Physics

Hornsby Girls High School

2021

HSC Task 4

Trial Examination

Student Number

General Instructions:

- Reading time – 5 minutes
- Working time – 3 hours
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided
- For questions in Section II, show all relevant working in questions involving calculations

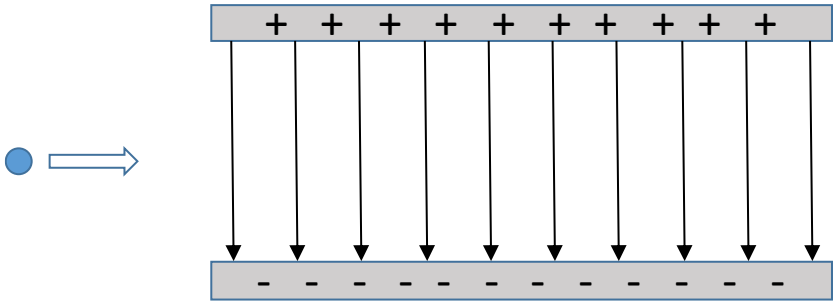
Total marks: 100

- Section I – 20 marks
- Attempt All Questions 1–20
- Allow about 35 minutes for this section
- Section II – 80 marks
- Attempt All Questions 21–34
- Allow about 2 hours and 25 minutes for this section

Section I: 20 marks

Attempt Questions 1–20. Allow about 35 minutes for this section. Use the multiple-choice answer sheet for Questions 1–20

1. Consider the electric field between two parallel plates.



Which particle, fired horizontally from the left and moving into the field, would experience the greatest electric force upwards?

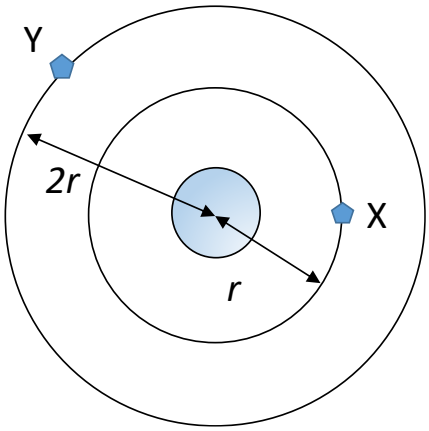
(A) An alpha particle

(B) An electron

(C) A proton

(D) An oxygen ion, O^{-2}

2. The diagram (not to scale) shows two identical satellites orbiting a planet. The orbital radius of the satellite X is r. Satellite Y, is 2r from the planet's centre.



How would the gravitational potential energy of satellite Y change if it was moved into the same orbit as X?

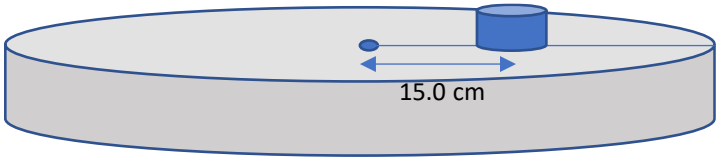
(A) It would increase by a factor of 2.

(B) It would decrease by a factor of 2.

(C) It would increase by a factor of 4.

(D) It would decrease by a factor of 4.

3. A 50 g mass is rotating at 25 revolutions per minute at 15 cm from the centre of a turntable



How would the angular velocity of this mass change if it continued to rotate with the same frequency, but was moved to a position 20 cm from the centre?

(A) The angular velocity would be 1.5 times greater.

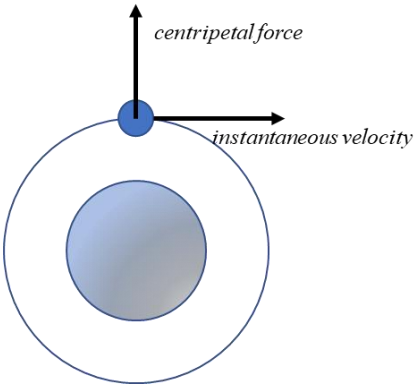
(B) The angular velocity would decrease by one third.

(C) The angular velocity would decrease by two thirds.

(D) The angular velocity would not change.

4. Which option best displays the directions of the centripetal force and instantaneous velocity of a satellite orbiting the earth?

(A)



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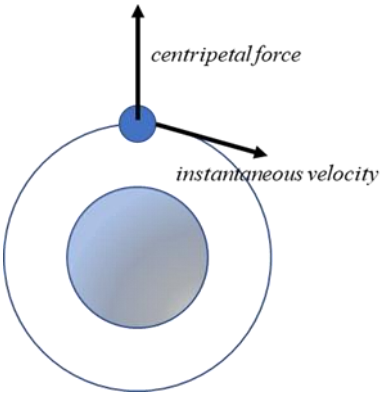
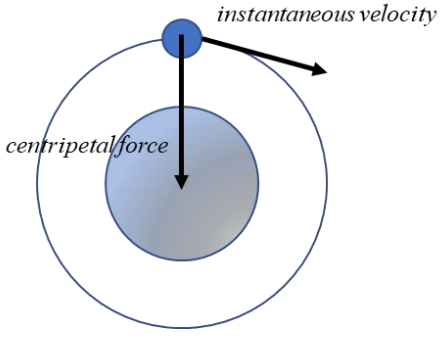
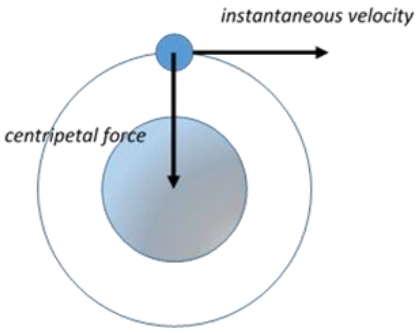


(C)



(D)



5. Which option identifies the characteristics of the motion of a charged particle when it is injected into a unform magnetic field?

(A) The vertical velocity is greater than the horizontal velocity.

(B) Both the net velocity and acceleration are constant.

(C) It has constant horizontal motion and uniformly accelerated vertical motion.

(D) It has constant vertical motion and uniformly accelerated horizontal motion.

6. A projectile is a launched directly upwards.
Which pair of graphs best displays how the horizontal velocity and vertical velocity change over time?

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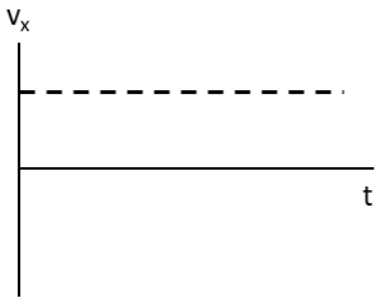

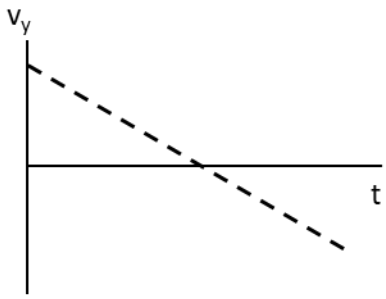

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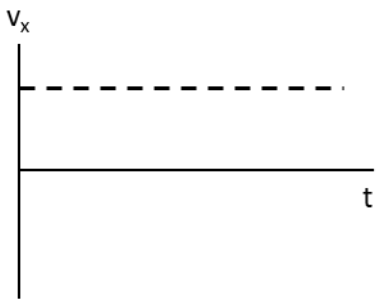

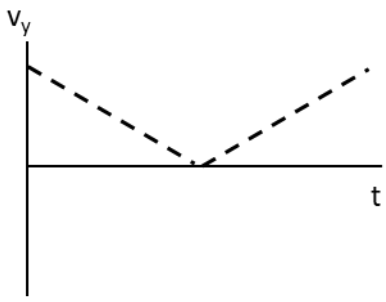

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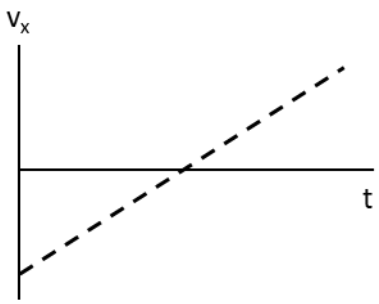

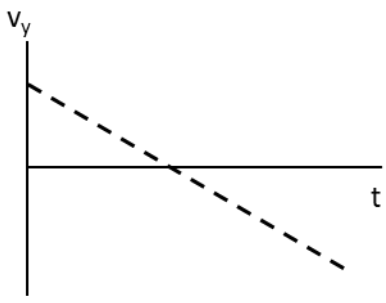

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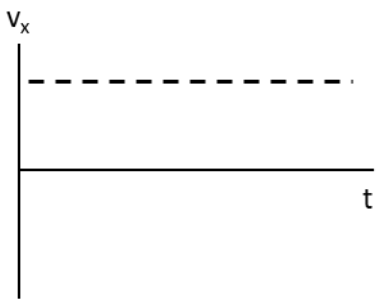
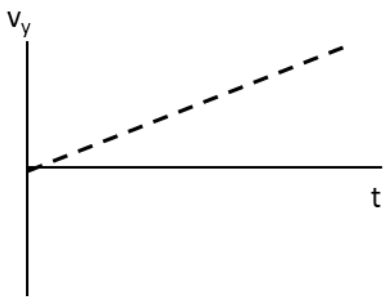
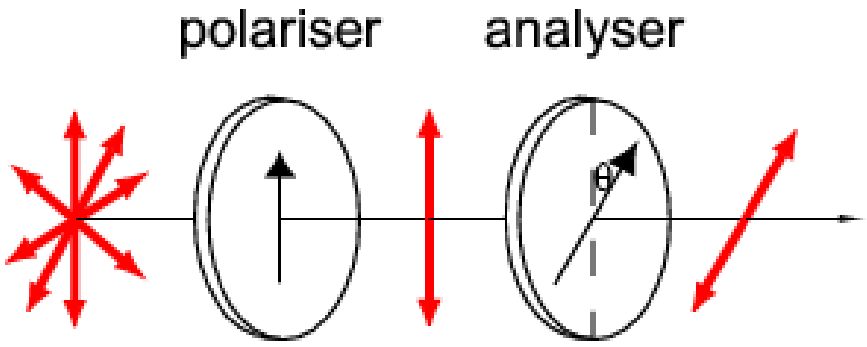




7. The diagram shows a polarising filter which has its polarising axis vertical and an analyser which has its polarising axis at an angle θ to the first as shown.



What value for angle θ will allow only 30% of the incident light intensity to pass though the analyser?

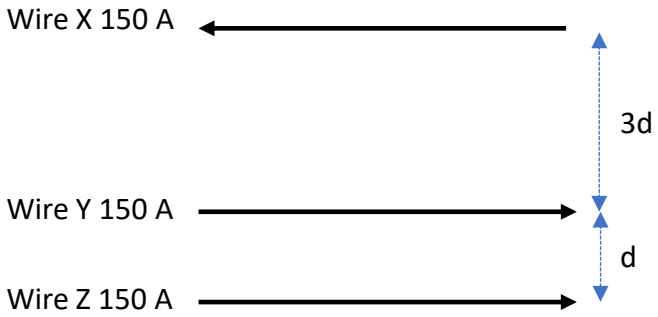
(A) 30°

(B) 33°

(C) 57°

(D) 70°

8. Three current-carrying wires are set up as shown. The net force on wire Y due to the other two wires in this situation is F.



What will happen to the force on Y if the currents in X and Z are each halved, but the distances stay the same?

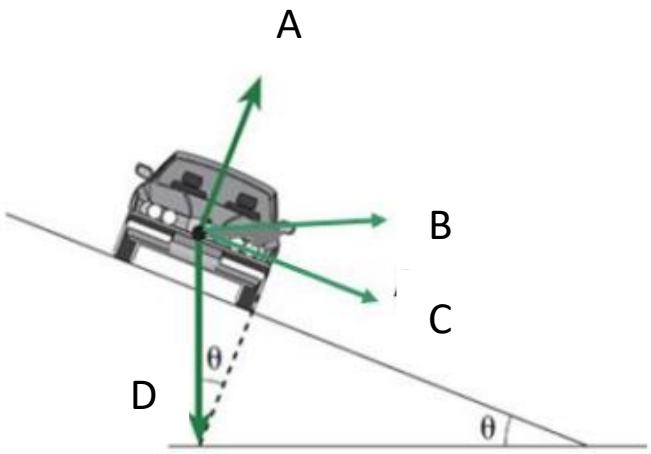
(A) It will halve to F/2.

(B) It will decrease by a factor of 4 to F/4

(C) It will double to 2F.

(D) It will quadruple to 4F.

