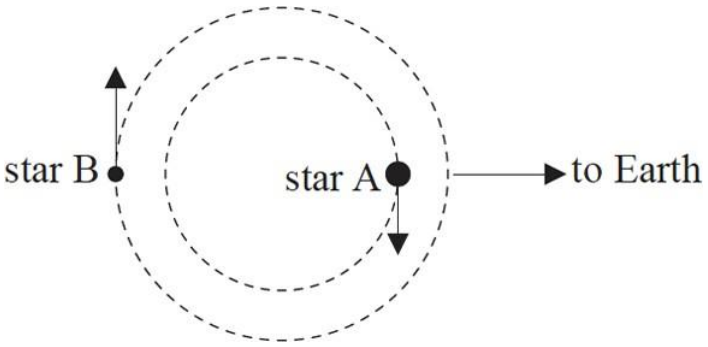
Show all relevant working out in questions involving calculations.

Extra writing space is provided in an extra writing booklet. If you use this space, clearly indicate which question you are answering.

Question 21 (6 marks)

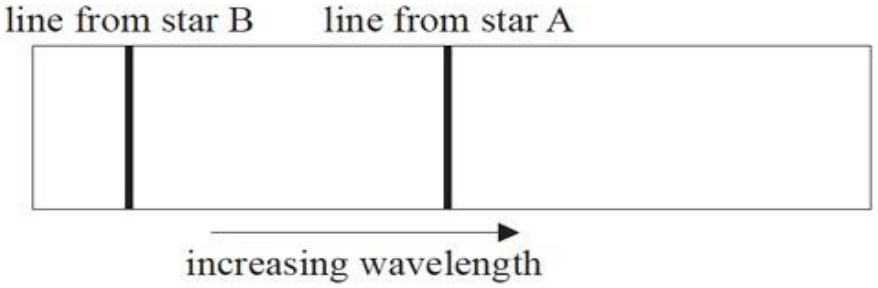
Stellar spectra of the stars provide us with information about stars and the universe.

a) Star A is part of a binary star system. The diagram shows the orbit of star A and the orbit of its companion, star B.



The diagram below shows the spectrum of the stars as observed from Earth. The spectrum shows one line from star A and one line from star B, when the stars are in the position shown in the diagram above.

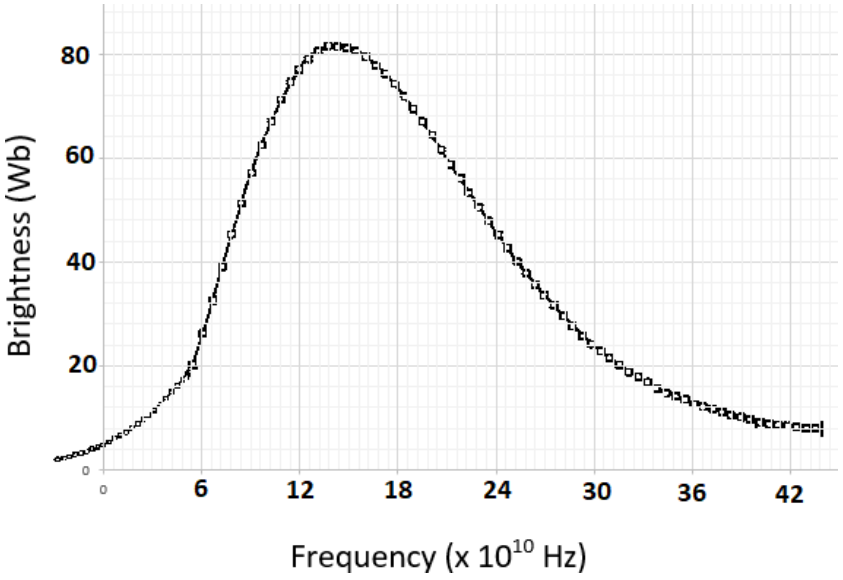
On the spectrum below, draw lines to show the approximate positions of these spectral lines after the stars have completed one quarter of a revolution. (2)



Question 21 continues pg12.

Question 21 continued

b) The following is a spectrum of the cosmic background radiation in space.



i) Determine the temperature of the cosmic background radiation (2)

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ii) Describe the significance of the cosmic background radiation. (2)

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End of Question 21

Question 22 (6 marks)

A 250 kW generating station produces power at 1000 volts. The electricity is then stepped up to 280 000 V for transmission to a nearby city. On the edge of the city, the electricity is stepped down to 10 000V and sent to a transformer station. Finally, the voltage is reduced to 1300 V in a local neighbourhood.

a) Explain why everyday transformers are not ideal. (3)

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b) Assuming all transformers are ideal (100% efficient), how much current is available for the neighbourhood? (3)

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Question 23 (6 marks)

Threshold frequency and work function are important ideas in the study of the photoelectric effect.

Tables A and B summarise the work functions of three metals and the photon energies of three UV light sources.

Table A			Table B	
Metal	*Work function (eV)*		*Light source*	*Photon energy (eV)*
Zinc	4.3		1	4.0
Iron	4.5		2	4.4
copper	4.7		3	5.0

a) Determine the electron's kinetic energy if light source 3 was shone on zinc metal. (2)

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b) Discuss the combinations of metals and UV light sources that could be best used to demonstrate the idea of threshold frequency and the idea of work function. (4)

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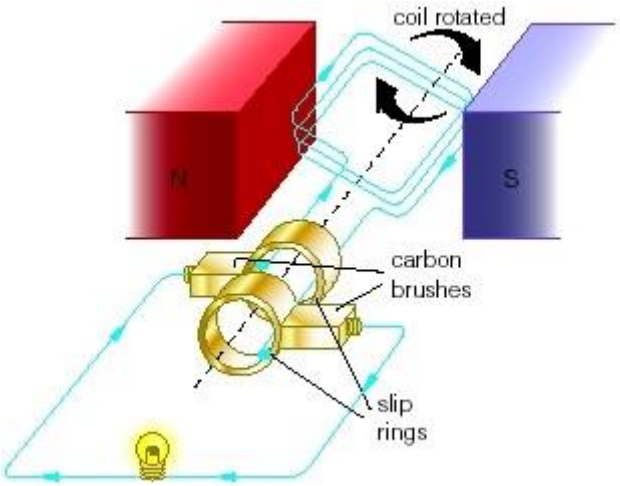
Question 24 (7 marks)

Generators and motors are used in everyday life.

a) A simple AC generator is shown in the diagram below.