9. The figure below shows a vehicle travelling in a horizontal circle at constant speed on a frictionless banked track.



Which arrow, A, B, C or D, represents the **direction** of the **normal force** on the vehicle?

10. A transformer with 1200 turns in the primary coil and 300 turns in the secondary coil draws a current of 1.75 A.

If the transformer is ideal, what is the current in the primary coil?

(A) 0.375 A

(B) 0.438 A

(C) 1.75 A

(D) 6.00 A

11. In one of Thomson's experiments in 1897 he accelerated electrons to a speed of 2.65×10^{7} ms^{-1}. What is the de Broglie wavelength of these electrons?

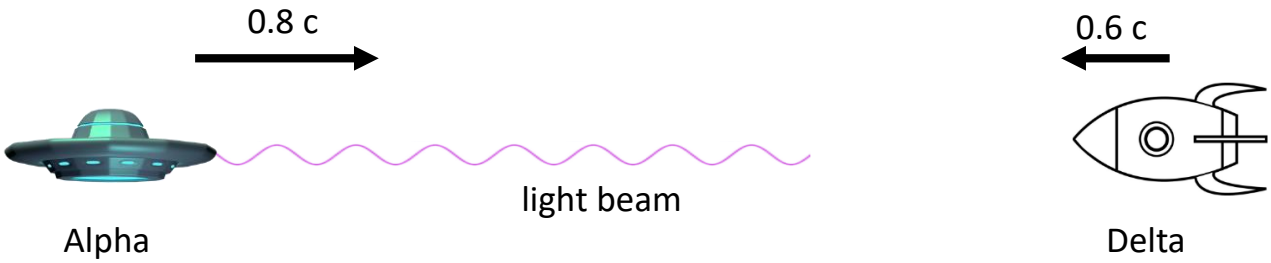
(A) 3.77×10^{-8} m

(B) 2.75×10^{-11} m

(C) 1.49×10^{-14} m

(D) 2.45×10^{-22} m

12. Two spaceships Alpha and Delta are traveling towards each other, with velocities relative to space as shown below.



If Alpha sent a beam of light to Delta, what would the velocity of the light be when it reaches Delta?

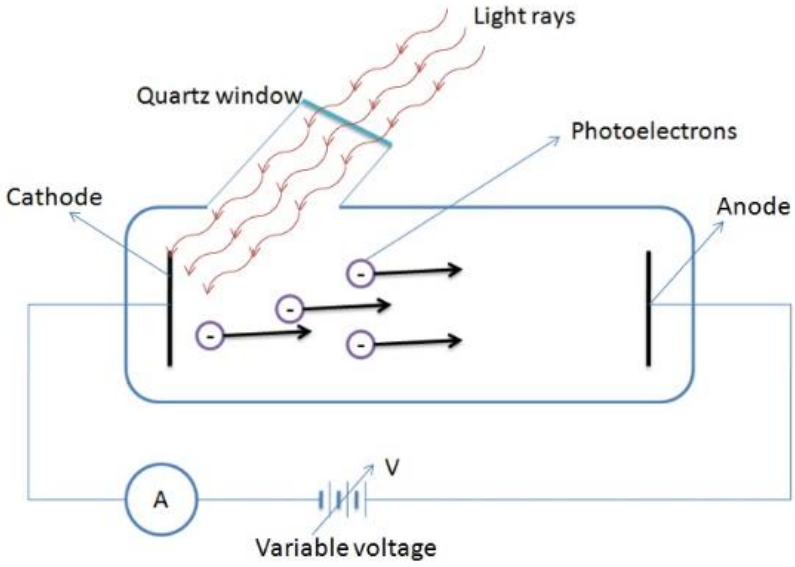
(A) 1.0 c

(B) 1.4 c

(C) 1.6 c

(D) 2.4c

13. The following experiment is set up to demonstrate the photoelectric effect. Light is directed onto a metal plate (cathode). The photocurrent is measured using the ammeter.



If the frequency of the light is increased, what effect will this have?

(A) the number of electrons emitted from metal plate will increase

(B) the stopping potential will decrease

(C) the maximum photoelectron kinetic energy will increase

(D) the photocurrent magnitude will increase

14. When pushing on a very heavy door to close it which of the following describes how to achieve maximum torque?

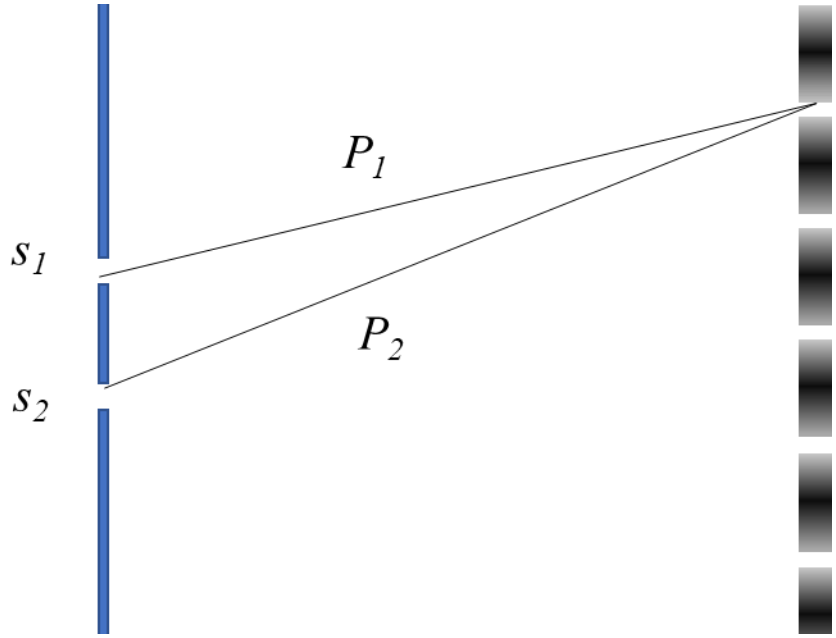
(A) The force should be applied at right-angles to the door at the smallest distance possible from the hinge

(B) The force should be applied at 45° to the door at the smallest distance possible from the hinge

(C) The force should be applied at right-angles to the door at the middle distance between the outer edge of the door and end of the hinge

(D) The force should be applied at right-angles to the door at the largest distance possible from the hinge

15. Monochromatic light of wavelength λ strikes a double slit and produces bright and dark fringes on a screen. Light from slit S_1 travels along path P_1 and light from slit S_2 travels along P_2 to produce the light fringe shown.



What is the difference in length between P_1 and P_2?

(A) λ

(B) $\frac{3\lambda}{2}$

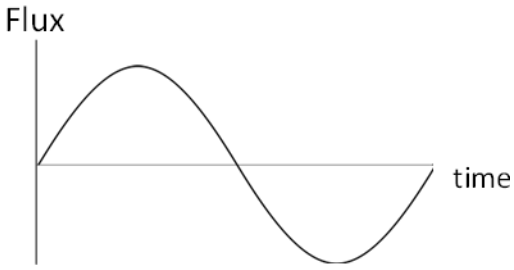
(C) 2λ

(D) $\frac{\lambda}{2}$

16. A coil in a simple DC motor rotates through 360º within a uniform magnetic field. Initially the normal to the plane of the coil is perpendicular to the field lines.

Which graph best shows how the magnetic flux through the coil varies over time through one rotation?

(A)



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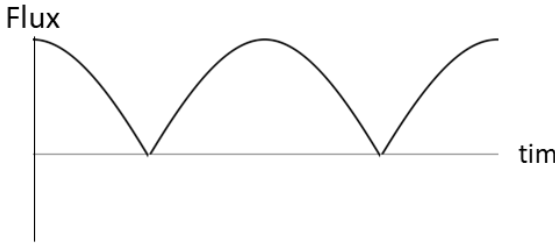
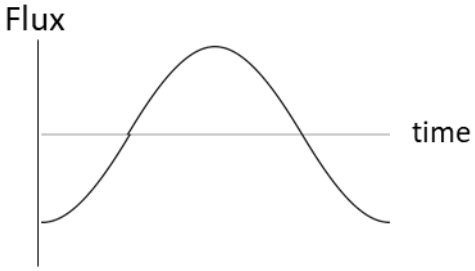
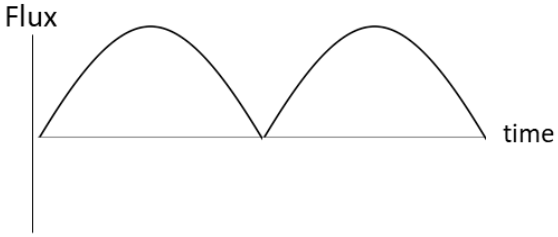


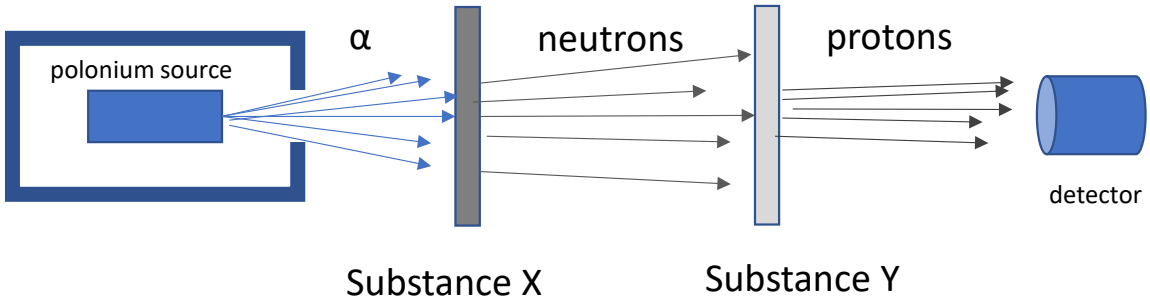
(C)



(D)



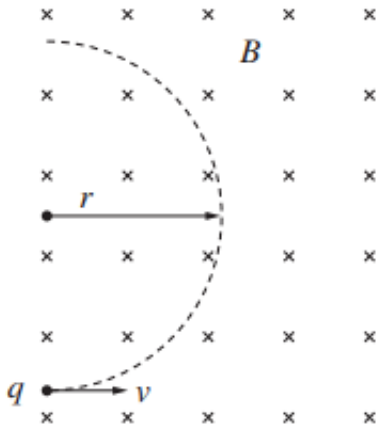
17. James Chadwick discovered the neutron. He achieved this by observing the properties of the neutron, performing an experiment like the experiment shown in the diagram.



What is substance *Y*?

(A) alpha emitter
(B) beta emitter
(C) beryllium
(D) paraffin wax

18. A charged particle, q, enters a uniform magnetic field B at velocity v. The particle follows a circular path of radius, r as shown.



If the velocity was **doubled** what other change could be made to keep the radius the same?

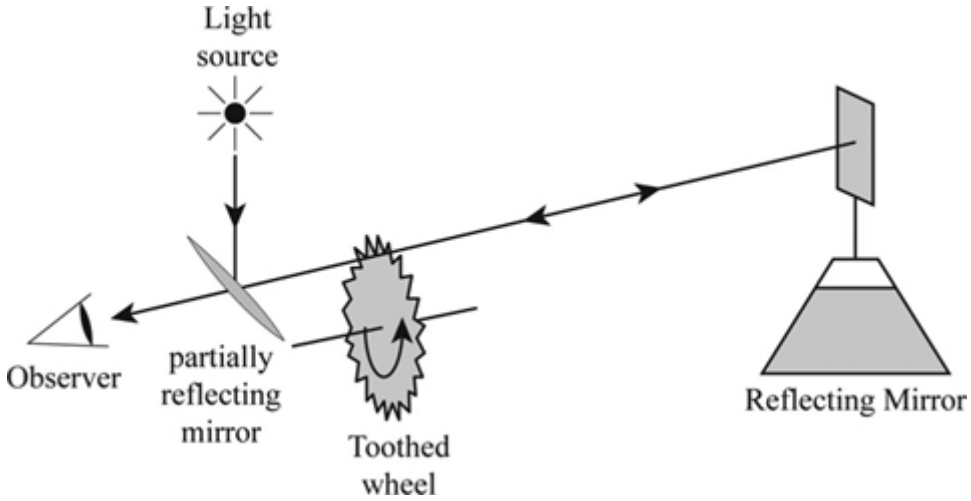
(A) double the charge

(B) halve the charge

(C) double the mass

(D) halve the field strength

19. The diagram shows an attempt to measure the speed of light by passing a beam through a toothed wheel and observing reflections from a distant mirror.



Which person is this experiment attributed to?

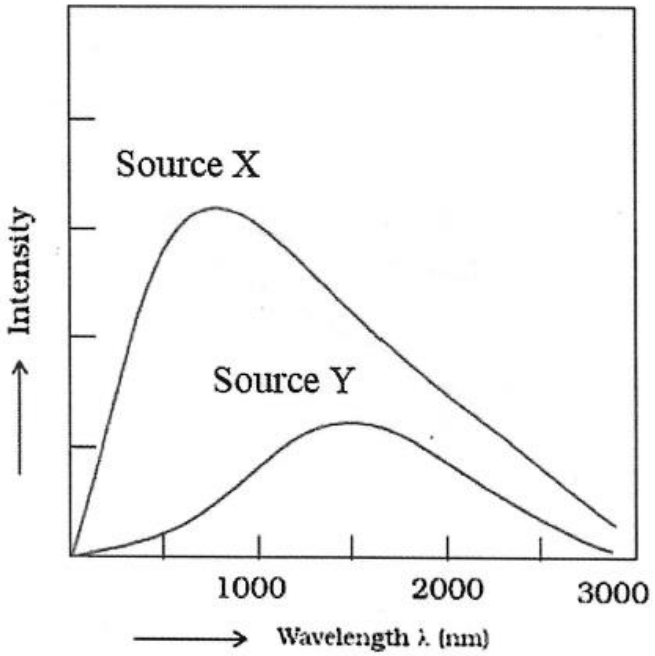
(A) Galileo

(B) Romer

(C) Fizeau

(D) Michelson

20. The diagram shows the intensity versus wavelength for spectra of light from sources X and Y



Which option is the best compares the temperatures of the two bodies?

(A) Source X has a higher temperature because peak wavelength is shorter than Y

(B) Source X has a higher temperature because the intensity its peak wavelength is higher than Y

(C) Source X has a higher temperature because the total area under the graph is greater than Y

(D) Source has a higher temperature because the intensity its peak wavelength is at a longer wavelength than that of X

Section II

80 marks

Attempt Questions 21–3

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 18 and 27 of this booklet. If you use these spaces, clearly indicate which question you are answering.

Question 21 3 marks

What is a geostationary satellite? (2)

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What is one important function of a geostationary satellite? (1)

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Question 22 (7 marks)

During the 1971 mission to the Moon, astronaut Alan Shepard hit a golf ball that landed 40.0 m from where he'd hit it. The surface of the moon where he hit the ball was level and flat.

(a) The moon has a mass of 7.342×10^{22} kg and a radius of 1737.4 km. Find the acceleration due to gravity on the moon (2)

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(b) Shepherd's ball was launched at an angle of 35.0º to the horizontal. Determine the initial launch speed of the ball. (3)

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(c) What was the maximum height above ground level reached by golf ball? (2)

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Question 23 (4 marks)

Students carried out an experiment to determine the relationship between the radius and velocity for a 55 g mass moving with a uniform circular motion. The centripetal force was kept constant for each variation in radius. The time for 10 complete cycles was measured. The results are shown in the table below.

Radius of path (cm)	Time for 10 cycles (s)
10	4.3
20	6.1
30	7.3
40	8.5
50	9.5
60	10.1

They were asked by their teacher to use all the results to determine the magnitude of the constant centripetal force.

List and explain the steps of the analysis required to calculate the centripetal force. (note: You are **not** required to calculate the force.)

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Question 24 (6 marks)

The table displays data from the 8 planets in our solar system.

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Mass (x 10^{24}kg)	0.33	4.87	5.97	0.642	1898	568	86.8	102
Diameter (km)	4879	12,104	12,756	6792	142,984	120,536	51,118	49,528
Density (kg/m3)	5427	5243	5514	3933	1326	687	1271	1638
Length of Day (hours)	4222.6	2802	24	24.7	9.9	10.7	17.2	16.1
Orbital Period (days)	88	224.7	365.2	687	4331	10,747	30,589	59,800
Average Distance from Sun (x10^6 km)	57.9	108.2	149.6	227.9	778.6	1433.5	2872.5	4495.1
Perihelion (x10^6 km)	46	107.5	147.1	206.6	740.5	1352.6	2741.3	4444.5
Aphelion (x 10^6 km)	69.8	108.9	152.1	249.2	816.6	1514.5	3003.6	4545.7

(a) Which planet in the table has the most elliptical orbit? (1)

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(b) At what distance from the sun is Mars travelling with its greatest orbital velocity? Which of Kepler's laws did you use to answer this? (2)

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(c) The mass of the Sun = 2.00×10^{30} kg. What is the average gravitational force between the Sun and Mercury? (3)

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Question 25 (4 marks)

A satellite is in a stable low earth orbit with a constant speed and altitude. The controller of the satellite wants to move it to a higher orbit. On board rockets are fired to increase the speed of the satellite and when the new orbit is reached the rockets are fired to reduce the speed.

Use your understanding of relevant physical principles to explain this sequence of events.

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Question 26 (4 marks)

Explain why electrical energy is transmitted over large distances at very high AC voltages and low currents.

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Question 27 (5 marks)

A charged particle, particle *X*, is moving perpendicular to an electric field. Another charged particle, particle *Y*, is moving perpendicular to a magnetic field. The particles are identical in charge, mass and have the same initial velocity.

(a) Outline ONE similarity and ONE difference between the behaviours of the particles in the fields. (2)

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(b) If the initial velocity of each particle was doubled, what effect would this have on the motion in each field? (3)

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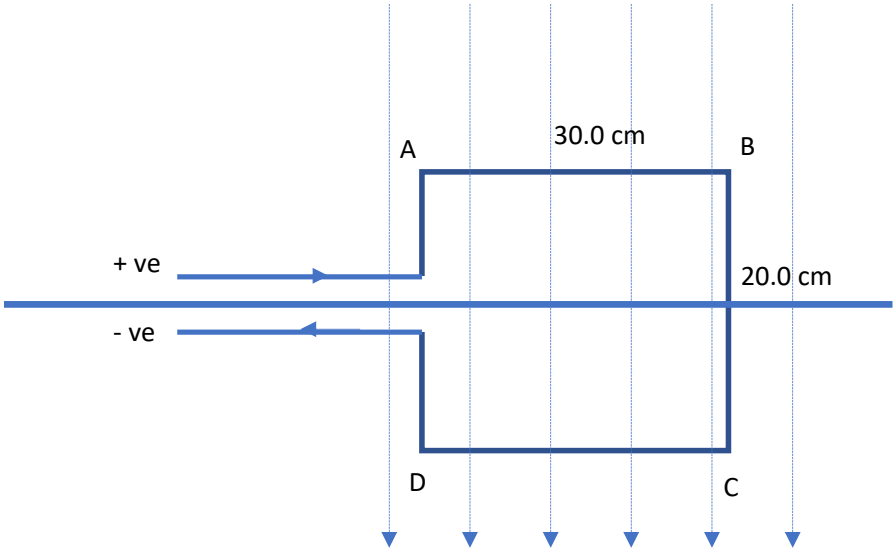
Question 28 (6 marks)

A motor uses a coil with 40 turns that has dimensions of 30.0 cm x 20.0 cm, as shown in the diagram. A current of 1.5 A flows through the coil in the direction shown. The coil is vertical and is in a magnetic field of 5.1 x 10^{-2} T directed as shown.



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

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(b) What is the magnitude and direction of the torque experienced by the coil in this position? (2)

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(c) The coil rotates because of the applied torque. What would happen to the magnitude of the torque as the coil rotates through 90º? (1)

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Question 29 (4 marks)

A circular loop of wire is dropped vertically to fall through a magnetic field as shown in the diagram. The plane of the coil is always perpendicular to the field lines.

A current flows in the direction shown in Fig 1. and the coil experiences a force in the opposite direction to the motion. However, when the coil is entirely inside the field, Fig. 2, there is no current and no opposing force.

Fig 1.

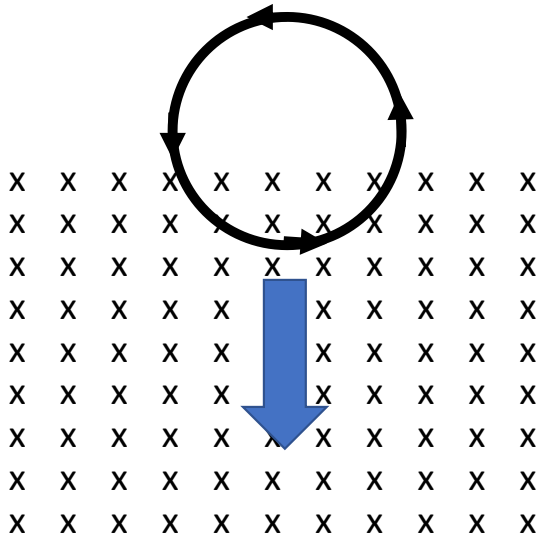
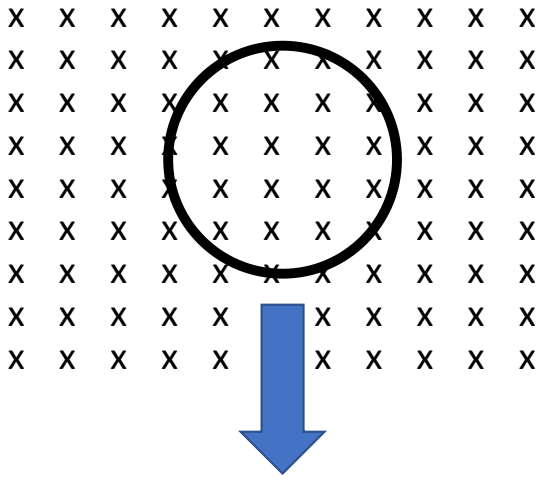


Fig 2.



Use your understanding of Faraday's law and Lenz's law to explain this scenario.

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Question 30 (4 marks)

A student placed lens B over lens A and noted that the intensity of light passing through was reduced in the region where the lenses overlap. Lens B was then rotated, and it was noted that even less light passed through.

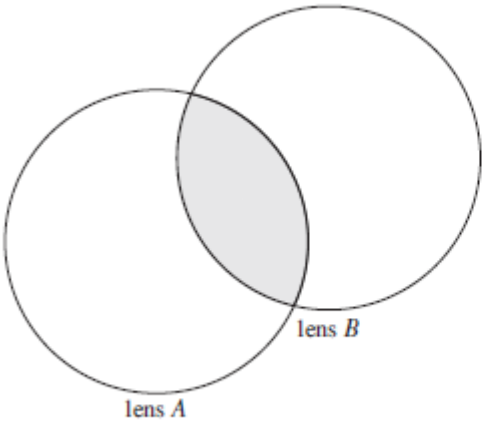

Figure 1

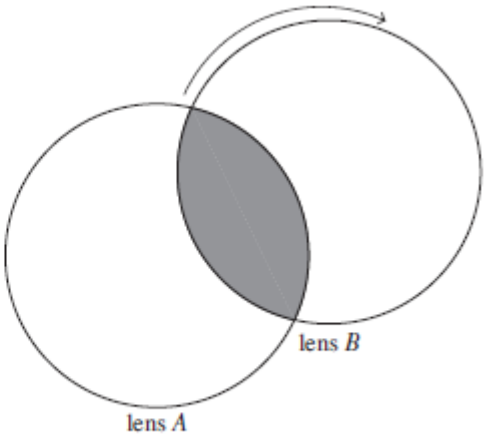

Figure 2

Explain the observations made by the student.

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Question 31 (3 marks)

A transformer in a laptop charger converts 240V AC into 6.0 V AC. When the charger is plugged into the laptop there is an output current of 500 mA. The charger has an energy efficiency of 90%.

Calculate the input current to the transformer in the charger.

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Question 32 (3 marks)

Calculate the energy of a photon of light which is emitted when an electron in an excited hydrogen atoms transitions from level 5 down to level 2.

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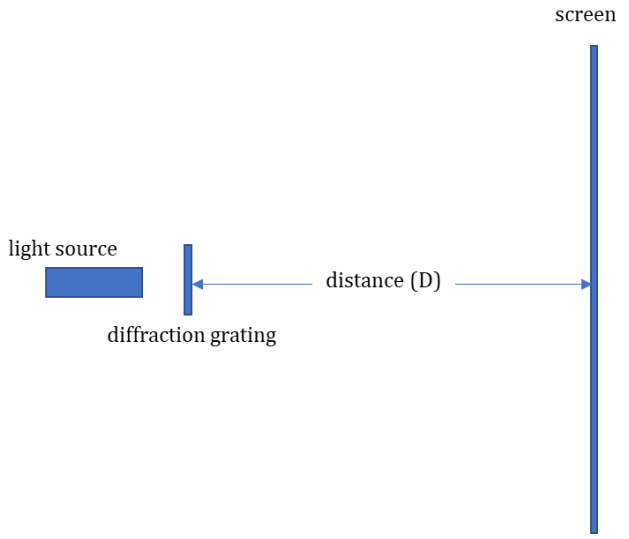
Question 33(4 marks)

A diffraction grating has 2000 lines per cm. It was placed between a monochromatic light source and a screen at a distance D.