Explain how the alternating current is produced, making specific reference to the labelled parts in the diagram. (4)

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b) Explain the difference between a DC motor and an AC induction motor. (3)

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Question 25 (7 marks)

Newton can be considered one of the greatest physicists with his studies of mechanics and optics.

a) Outline the experimental evidence that supports Newton's theory of light. (2)

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a) The average force of attraction on the Moon from the Sun is 4.4×10^{20} N. The Moon is 3.8×10^{5} km away from Earth. The distance of the Sun to the Earth is 151.83×10^{6} km and the mass of the Sun is 1.989×10^{30} kg.

Determine the gravitational force between the Earth and the Moon, taking the distance from the Sun to the Moon to be about the same as that from the Sun to the Earth. (4)

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Question 26 (4 marks)

Helium is the second most abundant element in the universe. The most common isotope of helium is $24He$ and a nucleus of this isotope has a rest energy of 3728 MeV.

In 2011, anti-helium nuclei were produced at the Relativistic Heavy Ion Collider. Nuclei of anti-helium are made up of anti-protons and anti-neutrons.

In one particular collision between an anti-helium nucleus and a helium nucleus, the nuclei are annihilated, and two photons are formed.

Calculate the maximum frequency of the photons produced in this annihilation. (4)

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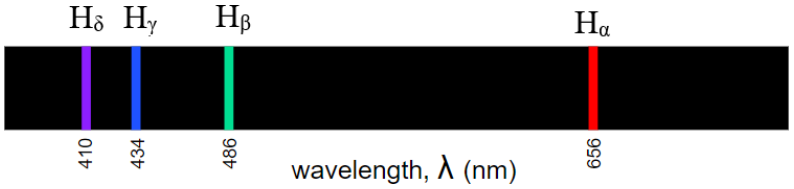
Question 27 (7 marks)

In a laboratory experiment, light from a hydrogen discharge lamp is used to produce a line emission spectrum. The line spectrum for hydrogen has four lines in the visible region, as shown.



(a) Show that H_α is the transition from n= 3 to n=2. (2)

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Question 27 continues pg18.

Question 27 continued

(b) Explain how emission spectrums can be used to support and refute Bohr's model of the atoms. (5)

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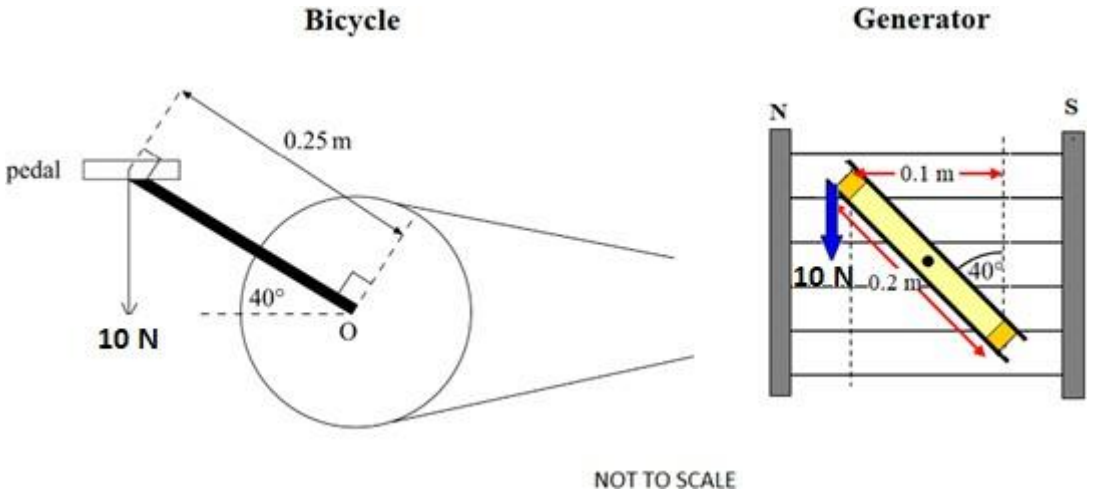
End of Question 27

Question 28 (4 marks)

The diagram shows a force of 10 N acting on a pedal of a bicycle and a generator coil.



Compare and contrast the changing in torque as the force is applied for one revolution.

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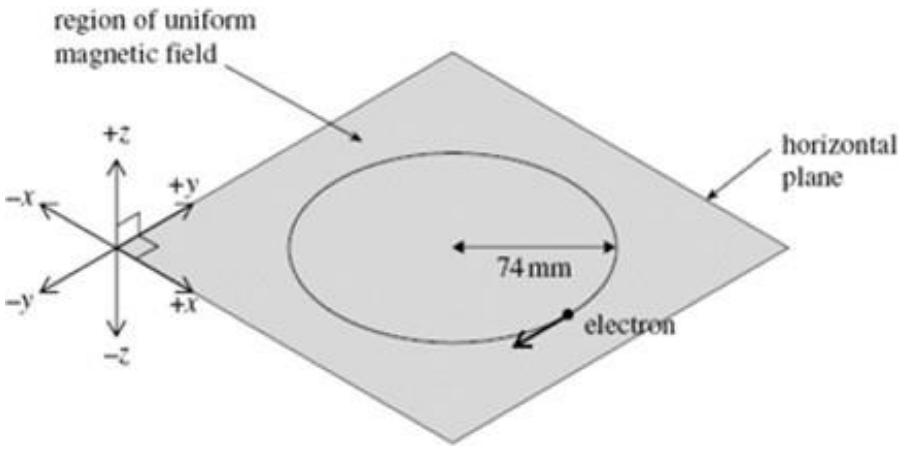
Question 29 (6 marks)

When travelling in a vacuum through a uniform magnetic field of flux density 0.43 mT, an electron moves as shown in the figure below.



a) Outline the motion of the electron in the uniform magnetic field. (2)

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b) How many times does an electron travel around the circle in one minute? (4)

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Question 30 (7 marks)

Explain how diffraction plays a significant role in changing models, ideas and theories in Physics. (7)