(a) A student shone monochromatic light at the diffraction grating and found a first-order maximum at an angle of 7.5 ° to the central maximum.

Find the wavelength of the light source. Express your answer in nanometres. (3)

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(b) If the distance D between the screen and the diffraction grating was decreased, what would happen to the distance between the maxima on the screen? (1)

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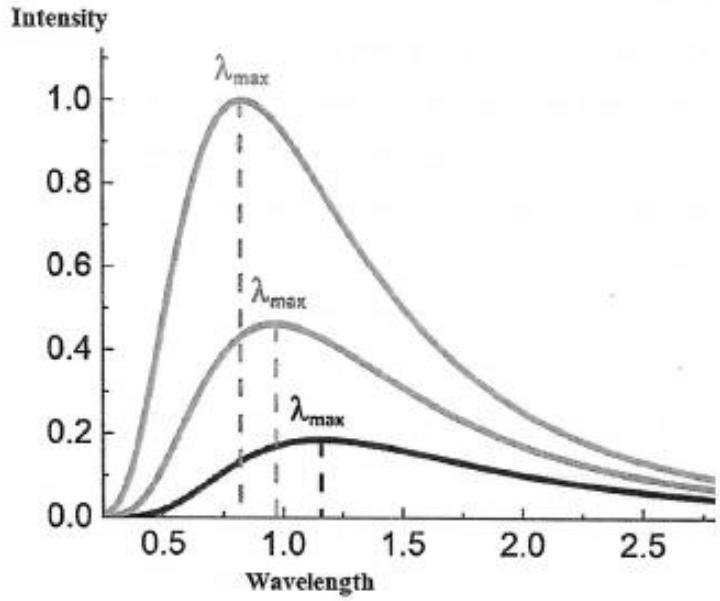
Question 34 (8 marks)

The graph shows the intensity vs wavelength for 3 black bodies at different temperatures.



(a) Black body radiation curves could not be explained using classical wave mechanics. What new interpretation did Max Planck introduce to explain the shape of the curves? (1)

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(b) Use Wien's law to estimate the temperature of the hottest of the three bodies. (3)

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Question 34 continued on next page

(c) Describe how Einstein used Planck's interpretation to explain the existence of the threshold frequency in the photoelectric effect. (4)

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Question 35 (6 marks)

Muons are unstable subatomic particles that decay into electrons and neutrinos with a mean lifetime of 2.2 μs. They are produced when cosmic rays bombard the upper atmosphere about 11.4 km above the earth's surface, and they travel very close to the speed of light relative to the earth.

Explain how observations of these muons can be used as evidence to support Einstein's Special Theory of Relativity of both length contraction and time dilation.

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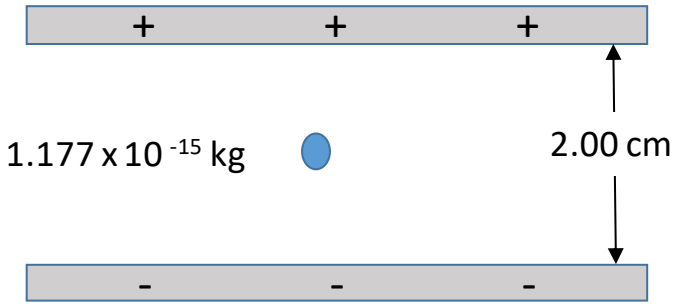
Question36 (4 marks)

An oil drop of mass 1.177×10^{-15} kg falls vertically into the evacuated space between two parallel charged plates, which are 2.00 cm apart. The oil drop is negatively charged.



(a) The voltage is altered so that it slows the oil drop until it is stationary. When the potential difference between the plates is 72.0 V, the oil drop stops moving. How many excess electrons are on the oil drop? **3**

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(b) An experiment with a similar approach was used by Robert Millikan. What did he conclude from his investigation? **1**

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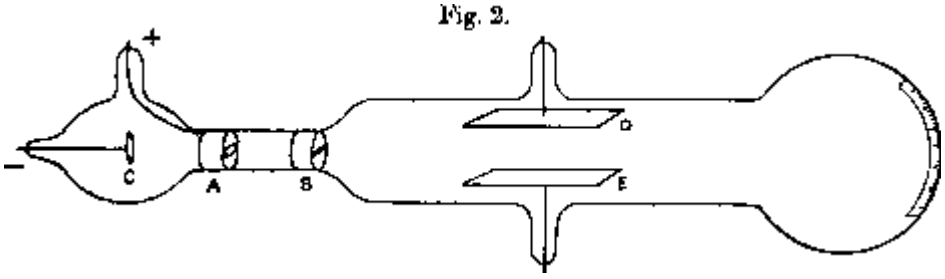
Question 37 (5 marks)

In 1889, JJ Thomson performed an investigation that determined the charge to mass ratio of the electron using the apparatus shown below.

Fig. 2.



Outline his procedure and how he derived the relationship $\frac{q}{m} = \frac{E}{rB^2}$

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Physics

Hornsby Girls High School
2021
HSC Task 4
Trial Examination

Student Number

General Instructions:

- Reading time – 5 minutes
- Working time – 3 hours
- NESA approved calculators may be used
- A data sheet, formulae sheet and Periodic Table are provided
- For questions in Section II, show all relevant working in questions involving calculations

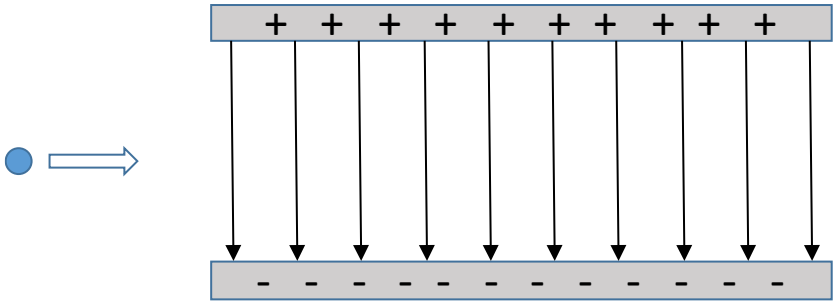
Total marks: 100

- Section I – 20 marks
- Attempt All Questions 1–20
- Allow about 35 minutes for this section
- Section II – 80 marks
- Attempt All Questions 21–34
- Allow about 2 hours and 25 minutes for this section

Section I: 20 marks

Attempt Questions 1–20. Allow about 35 minutes for this section. Use the multiple-choice answer sheet for Questions 1–20

1. Consider the electric field between two parallel plates.



Which particle, fired horizontally from the left and moving into the field, would experience the greatest electric force upwards?

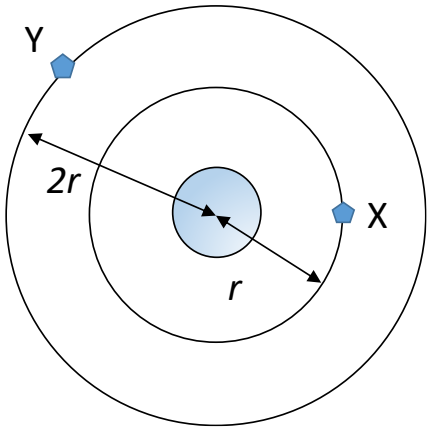
(A) An alpha particle

(B) An electron

(C) A proton

(D) An oxygen ion, O^{-2}

2. The diagram (not to scale) shows two identical satellites orbiting a planet. The orbital radius of the satellite X is r. Satellite Y, is 2r from the planet's centre.



How would the gravitational potential energy of satellite Y change if it was moved into the same orbit as X?

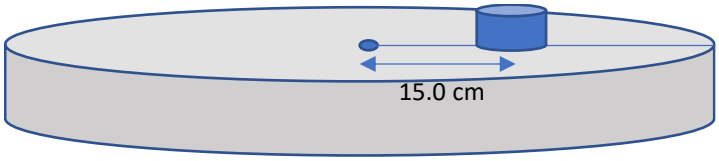
(A) It would increase by a factor of 2.

(B) It would decrease by a factor of 2.

(C) It would increase by a factor of 4.

(D) It would decrease by a factor of 4.

3. A 50 g mass is rotating at 25 revolutions per minute at 15 cm from the centre of a turntable



How would the angular velocity of this mass change if it continued to rotate with the same frequency, but was moved to a position 20 cm from the centre?

(A) The angular velocity would be 1.5 times greater.

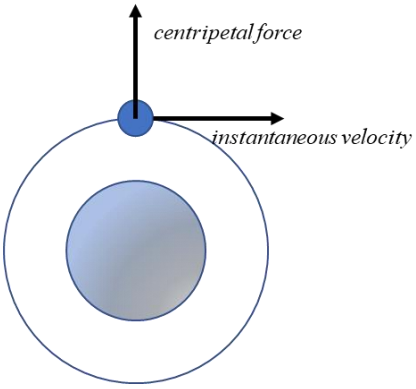
(B) The angular velocity would decrease by one third.

(C) The angular velocity would decrease by two thirds.

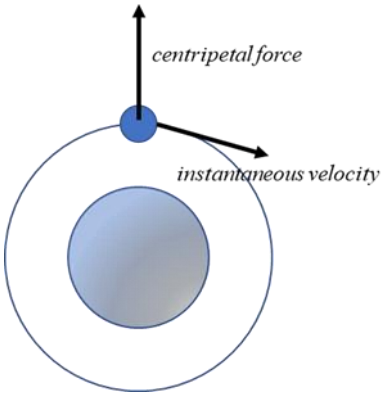
(D) The angular velocity would not change.

4. Which option best displays the directions of the centripetal force and instantaneous velocity of a satellite orbiting the earth? D

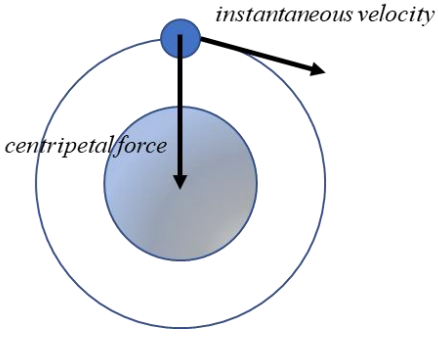
(A)



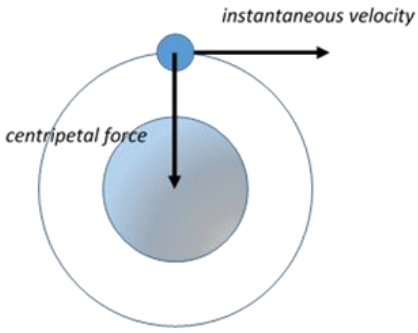
(B)



(C)



(D)



5. Which option identifies the characteristics of the motion of a charged particle when it is injected into a unform magnetic field?

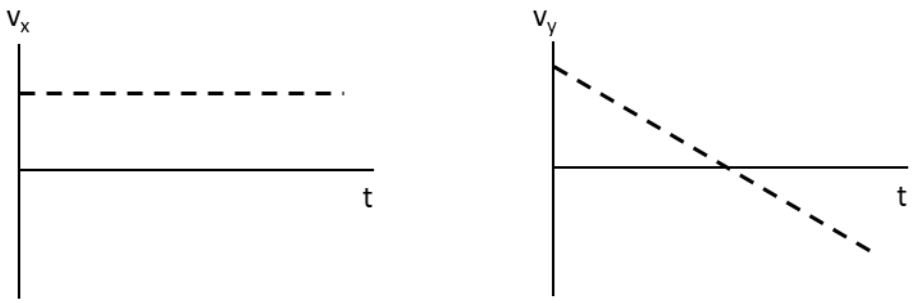
(A) The vertical velocity is greater than the horizontal velocity.

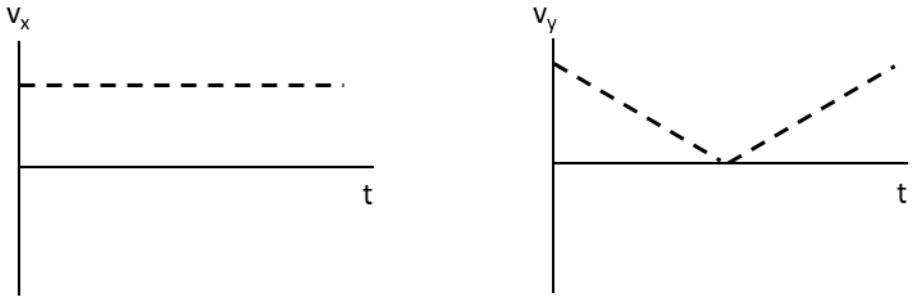
(B) Both the net velocity and acceleration are constant.

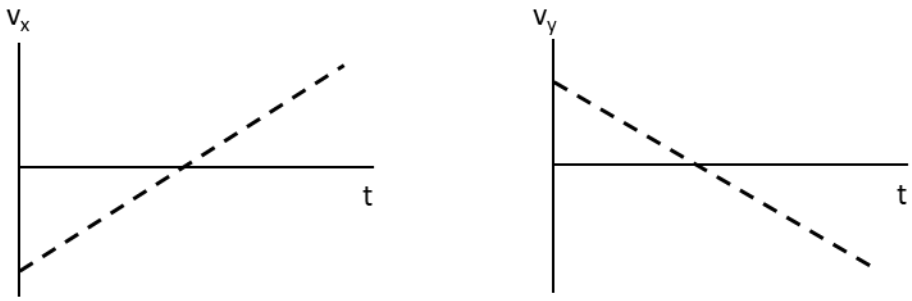
(C) It has constant horizontal motion and uniformly accelerated vertical motion.

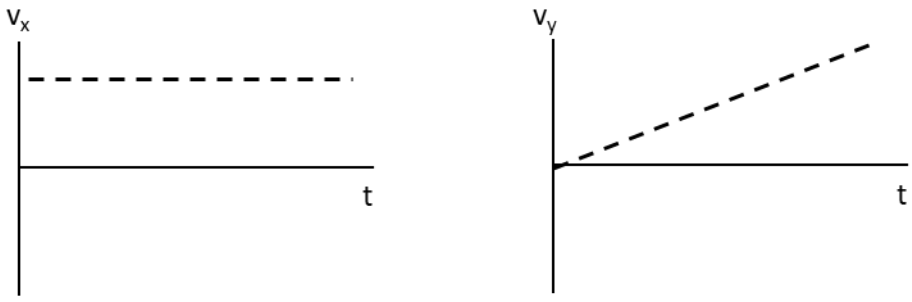
(D) It has constant vertical motion and uniformly accelerated horizontal motion.

6. A projectile is a launched directly upwards.
Which pair of graphs best displays how the horizontal velocity and vertical velocity change over time? A

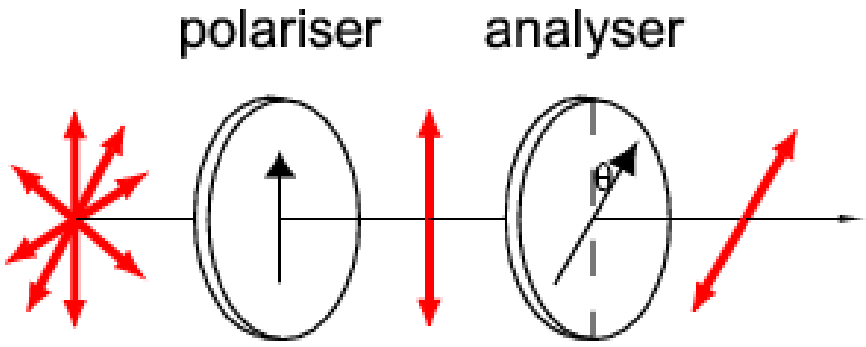
(A 

(B 

(C 

(D 

7. The diagram shows a polarising filter which has its polarising axis vertical and an analyser which has its polarising axis at an angle θ to the first as shown.



What value for angle θ will allow only 30% of the incident light intensity to pass though the analyser?

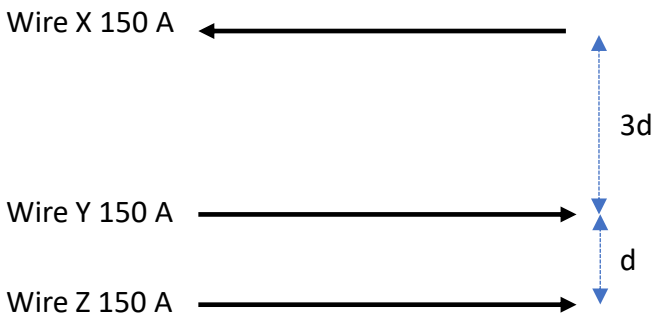
(A) 30°

(B) 33°

(C) 57°

(D) 70°

8. Three current-carrying wires are set up as shown. The net force on wire Y due to the other two wires in this situation is F.



What will happen to the force on Y if the currents in X and Z are each halved, but the distances stay the same?

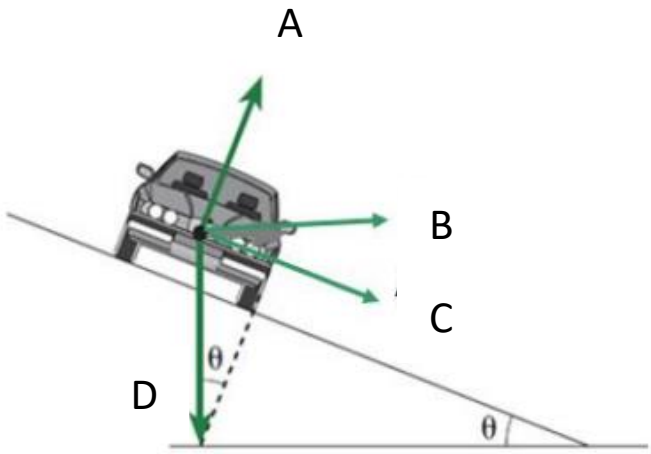
(A) It will halve to F/2.

(B) It will decrease by a factor of 4 to F/4

(C) It will double to 2F.

(D) It will quadruple to 4F.

9. The figure below shows a vehicle travelling in a horizontal circle at constant speed on a frictionless banked track.



Which arrow, A, B, C or D, represents the **direction** of the **normal force** on the vehicle?

10. A transformer with 1200 turns in the primary coil and 300 turns in the secondary coil draws a current of 1.75 A.

If the transformer is ideal, what is the current in the primary coil?

(A) 0.375 A

(B) 0.438 A

(C) 1.75 A

(D) 6.00 A

11. In one of Thomson's experiments in 1897 he accelerated electrons to a speed of 2.65×10^{7} ms^{-1}. What is the de Broglie wavelength of these electrons?

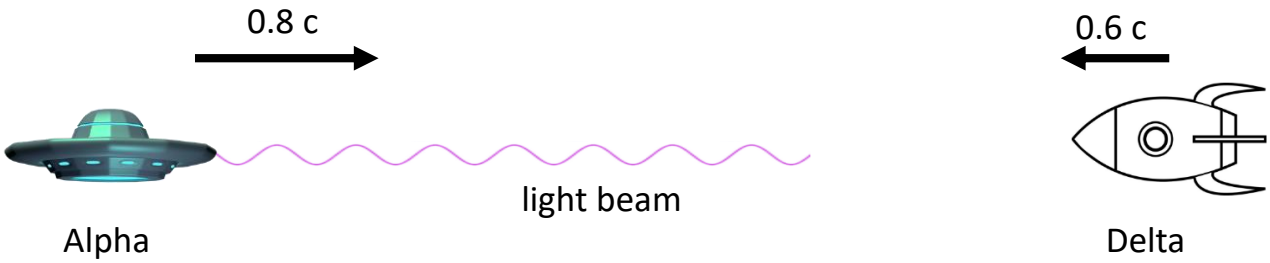
(A) 3.77×10^{-8} m

(B) 2.75×10^{-11} m

(C) 1.49×10^{-14} m

(D) 2.45×10^{-22} m

12. Two spaceships Alpha and Delta are traveling towards each other, with velocities relative to space as shown below.



If Alpha sent a beam of light to Delta, what would the velocity of the light be when it reaches Delta?

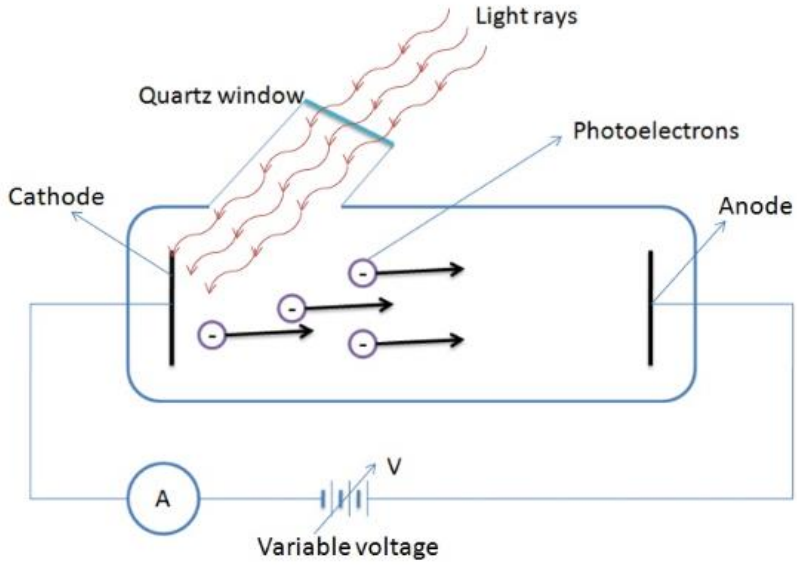
(A) 1.0 c

(B) 1.4 c

(C) 1.6 c

(D) 2.4c

13. The following experiment is set up to demonstrate the photoelectric effect. Light is directed onto a metal plate (cathode). The photocurrent is measured using the ammeter.



If the frequency of the light is increased, what effect will this have?

(A) the number of electrons emitted from metal plate will increase

(B) the stopping potential will decrease

(C) the maximum photoelectron kinetic energy will increase

(D) the photocurrent magnitude will increase

14. When pushing on a very heavy door to close it which of the following describes how to achieve maximum torque?

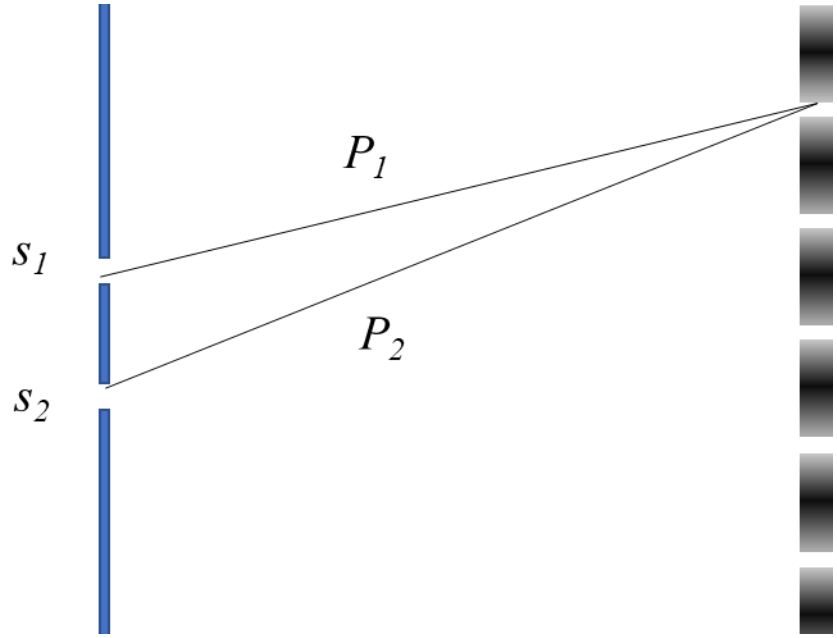
(A) The force should be applied at right-angles to the door at the smallest distance possible from the hinge

(B) The force should be applied at 45° to the door at the smallest distance possible from the hinge

(C) The force should be applied at right-angles to the door at the middle distance between the outer edge of the door and end of the hinge

(D) The force should be applied at right-angles to the door at the largest distance possible from the hinge

15. Monochromatic light of wavelength λ strikes a double slit and produces bright and dark fringes on a screen. Light from slit S_1 travels along path P_1 and light from slit S_2 travels along P_2 to produce the light fringe shown.



What is the difference in length between P_1 and P_2?