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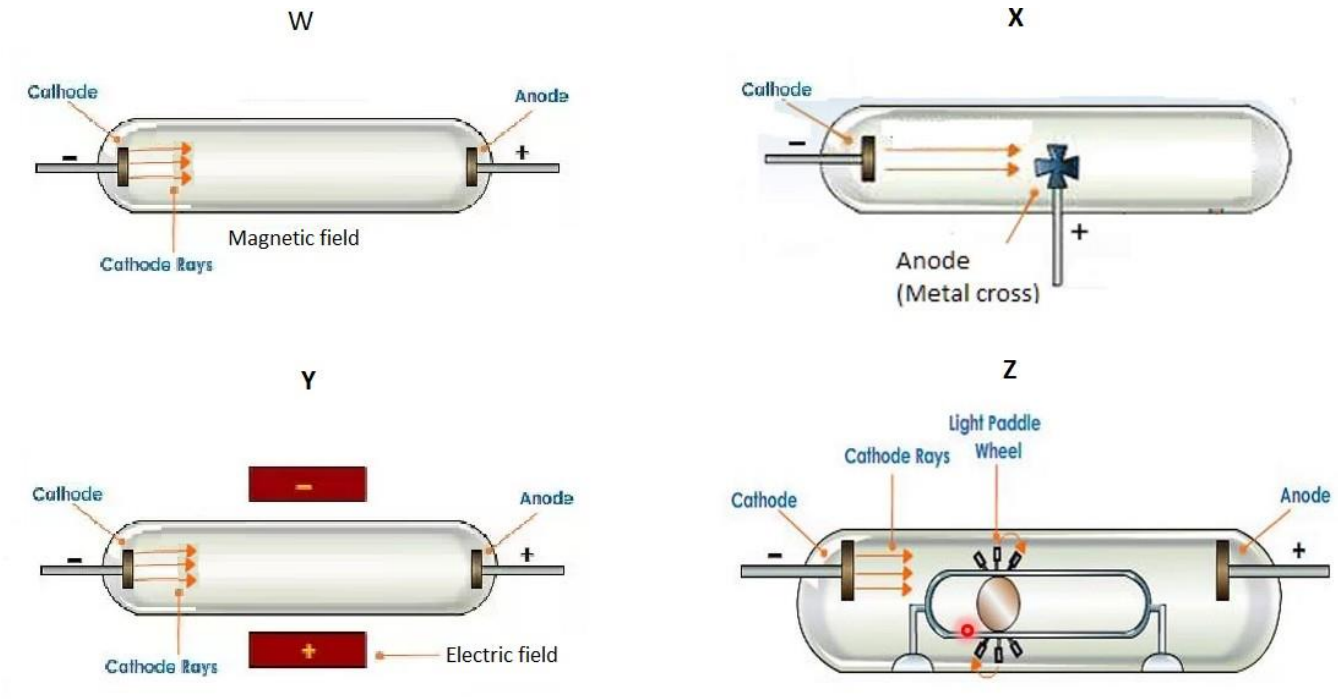
Question 31 (6 marks)

The following diagram shows experiments used to understand cathode rays using 1000 V. The magnetic and electric tube had a fluorescence screen, and the metal cross and paddle wheel were coated in fluorescent material.



a) Explain what will happen if the voltage between the cathode and anode is then doubled for the paddle wheel experiment. (2)

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Question 31 continues pg23.

b) How did each experiment contribute to improving our understanding of cathode rays? (4)

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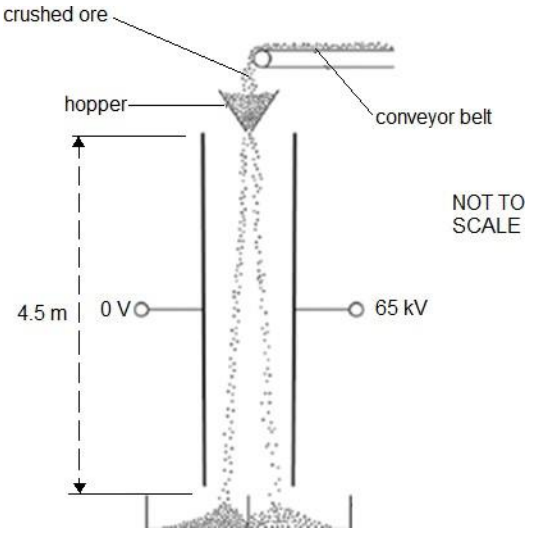
End of Question 31

Question 32 (7 marks)

The picture shows a system that separates two minerals from the ore containing them using an electric field.



The crushed particles of the two different minerals gain opposite charges due to friction as they travel along the conveyor belt and through the hopper. When they leave the hopper, they fall 4.5 metres between two parallel plates that are separated by 0.35 m.

a) Explain why the time to fall vertically between the plates is independent of the mass of a particle. Support your answer with an equation. (2)

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a) A particle with a specific charge-to-mass ratio of 1.2×10^{-6} C kg^{-1} falls between the plate. Determine the total horizontal deflection of a particle that occurs when falling between the plates. (5)

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Question 33 (7 marks)

An orbiting satellite will have kinetic energy and gravitational potential energy.

By deriving the equation for the total energy of a satellite in its orbit, draw a graph to show the relationship between the satellite's kinetic energy, gravitational potential energy, and total energy with the radius of the orbit. (7)

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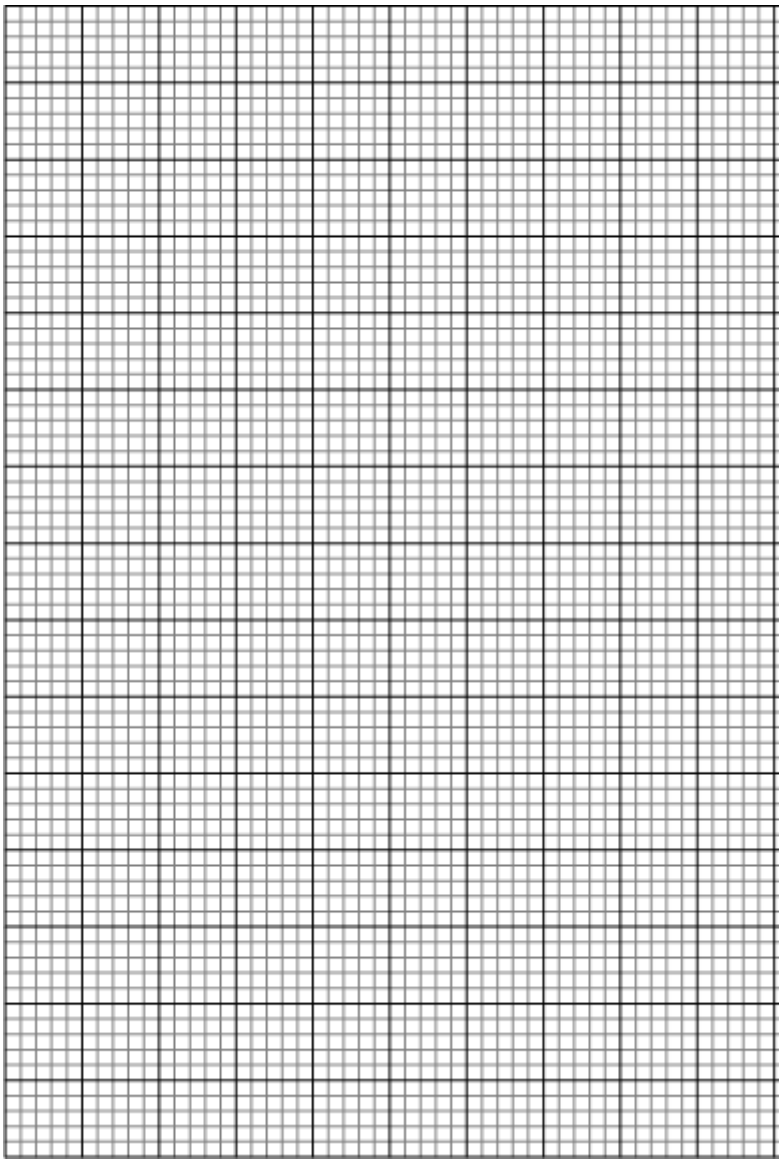