(A) λ

(B) $\frac{3\lambda}{2}$

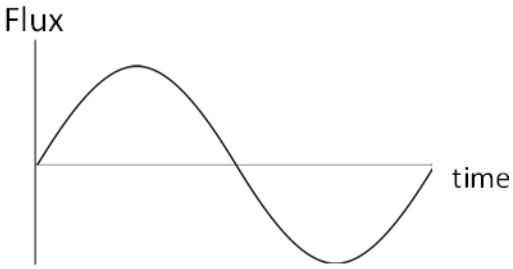
(C) 2λ

(D) $\frac{\lambda}{2}$

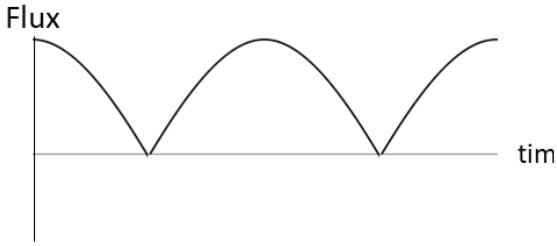
16. A coil in a simple DC motor rotates through 360º within a uniform magnetic field. Initially the normal to the plane of the coil is perpendicular to the field lines.

Which graph best shows how the magnetic flux through the coil varies over time through one rotation? A

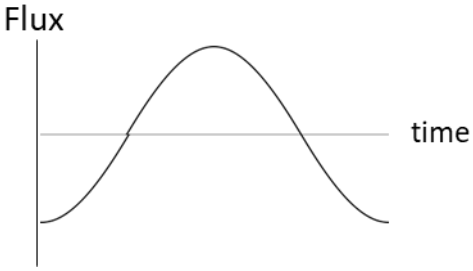
(A)



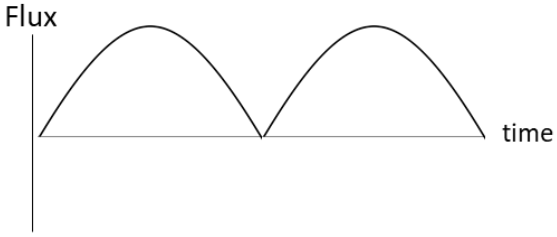
(B)



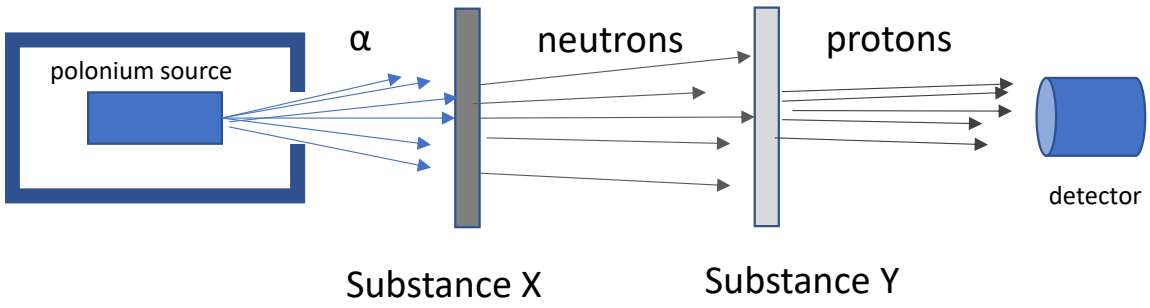
(C)



(D)



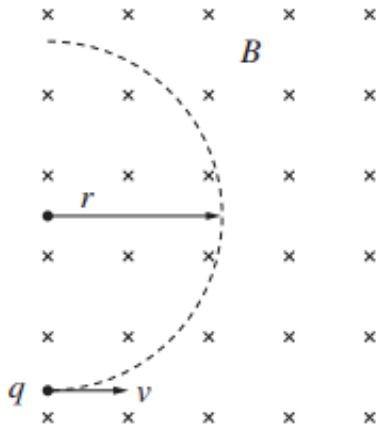
17. James Chadwick discovered the neutron. He achieved this by observing the properties of the neutron, performing an experiment like the experiment shown in the diagram.



What is substance *Y*?

(A) alpha emitter
(B) beta emitter
(C) beryllium
(D) paraffin wax

18. A charged particle, q, enters a uniform magnetic field B at velocity v. The particle follows a circular path of radius, r as shown.



If the velocity was **doubled** what other change could be made to keep the radius the same?

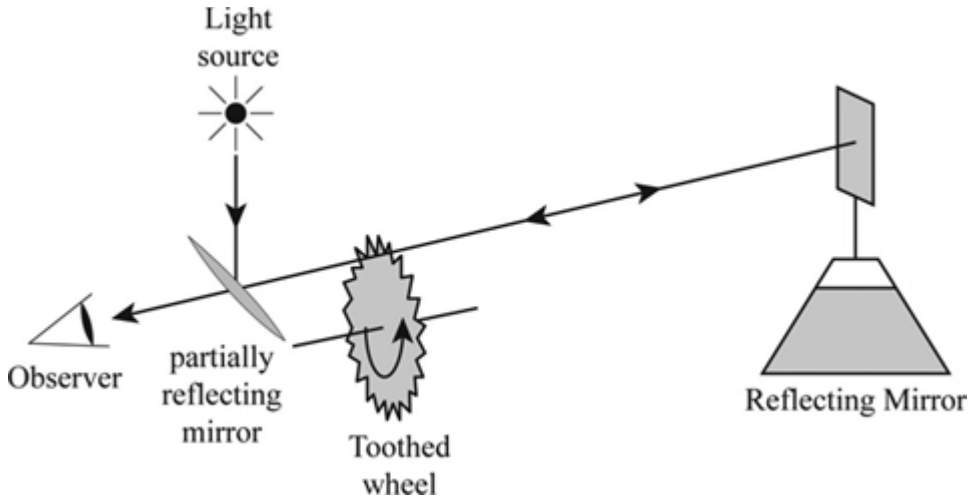
(A) double the charge

(B) halve the charge

(C) double the mass

(D) halve the field strength

19. The diagram shows an attempt to measure the speed of light by passing a beam through a toothed wheel and observing reflections from a distant mirror.



Which person is this experiment attributed to?

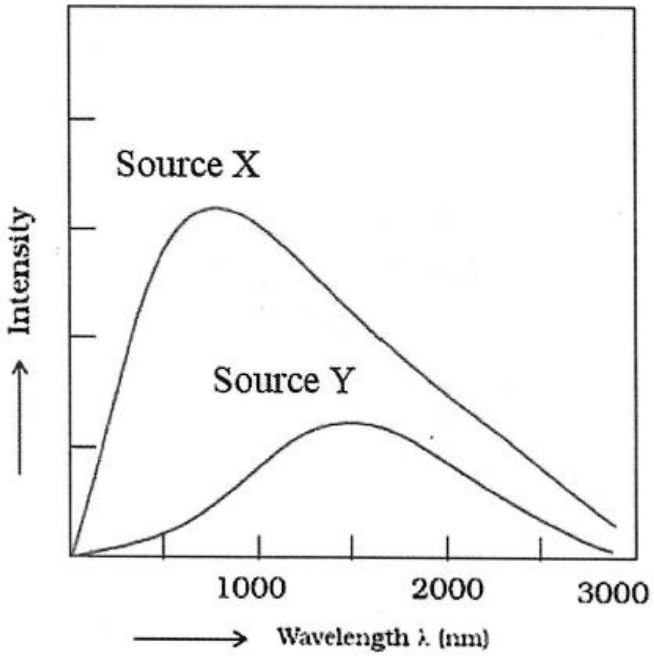
(A) Galileo

(B) Romer

(C) Fizeau

(D) Michelson

20. The diagram shows the intensity versus wavelength for spectra of light from sources X and Y



Which option is the best compares the temperatures of the two bodies?

(A) Source X has a higher temperature because peak wavelength is shorter than Y

(B) Source X has a higher temperature because the intensity its peak wavelength is higher than Y

(C) Source X has a higher temperature because the total area under the graph is greater than Y

(D) Source has a higher temperature because the intensity its peak wavelength is at a longer wavelength than that of X

Section II

80 marks

Attempt Questions 21–3

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 18 and 27 of this booklet. If you use these spaces, clearly indicate which question you are answering.

Question 21 3 marks

What is a geostationary satellite? (2)

2 marks	correctly identifies **2** features e g • 24 hour period • equatorial orbital plane • 36 000 km altitude
1 mark	correctly identifies 1 feature

Sample answer

A geostationary satellite has an orbital period that is the same as the earths rotational period of 24 hrs. The orbital plane is in the same plane as the equator of the earth.

What is one important function of a geostationary satellite? (1)

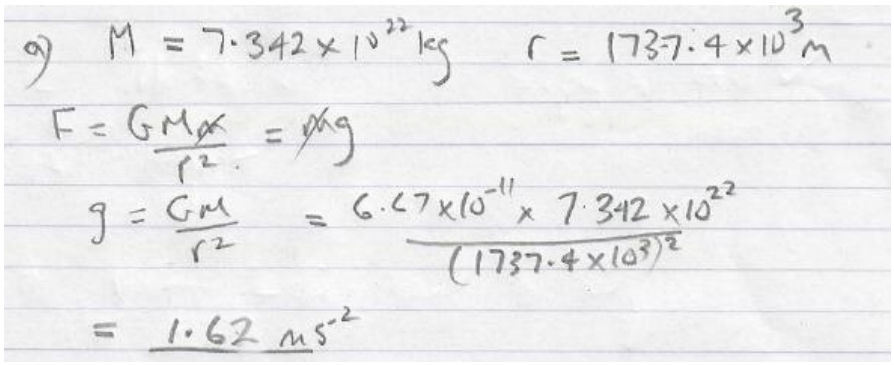
1 mark	correctly identifies one specific use • weather observations • telecommunications • oceanography

Question 22 (7 marks)

During the 1971 mission to the Moon, astronaut Alan Shepard hit a golf ball that landed 40.0 m from where he'd hit it. The surface of the moon where he hit the ball was level and flat.

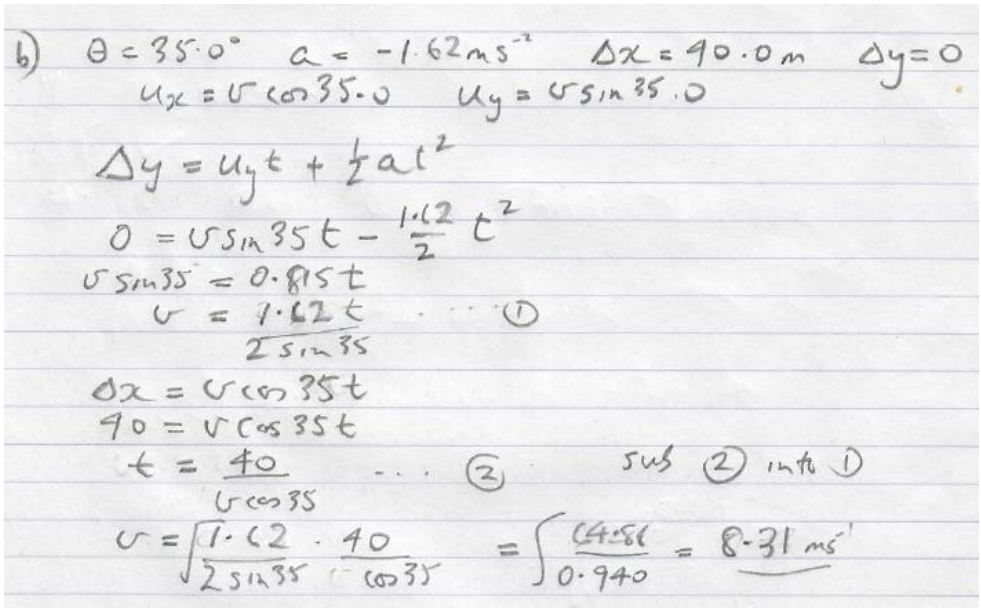
(a) The moon has a mass of 7.342×10^{22} kg and a radius of 1737.4 km. Find the acceleration due to gravity on the moon (2)

2 marks	• correctly substitutes into correct formula to find the acceleration due to gravity
1 mark	• substitutes into correct formula to find the acceleration due to gravity with errors such as incorrect use of units



(b) Shepherd's ball was launched at an angle of 35.0º to the horizontal. Determine the initial launch speed of the ball. (3)

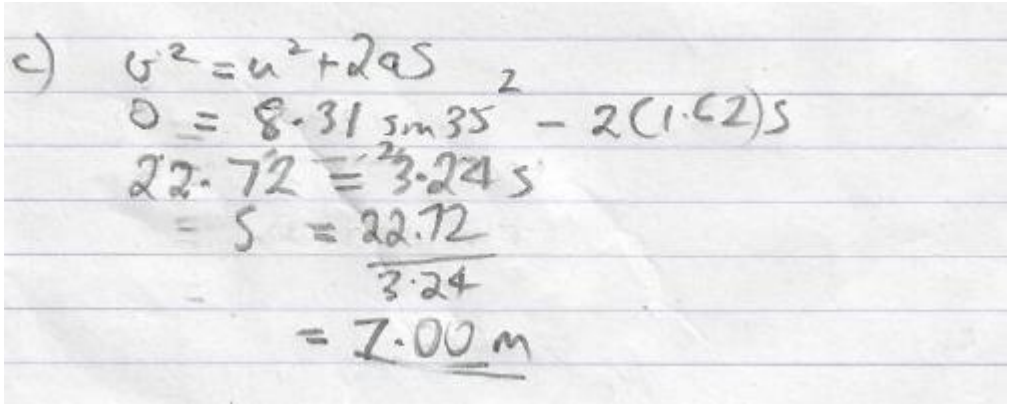
3 marks	• uses a relevant approach to correctly find the initial speed of the ball
2 marks	• uses a relevant approach to find the initial speed of the ball but makes an error
1 mark	• makes an attempt to find the velocity



(c) What was the maximum height above ground level reached by golf ball? (2)

2 marks	• applies an appropriate method to correctly determine the height
1 mark	• makes an attempt but does not correctly determine the height

sample answer



Question 23 (4 marks)

Students carried out an experiment to determine the relationship between the radius and velocity for a 55 g mass moving with a uniform circular motion. The centripetal force was kept constant for each variation in radius. The time for 10 complete cycles was measured. The results are shown in the table below.

Radius of path (cm)	Time for 10 cycles (s)
10	4.3
20	6.1
30	7.3
40	8.5
50	9.5
60	10.1

They were asked by their teacher to use all the results to determine the magnitude of the constant centripetal force.

List and explain the steps of the analysis required to calculate the centripetal force. (note: You are **not** required to calculate the force.)

4 marks	lists and explains all the steps
3 marks	lists all the steps but there is a lack of explanation or lists and explains most steps
2 marks	lists some of the steps or or explains some of the steps
1 marks	provides some relevant information

sample answer

We need to use the mathematical model $F_c = mv^2/r$

Given there are multiple data sets we need to use graphical analysis to combine the results

First find the linear velocity from the data using $v = 2\pi r/T$ where T = time (s) for 10 cycles divided by 10, and r is converted to m

Plot a graph of v^2 vs r

Find the gradient which will F_c /m

Find F_c = gradient x m, ensuring that m is expressed in kg.

Question 24 (6 marks)

The table displays data from the 8 planets in our solar system.

	Mercury	Venus	Earth	Mars	Jupiter	Saturn	Uranus	Neptune
Mass (x 10^{24}kg)	0.33	4.87	5.97	0.642	1898	568	86.8	102
Diameter (km)	4879	12,104	12,756	6792	142,984	120,536	51,118	49,528
Density (kg/m3)	5427	5243	5514	3933	1326	687	1271	1638
Length of Day (hours)	4222.6	2802	24	24.7	9.9	10.7	17.2	16.1
Orbital Period (days)	88	224.7	365.2	687	4331	10,747	30,589	59,800
Average Distance from Sun (x10^6 km)	57.9	108.2	149.6	227.9	778.6	1433.5	2872.5	4495.1
Perihelion (x10^6 km)	46	107.5	147.1	206.6	740.5	1352.6	2741.3	4444.5
Aphelion (x 10^6 km)	69.8	108.9	152.1	249.2	816.6	1514.5	3003.6	4545.7

(a) Which planet in the table has the most elliptical orbit? (1)

1 mark correctly identifies Mercury

(b) At what distance from the sun is Mars travelling with its greatest orbital velocity? Which of Kepler's laws did you use to answer this? (2)

2 marks	provides distance and correct law
1 mark	provides distance or correct law

Sample answer

This occurs at the closest point to the sun, which is the perihelion 206.6 x 10^6 km. This is from Kepler's Second Law (or Law of Equal Areas).

(c) The mass of the Sun = 2.00×10^{30} kg. What is the average gravitational force between the Sun and Mercury? (3)

3 marks	correctly substitutes into equation correctly find answer with units and correct sig fig
2 marks	correctly calculates answers but error with units or correct sig fig or substitutes into correct equation but makes an error in a variable such as not converting r to m or substitutes into correct equation but makes a calculation error in a variable such as not squaring the radius
1 mark	provides correct equation

24 c) $M = 2.00 \times 10^{30}$ kg $m = 0.33 \times 10^{24}$ kg
$r = 57.9 \times 10^{9}$ m

$$F = \frac{GMm}{r^2}$$
$$= \frac{6.67 \times 10^{-11} \times 2.00 \times 10^{30} \times 0.33 \times 10^{24}}{(57.9 \times 10^{9})^2}$$
$$= 1.31 \times 10^{22} \text{ N}$$

Question 25 (4 marks)

A satellite is in a stable low earth orbit with a constant speed and altitude. The controller of the satellite wants to move it to a higher orbit. On board rockets are fired to increase the speed of the satellite and when the new orbit is reached the rockets are fired to reduce the speed.

Use your understanding of relevant physical principles to explain this sequence of events.

4 marks	provides a full explanation related to law of conservation of energy, orbital velocity and Newtons laws
3 marks	provides an explanation related to two physical principles/laws
2 marks	provides an explanation for part of the manoeuvre related to one physical principle
1 mark	provides some relevant information

Sample answer

To move to a higher orbit the satellite must gain gravitational energy. By the law of conservation of energy this comes from the conversion of chemical energy into kinetic energy in the rocket engine.

Rocket engines are Newton's 3rd aw in action, the exhaust gases apply a force to the rocket, and the rocket applies a reaction force. The unbalanced force causes an acceleration.

When the satellite reaches the new orbit, the orbital velocity is less than for the previous orbit according to $v = \sqrt{\frac{Gm}{r}}$. Therefore, the rockets apply a force in the opposite direction of motion which slows the satellite according to Newton 2nd law of motion F = ma

Question 26 (4 marks)

Explain why electrical energy is transmitted over large distances at very high AC voltages and low currents.

4 marks	full explanation which relates • AC to the use of transformers • Power consumption in the lines to $P = I^2R$ • High voltage transmission to lower line current • line loss to efficiency
3 marks	explanation which relates to 3 of the above

2 marks	explanation which relates to 2 of the above
1 mark	provides one piece of relevant information

Electrical energy is transmitted using AC because AC can be readily transformed to higher or lower voltage using transformers
Power is transmitted at high voltages because $P = IV$, the higher the voltage the lower the current.
The power lost in the transmission lines with a resistance R is given by $P_{loss} = I^2R$.
This means that lower currents mean less loss of power in the lines which makes the transmission more efficient.

Question 27 (5 marks)

A charged particle, particle *X*, is moving perpendicular to an electric field. Another charged particle, particle *Y*, is moving perpendicular to a magnetic field. The particles are identical in charge, mass and have the same initial velocity.

(a) Outline ONE similarity and ONE difference between the behaviours of the particles in the fields. (2)

2 marks	correctly identifies ONE similarity and ONE difference
1 mark	correctly identifies ONE similarity or ONE difference

sample answer

similarities - both particles are deflected to the right/ both trajectories are curved

difference - path shape - X parabolic, Y is circular

(b) If the initial velocity of each particle was doubled, what effect would this have on the motion in each field? (3)

3 marks	correctly describes the changes to the path of each particle
2 marks	correctly describes the changes to the path of one particle and incorrectly describe a change in the other
1 mark	outlines some change to one or both paths

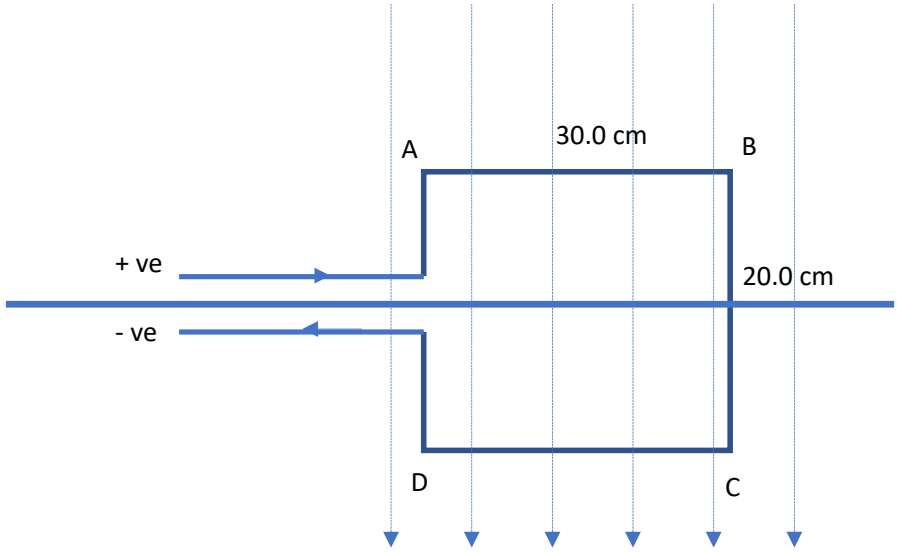
sample answer

For particle X, F = Eq increasing speed would have no effect on the force, but the force would act for less time therefore the curve of the parabolic path would be less

For particle Y, $F = qvB = mv^2/r$ therefore $r = mv/qB$ so r is proportional to v, so the radius of the circular path would double

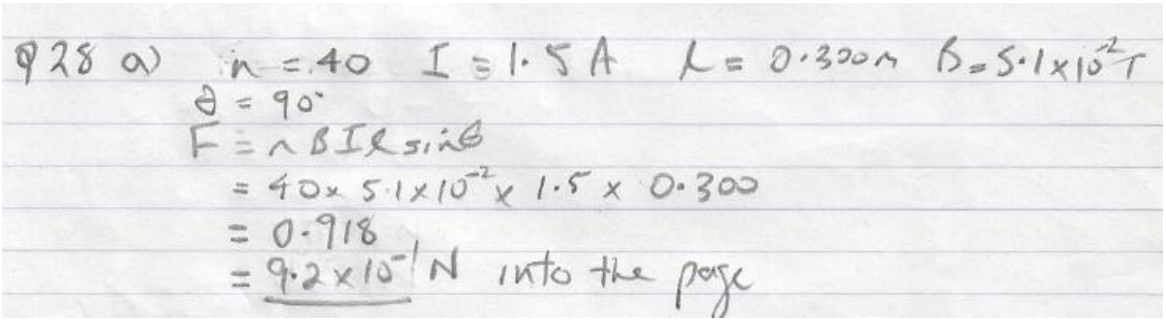
Question 28 (6 marks)

A motor uses a coil with 40 turns that has dimensions of 30.0 cm x 20.0 cm, as shown in the diagram. A current of 1.5 A flows through the coil in the direction shown. The coil is vertical and is in a magnetic field of 5.1 x 10^{-2} T directed as shown.



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

3 marks	correctly calculate the force and gives correct direction
2 marks	correctly calculate the force but not direction or give correct direction but makes error in substitution eg leaves off n = 40
1 mark	correctly shows direction or substitutes into appropriate formula with error



(b) What is the magnitude and direction of the torque experienced by the coil in this position? (2)

2 marks	correctly calculate the torque and gives correct direction
1 mark	correctly calculate the torque or gives correct direction

b) $A = 0.300 \times 0.200 = 0.0600\ m^2$ $\theta = 0°$

$\tau = nBIA\sin\theta$

$= 40 \times 5.1 \times 10^{-2} \times 1.5 \times 0.0600$

$= 0.183$

$= 0.18\ Nm$ AB into page DC out of page

(c) The coil rotates because of the applied torque. What would happen to the magnitude of the torque as the coil rotates through 90º? (1)

1 mark it reduces to zero

Question 29 (4 marks)

A circular loop of wire is dropped vertically to fall through a magnetic field as shown in the diagram. The plane of the coil is always perpendicular to the field lines.

A current flows in the direction shown in Fig 1. and the coil experiences a force in the opposite direction to the motion. However, when the coil is entirely inside the field, Fig. 2, there is no current and no opposing force.

Fig 1.