End of Test

ANSWERS

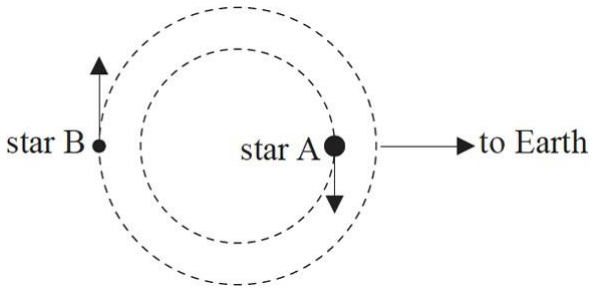
Start Here

1	AO	BO	CO	DO	**11**	AO	BO	CO	DO
2	AO	BO	CO	DO	**12**	AO	BO	CO	DO
3	AO	BO	CO	DO	**13**		BO	CO	DO
4	AO	BO	CO	DO	**14**	AO	BO	CO	DO
5	AO	BO	CO	DO	**15**	AO	BO	CO	DO
6	AO	BO	CO	DO	**16**	AO	BO	CO	DO
7	AO	BO	CO	DO	**17**	AO	BO	CO	DO
8	AO	BO	CO	DO	**18**	AO	BO	CO	DO
9	AO	BO	CO	DO	**19**	AO	BO	CO	DO
10	AO	BO	CO	DO	**20**	AO	BO	CO	DO

Question 21 (6 marks)

Stellar spectra of the stars provide us with information about stars and the universe.

a) Star A is part of a binary star system. The diagram shows the orbit of star A and the orbit of its companion, star B.

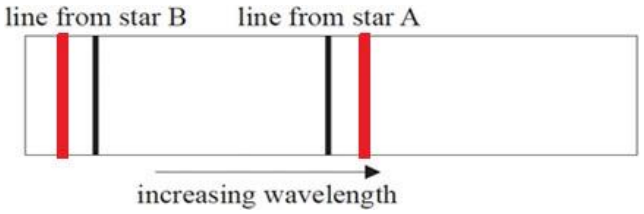


The diagram below shows the spectrum of the stars as observed from Earth. The spectrum shows one line from star A and one line from star B, when the stars are in the position shown in the diagram above.

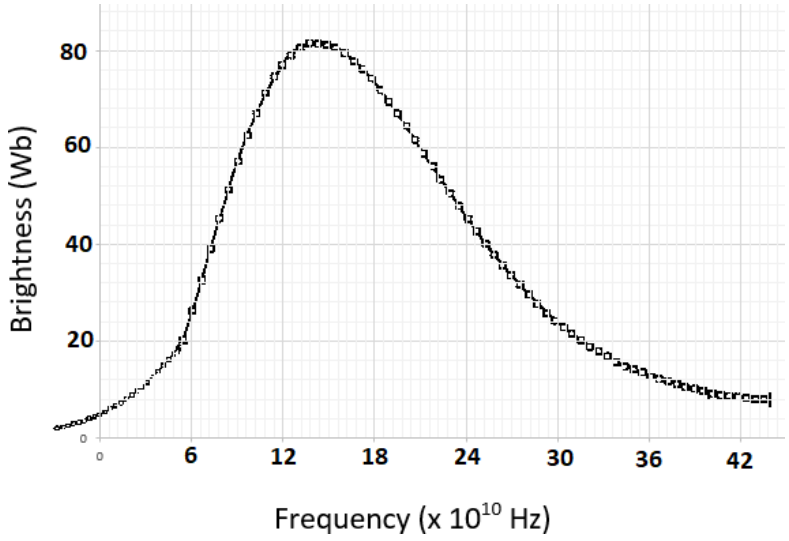
On the spectrum below, draw lines to show the approximate positions of these spectral lines after the stars have completed one quarter of a revolution. (2)

Marking Criteria	Marks
• Provides correct shift for star A and star B	2
• Provides correct shift for star A OR star B	1

Sample answer



b) The following is a spectrum of the cosmic background radiation in space.



iii) Determine the temperature of the cosmic background radiation (2)

Marking Criteria	Marks
• Correctly calculates T	2
• Provide a step to calculate T	1

Sample answer

Peak frequency at 13×10^{10} Hz

So $\lambda = \frac{3\times10^{8}}{13\times10^{10}} = 2.30769\times10^{-3}$

So $T = \frac{b}{2.30769\times10^{-3}} = 1.2558\ K$

iv) Describe the significance of the cosmic background radiation. (2)

Marking Criteria	Marks
• Relates cosmic background radiation to Big Bang theory	2
• Provides some relevant information	1

Sample answer

The cosmic background radiation provides evidence for the Big Bang Theory as it is the left-over energy/remnants of the energy released in the Big Bang, the energy in the explosion has cooled to the microwave region of EMR .

Question 22 (6 marks)

A 250 MW generating station produces power at 1000 volts. The electricity is then stepped up to 280 000 V for transmission to a nearby city. On the edge of the city, the electricity is stepped down to 10 000V and sent to a transformer station. Finally, the voltage is reduced to 1300 V in a local neighbourhood.

a) Explain why everyday transformers are not ideal. (3)

Marking Criteria	Marks
• Provides an explanation for causes of resistive heating and links incomplete flux linkage to induced emf	3
• Provides an explanation for causes of resistive heating OR links incomplete flux linkage to induced emf	2
• Provides some relevant information	1

Sample answer

For everyday transformers, there is energy lost through resistive heating in the wires and the creation of eddy currents in the laminated iron core due to the changing magnetic flux. There is also incomplete flux linkage where the magnetic field is lost around edges and not aligned with the iron core to intensify the magnetic this leads to inefficiency as there are less permeated flux lines to induce emf in the second coil.

b) Assuming all transformers are ideal (100% efficient), how much current is available for the neighbourhood? (3)

Marking Criteria	Marks
• Provides complete steps to calculate the current	3
• Provides steps to calculate the current	2

• Provides a step to calculate current	1

Sample answer

$P = 250 \times 10^3 = IV$, therefore, $I_1 = \frac{250 \times 10^3}{1000} = 250\ A.$

Now, $\frac{V_1}{V_2} = \frac{I_2}{I_1}$ so $\frac{1000}{280000} = \frac{I_2}{250}$, $I_2 = 0.89286\ A$

Similarly, $\frac{V_2}{V_3} = \frac{I_3}{I_2}$ so $I_3 = \frac{280000}{10000} \times 0.89268 = 25$ A

Therefore, current in the neighbourhood, $I_4 = \frac{10000}{1300} \times 25 = 192.3\ A$

Question 23 (6 marks)

Threshold frequency and work function are important ideas in the study of the photoelectric effect.

Tables A and B summarise the work functions of three metals and the photon energies of three UV light sources.

Table A			Table B	
Metal	*Work function (eV)*		*Light source*	*Photon energy (eV)*
Zinc	4.3		1	4.0
Iron	4.5		2	4.4
copper	4.7		3	5.0

a) Determine the electron's kinetic energy if light source 3 was shone on zinc metal. (2)

Marking Criteria	**Marks**
• Provides steps to correctly calculate KE	2
• Provides steps to calculate KE	1

Sample answer

$E = \phi + KE, KE = E - \phi\ so\ KE = 5.0 - 4.3,$

$\frac{1}{2}mv^2 = 0.7$, so $v = \sqrt{\frac{2 \times 0.7 \times 1.602 \times 10^{-19}}{9.109 \times 10^{-31}}} = 496203 = 4.96 \times 10^5\ ms^{-1}$

b) Discuss the combinations of metals and UV light sources that could be best used to demonstrate the idea of threshold frequency and the idea of work function. (4)

Marking Criteria	Marks
• Discuss the combination of metals and light sources for both experiments. • Relating the experiments to the definitions of threshold frequency and work functions	4
• Discuss the combination of metals and light sources. • Relating the experiments to the definitions of threshold frequency and work functions	3
• Discuss the combination of metals and light sources. • Relating the experiments to the definitions of threshold frequency or work functions	2
• Provides some relevant information	1

Sample answer

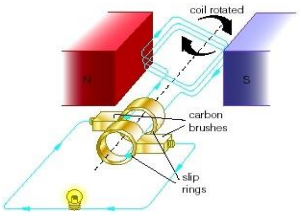
To demonstrate the idea of work function, you would use zinc metals with the three different light sources to show that the photon energy of light source 1 is not enough to liberate photoemission. However, light sources 2 and 3 would have enough energy.

To demonstrate the idea of threshold frequency, you would use light source 2 and the different metals to show the idea of threshold frequency, that the frequency of light should 2 is below the threshold frequency of iron and copper, which is why there is no photoemission, however, with zinc, there is photoemission as it is beyond the threshold.

Question 24 (7 marks)

Generators and motors are used in everyday life.

a) A simple AC generator is shown in the diagram below.



Explain how the alternating current is produced, making specific reference to the labelled parts in the diagram. (4)

Description	Marks
As the coil rotates, each side travels up or down, cutting across the magnetic flux present.	1
The current induced in each side of the coil changes direction every half turn of the coil.	1
Each side of the coil is attached to the external circuit by a slip ring.	1
The slip ring maintains sliding contact with the carbon brushes so the current in each ring changes direction every half turn, which produces an AC current.	1
Total	**4**

Sample answer
As the coil rotates, each side travels up or down, cutting across the magnetic flux present.

The current induced in each side of the coil changes direction every half turn of the coil.

Each side of the coil is attached to the external circuit by a slip ring.

The slip ring maintains sliding contact with the carbon brushes so the current in each ring changes direction every half turn, which produces an AC current.

b) Explain the difference between a DC motor and an AC induction motor. (3)

Marking Criteria	**Marks**
• Explains 3 differences using structure and function	3
• Outlines 2 differences using structure and function	2
• Explains 1 difference	1

Sample answer

DC motor	AC induction motor
A DC motor uses a current-carrying coil in a magnetic field. The coil experiences a torque due to the interaction of the field with the current. This makes the coil rotate. The net result is the conversion of *electric potential energy* into *kinetic energy*.	An AC induction motor uses the principle of electromagnetic induction, as described by Faraday's Law. No current is supplied directly to the rotating coils, but a current is induced in them by using a changing magnetic field. The changing magnetic field is produced by an AC current
A DC motor runs on direct current. The commutator and brushes changes the electrical contacts on the wires as the coil's momentum carries it past its balance point. Brushes made of graphite or carbon blocks usually provide the sliding contact. Without the commutators and brushes the motor would not spin: it would either stop or just flip back and forth	The rotor sits between the poles of two electromagnets. The AC supplied to the coils of the electromagnets creates an oscillating magnetic field that induces a current in the squirrel cage, which acts as the rotor coils.
A DC motor consists of two main parts; the stator and the rotor. The stator is the part of the motor that doesn't move. It includes the casing of the motor and the magnets. The input wires and brushes are also usually attached to the stator. The rotor is the rotating part. The rotor consists of the armature, which holds the coils (windings), the coils themselves, and the commutators	The rotor (the rotating part) consists of a cylinder with metal rods embedded in it along the length of the cylinder. These are electrically connected at each end of the cylinder to form closed loops. This forms a 'squirrel cage'

Question 25 (7 marks)

Newton can be considered one of the greatest physicists with his studies of mechanics and optics.

a) Outline the experimental evidence that supports Newton's theory of light. (2)

Marking Criteria	Marks
• Outlines refraction, reflection and rectilinear propagation of light	2
• Provides some relevant information	1

Sample answer

Newton's corpuscle theory can explain the experimental evidence of light travelling in straight lines (rectilinear propagation of light). It can also explain reflection -light bouncing off a mirror, conservation of energy in an elastic collision that is the angle of incidence equals the angle of reflection. At that time, due to limited technology in experimental design, it can also explain the refraction of light, that is, light speeds up as it travels through water (light changing speed as it travels through different mediums).

b) The average force of attraction on the Moon from the Sun is 4.4×10^{20} N. The Moon is 3.8×10^{5} km away from Earth. The distance of the Sun to the Earth is 151.83×10^{6} km and the mass of the Sun is 1.989×10^{30} kg.

Determine the gravitational force between the Earth and the Moon, taking the distance from the Sun to the Moon to be about the same as that from the Sun to the Earth. (4)

Marking Criteria	Marks
• Provides steps to correctly calculates F	4
• Provides steps to calculates F	3
• Provides steps to correctly calculate F or M	2
• Provides a correct step	1

Sample answer

Moon and Sun system:

$$F = \frac{GM_s M_m}{r^2} \text{ so } 4.4\times10^{20} = \frac{G\times1.989\times10^{30}M_m}{(151.83\times10^{6}\times10^{3})^2}, \text{ therefore } M_m = \frac{4.4\times10^{20}(151.83\times10^{6}\times10^{3})^2}{G\times1.989\times10^{30}} = 7.6455\times10^{22}$$

$$F = \frac{G(6.0\times10^{24}\times7.6655\times10^{22})}{(3.8\times10^{5})^2} = 2.11893\times10^{20}\ N$$

Question 26 (4 marks)

Helium is the second most abundant element in the universe. The most common isotope of helium is $24He$ and a nucleus of this isotope has a rest energy of 3728 MeV.

In 2011, anti-helium nuclei were produced at the Relativistic Heavy Ion Collider. Nuclei of anti-helium are made up of anti-protons and anti-neutrons.

In one particular collision between an anti-helium nucleus and a helium nucleus, the nuclei are annihilated, and two photons are formed.

Calculate the maximum frequency of the photons produced in this annihilation. (4)

Marking Criteria	Marks
• Provides steps to correctly calculate frequency with 4 sig fig.	4
• Provides steps to correctly calculate frequency.	3
• Provides steps to calculate frequency	2
• Provides a step to correctly calculate frequency	1

Sample answer

Mass of anti-helium= mass of helium

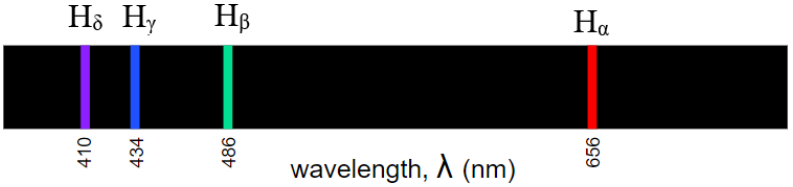
$$Rest\ energy = 2\times3728 = 7456\ MeV = 7456\times10^{6}\times1.602\times10^{-19} = 1.1944512\times10^{-9}\ \text{J}$$

$$\text{Energy of each photon} = \frac{1.1944512\times10^{-9}}{2} = 5.972256\times10^{-10}\ J$$

$$E = hf,\ so\ f = \frac{5.972256\times10^{-10}}{6.626\times10^{-34}} = 9.01336553\times10^{23} = 9.013\times10^{23}\ Hz$$

Question 27 (7 marks)

In a laboratory experiment, light from a hydrogen discharge lamp is used to produce a line emission spectrum. The line spectrum for hydrogen has four lines in the visible region, as shown.



(a) Show that H_α is the transition from n= 3 to n=2. (2)

Marking Criteria	Marks
• Provides steps to correctly determine λ	2
• Provides steps to determine λ	1

Sample answer

$\frac{1}{\lambda} = R_H\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = 1523681.111$ therefore $\lambda = 6.563\times10^{-7} = \lambda = 656.3\times10^{-9} = 656nm$ which is Hα

(b) Explain how emission spectrums can be used to support and refute Bohr's model of the atoms. (5)

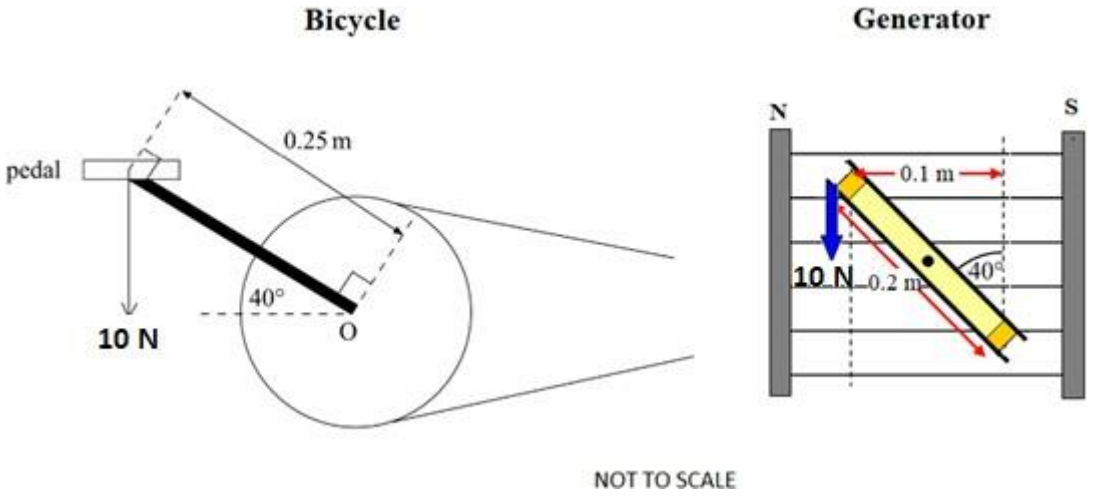
Marking Criteria	**Marks**
• Provides an extensive explanation of how emission spectrum can be used to support and refute Bohr's model of the atoms	5
• Provides a thorough explanation of how emission spectrum can be used to support and refute Bohr's model of the atoms	4
• Provides a sound explanation of how emission spectrum can be used to support and refute Bohr's model of the atoms	3
• Provides a basic explanation of how emission spectrum can be used to support and refute Bohr's model of the atoms	2
• Provides some relevant information	1

Sample answer

Bohr's model is where electrons are orbiting around the nucleus in discrete energy shells. The discrete emission lines for hydrogen support Bohr's model, especially his postulate, where energy is emitted when electrons jump from an excited state back to their ground stationary state and release a discrete photon of energy. An experimental emission spectra evidence that can refute Bohr's model is the zeemen effect where one emission line can be split into two in the presence of a magentci field, based on Bohr's model the electron orbits in fixed circular shell that is discrete with an integer of angular momentum nh/2□, then how can it be split up and change in value in the presence of a magnetic field. Another emission spectra observation is the different intensity of the spectra line based on Bohr's model wach shell has a discrete energy shell why is one energy jump more preferred that the other even though it's not the least energy jump.

Question 28 (4 marks)

The diagram shows a force of 10 N acting on a pedal of a bicycle and a generator coil.



Compare and contrast the changing in torque as the force is applied for one revolution.

Marking Criteria	Marks
• Compare and contrast the changing torque. • Provides steps to correctly calculate the initial torque for both scenarios	4
• Compare and contrast the changing torque. • Provides steps to calculate the initial torque for both scenarios	3
• Compare or contrast the changing torque. • Provides a step to correctly calculate the initial torque	2
• Provides some relevant information	1

Sample answer

The initial torque for both scenarios is in the same direction however, the

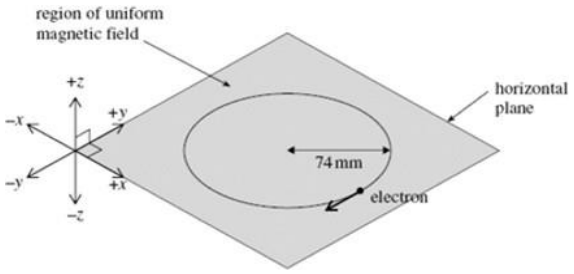
Bicycle initial torque $= 10 \times 0.25 \times \cos cos\ 40 = 1.915\ Nm$

Generator initial torque = $10 \times 0.1 \times \cos cos\ 50 = 0.64279\ Nm$

In both scenarios of the pedal and coil rotating down, the torque increases to a maximum when the plane of the axis rotation is 0 (to the ground for the bicycle and to the magnet field lines for the generator), it then reaches a minimum= 0 when the pedal is 90 degrees to the ground, and the coil is 90 degrees to the magnetic field lines. However, the change in torque for the bicycle will be faster than the coil. After 90 degrees, the torque for both would increase similarly to the going down scenario.

Question 29 (6 marks)

When travelling in a vacuum through a uniform magnetic field of flux density 0.43 mT, an electron moves as shown in the figure below.



a) Outline the motion of the electron in the uniform magnetic field. (2)

Marking Criteria	Marks
• Outlines the vleocity and acceleration of the electron	2
• Provides some relevant information	1

Sample answer

There will be a constant acceleration to the centre of the circle and the velocity of the electron is constantly changing in direction but not magnitude and thus the electron would travel in uniform horizontal circle.

b) How many times does an electron travel around the circle in one minute? (4)

Marking Criteria	Marks
• Provides steps to correctly calculate the numbers of revolution in one minute	4
• Provides steps to calculate the numbers of revolution in one minute	3
• Provides steps to calculate the numbers of revolution	2
• Provides some relevant information	1

Sample answer

$F_E = F_c$ so $qvB = \frac{mv^2}{r}$ therefore, $v = \frac{qBr}{m}$, hence $v = \frac{1.602\times10^{-19}\times0.43\times10^{-3}\times74\times10^{3}}{9.109\times10^{-31}} = 5596183.994\ ms^{-1}$

Now

Orbital period $= \frac{2\pi r}{v} = \frac{2\pi\times74\times10^{3}}{5596183.994} = 8.308442204\times10^{-8}$ sec

So, in 1 min $= \frac{60}{8.308442204\times10^{-8}} = 722157036 = 7.2\times10^{8}$

Question 30 (7 marks)

Explain how diffraction plays a significant role in changing models, ideas and theories in Physics. (7)

Marking Criteria	Marks
• Relates diffraction as experimental evidence for the model of light and changing theories of atomic structure up until Schrodinger	7
• Relates diffraction as experimental evidence for the model of light and changing theories of atomic structure	5-6
• Relates diffraction as evidence for the model of light and changing theories of atomic structure	3-4
• Provides some relevant information	1-2

Sample answer

Young's double slit experiment showed that light was diffracted which is a property of waves this cement the wave model of light and refute conclusive Newton's corpuscle theory. So, diffraction played a significant role in changing or understanding light.

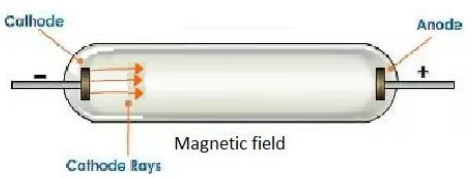
A diffraction grating is also used to observe the spectra of starts- especially the fact that most stars are exhibiting red shift which supports the big bang as has changed the static universe to the expanding universe.

Davisson and Germer's crystal lattice experiment where they wanted to map the scattering of electrons through a metal lattice to see its shape accidentally also showed that electrons underwent diffraction if the gaps between the atoms were small enough. Electrons were known to be a particle the fact that it showed diffraction patterns implies that they also had wave properties. This was the experimental evidence for de Broglie's mathematical hypothesis that electrons travel as standing waves around the nucleus. This idea of electrons orbiting the nucleus as waves have led to the Schrodinger wave number and the acceptance of an electron probability cloud.

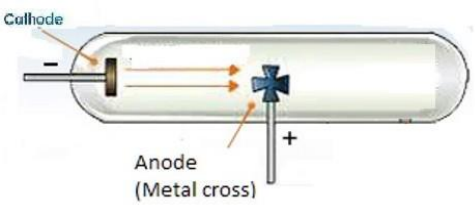
Question 31 (6 marks)

The following diagram shows experiments used to understand cathode rays using 1000 V. The magnetic and electric tube had a fluorescence screen, and the metal cross and paddle wheel were coated in fluorescent material.

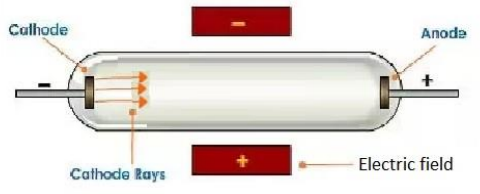
W



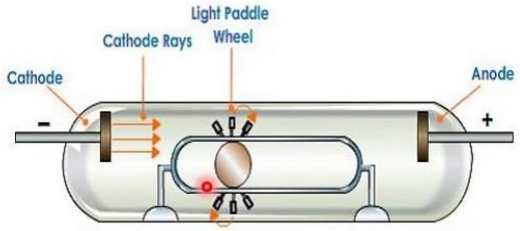
X



Y



Z



a) Explain what will happen if the voltage between the cathode and anode is then doubled for the paddle wheel experiment. (2)

Marking Criteria	Marks
• Explain the change in energy and momentum of the paddle wheel	2
• Provide some relevant information	1

Sample answer

As the voltage increase, the kinetic energy of each cathode rays also increases $W=qV=1/2mv^2$. As a result, the paddle wheel would fluorescence brighter. An increase in energy would increase the velocity thus increase the momentum so the paddle wheel will travel faster.

b) How did each experiment contribute to improving our understanding of cathode rays? (4)

Marking Criteria	Marks
• Explain the properties of the cathode rays that each experiment demonstrated	4
• Explain the properties of the cathode rays that 3 experiments demonstrated	3
• Explain the properties of the cathode rays that 2 experiments demonstrated	2
• Provides some relevant information	1

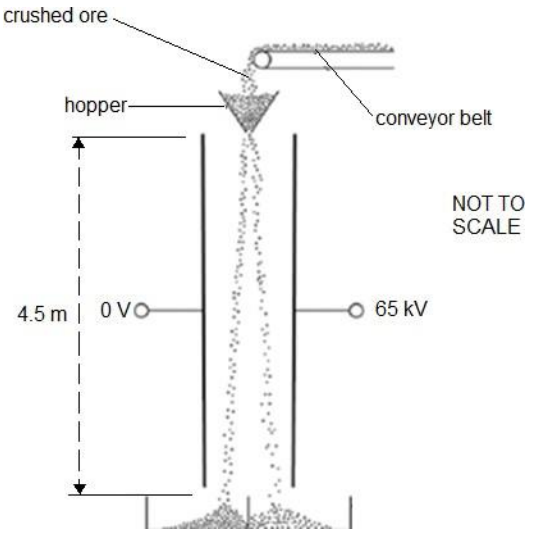
Sample answer

In experiment W, the cathode rays were deflected in the presence of a magnetic field, this shows us the that it was a particle, and the direction of the deflection shows that it was negative in nature. Similarly

in experiment Y, the cathode rays were deflected in an electric field. Experiment X shows that these cathode rays travel in a straight line as it was blocked by the Maltese cross. In experiment Z, it showed that the cathode rays were a particle in order to spin the paddle wheel by momentum since if it waves carrying photons of energy, it would not have enough energy to push the paddle wheel.

Question 32 (7 marks)

The picture shows a system that separates two minerals from the ore containing them using an electric field.



The crushed particles of the two different minerals gain opposite charges due to friction as they travel along the conveyor belt and through the hopper. When they leave the hopper, they fall 4.5 metres between two parallel plates that are separated by 0.35 m.

b) Explain why the time to fall vertically between the plates is independent of the mass of a particle. Support your answer with an equation. (2)

Marking Criteria	**Marks**
• Provides an explanation with an equation	2
• Provides an explanation or an equation	1

Sample answer

$F = ma = m_o g = \frac{GM_p M_o}{r^2}$, so $g = \frac{GM_p}{r^2}$

Then $s = ut + \frac{1}{2}at^2$ thus $t = \sqrt{\frac{2s}{g}}$ so $t = \sqrt{\frac{2s}{\frac{GM_p}{r^2}}}$ is dependent on the mass of the planet, radius of planet and height of drop.

c) A particle with a specific charge to mass ratio of 1.2×10^{-6} C kg^{-1} falls between the plate. Determine the total horizontal deflection of a particle that occurs when falling between the plates. (5)

Marking Criteria	**Marks**

• Provides steps to correctly calculate the defection of the particle with justification	5
• Provides steps to correctly calculate the defection of the particle	4
• Provides steps to calculate the defection of the particle with units	3
• Provides steps to calculate time flight or acceleration	2
• Provides some relevant information	1

Sample answer

$s = ut + \frac{1}{2}at^2$ thus $t = \sqrt{\frac{2s}{g}} = \sqrt{\frac{2\times4.5}{9.8}} = 0.9586148475\text{sec}$

$F_E = ma = qE$, therefore $a = \frac{qE}{m}$, however, $\frac{q}{m} = 1.2\times10^{-6}$, and $E = \frac{V}{d} = \frac{65\times10^3}{0.35} = 185714.2857$

Thus $a = 1.2\times10^{-6}\times185714.2857 = 0.2228571429$

So $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}\times0.2228571429\times0.9586148475^2 = 0.102964$ = 0.10 m

Question 33 (7 marks)

An orbiting satellite will have kinetic energy and gravitational potential energy.

By deriving the equation for the total energy of a satellite in its orbit, draw a graph to show the relationship between the satellite's kinetic energy, gravitational potential energy, and total energy with the radius of the orbit. (7)

Marking Criteria	**Marks**
• Provides a complete derivation of E_T in reference to U • Provides a graph with correct ratio	7
• Provides a derivation of E_T in reference to U • Provides a graph with correct ratio	5-6
• Provides a derivation of E_T • Provides a graph	3-4
• Provides some relevant information. • Attempts to derive an equation	1-2

Sample answer

The total energy of a satellite is equal to the gravitational potential energy and its kinetic energy,

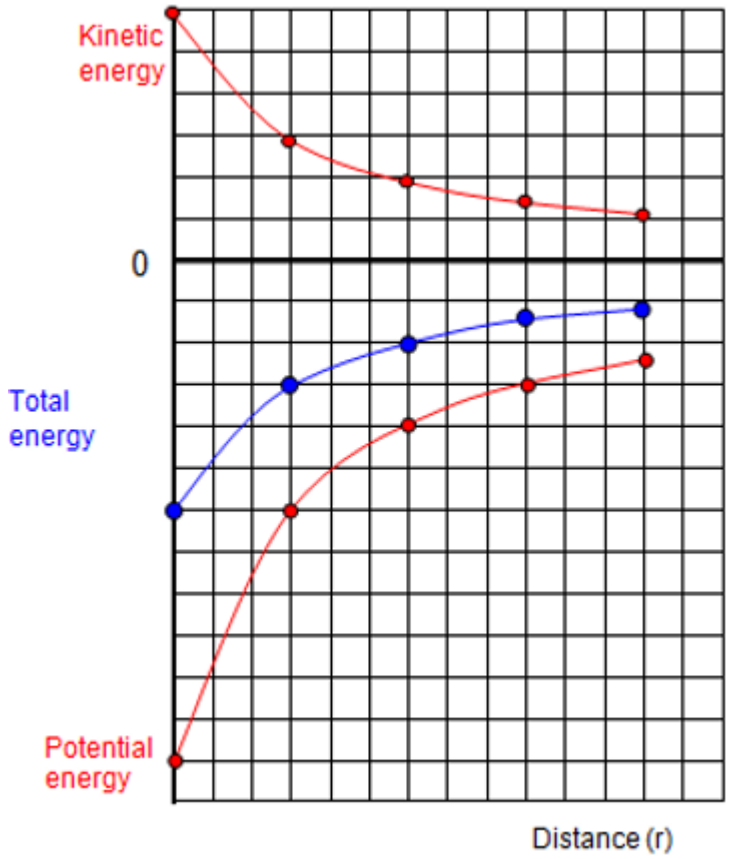
Thus $E_T = U + K$

As satellite moves to a higher orbit, it gains gravitational potential energy, due to the conservation law of energy, as the satellite gains gravitational potential energy it must also lose kinetic energy.

Since orbital velocity is $v = \sqrt{\frac{GM}{r}}$ therefore, $k = \frac{1}{2} m\frac{GM}{r} = \frac{1}{2} U$

Thus $E_T = -\frac{GMm}{r} + \frac{1}{2}\frac{GMm}{r} = -\frac{1}{2}\frac{GMm}{r} = \frac{1}{2}U$

Thus $k = -\frac{1}{2}U$, and $E_T = \frac{1}{2} U$. So the graph is as sown below.



End of Test