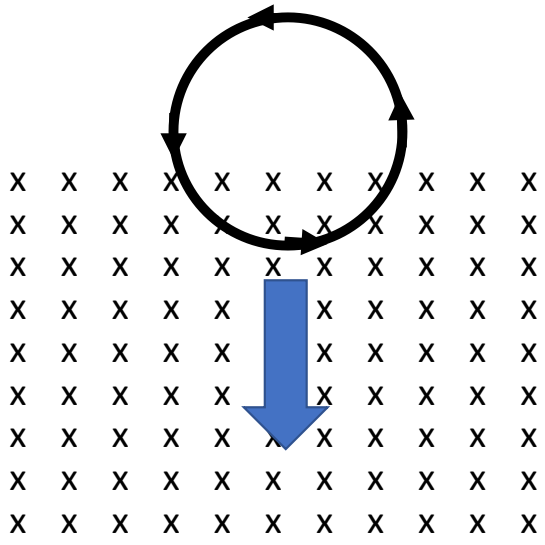
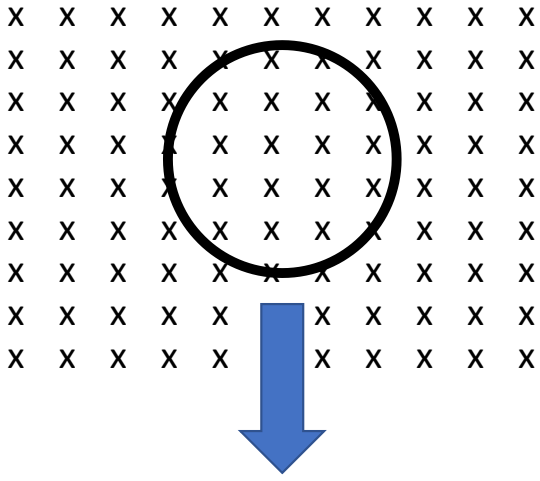


Fig 2.



Use your understanding of Faraday's law and Lenz's law to explain this scenario.

4 marks	Full explanation of both Figures, including Faradays Law, Lenz's law current and forces
3 marks	Full explanation of one Figure, partial explanation of the other
2 marks	Full explanation of one Figur only or two partial explanations of the both

1 mark	provides some relevant infomation

In Fig 1 the coil is entering a magnetic field therefore it is experiencing a change in flux. According to Faradays law, this will induce a voltage. $V = -n \frac{\Delta \varphi}{\Delta t}$. Since there is a circuit, a current will flow. According to Lenz's law the current will flow to oppose the change, therefore the loop will experience a retarding force.

Once the loop in entirely in the field Fig 2, there is no net change in flux therefore there is no induced voltage or current, so there is not retarding force.

Question 30 (4 marks)

A student placed lens B over lens A and noted that the intensity of light passing through was reduced in the region where the lenses overlap. Lens B was then rotated, and it was noted that even less light passed through.

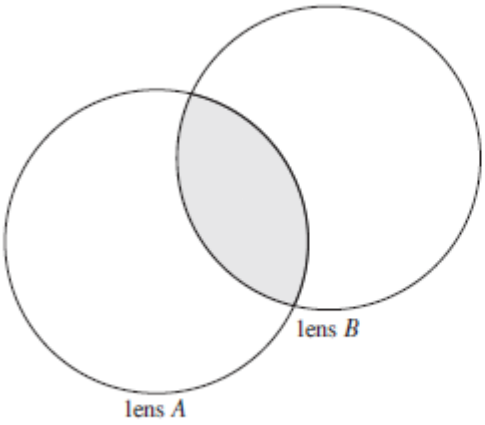


Figure 1

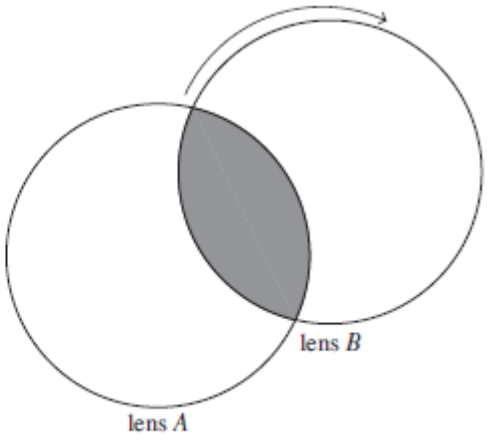


Figure 2

Explain the observations made by the student.

4 marks	Full explanation related to axis of polarisation, angle using Malus Law
3 marks	
2 marks	
1 mark	

Lens A and Len B are both polarised. The light passing through A is polarised

In fig 1 the axes of polarization of the lenses are at an angle θ so that the light intensity is reduced according to Malus Law $I = I_{max}\cos^2\theta$.

In figure 2, the angle between the axes has increased, therefore the intensity of the light transmitted is decreased.

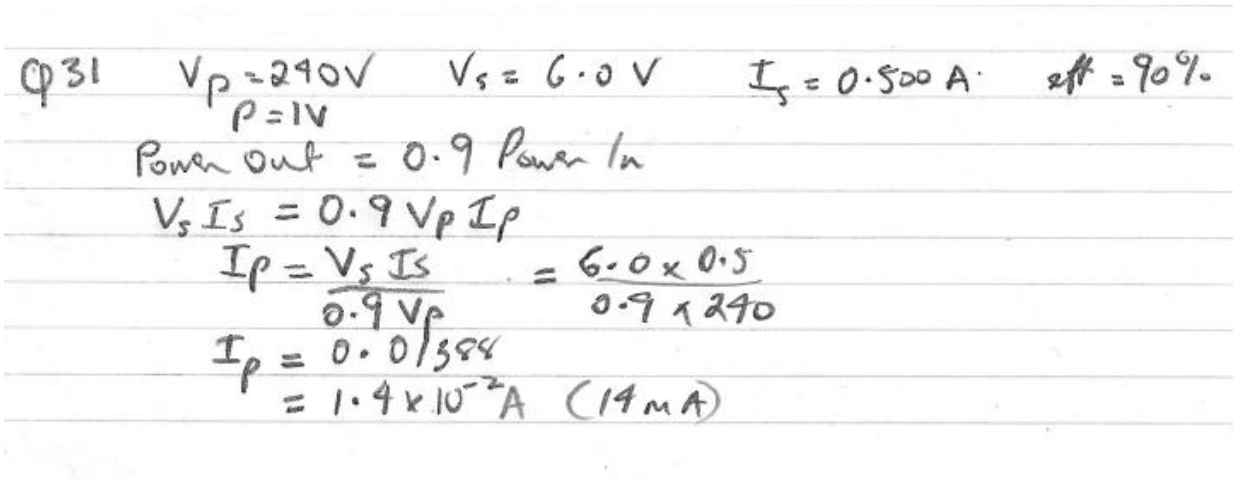
θ

Question 31 (3 marks)

A transformer in a laptop charger converts 240V AC into 6.0 V AC. When the charger is plugged into the laptop there is an output current of 500 mA. The charger has an energy efficiency of 90%.

Calculate the input current to the transformer in the charger.

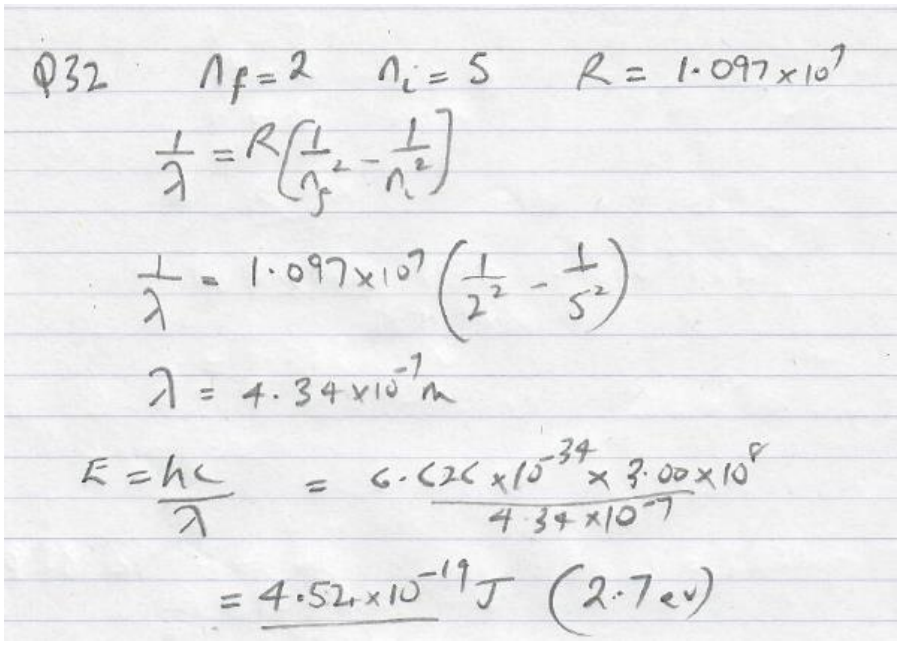
3 marks	Correctly calculates the current
2 marks	Uses current and voltage relationships to calculate input current but makes an error based on efficiency
1 mark	uses a relevant equation to do some working



Question 32 (3 marks)

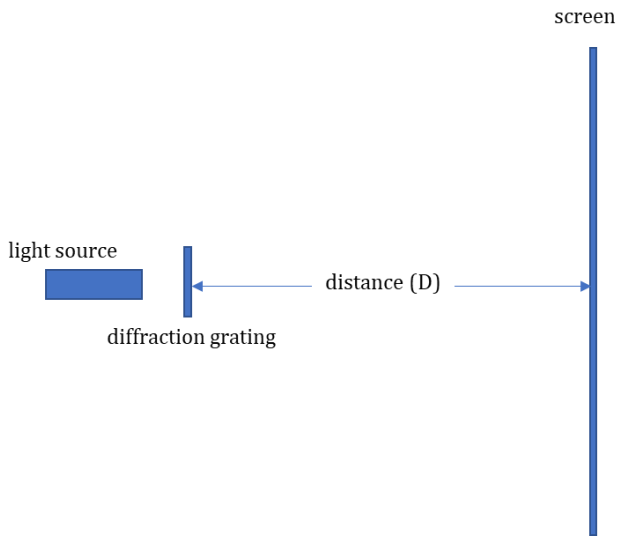
Calculate the energy of a photon of light which is emitted when an electron in an excited hydrogen atoms transitions from level 5 down to level 2.

3 marks	uses Rydberg equation to find the wavelength uses E = hc/λ to find photon energy
2 marks	uses Rydberg equation to find the wavelength and uses E = hc/λ to find photon energy but makes a calculation error or uses Rydberg equation to find the wavelength
1 mark	uses a relevant equation to do some working



Question 33(4 marks)

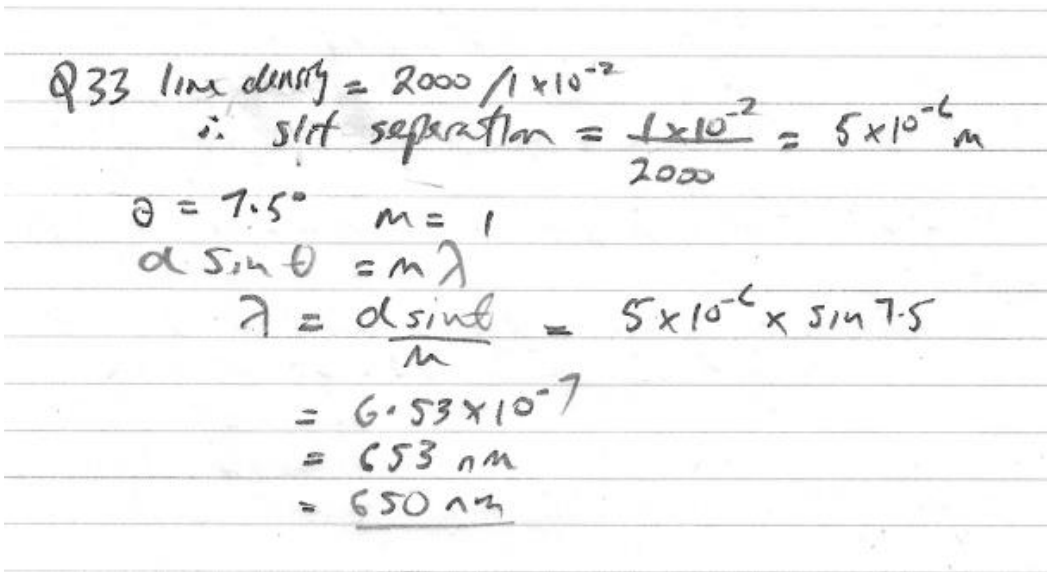
A diffraction grating has 2000 lines per cm. It was placed between a monochromatic light source and a screen at a distance D.



(a) A student shone monochromatic light at the diffraction grating and found a first-order maximum at an angle of 7.5 ° to the central maximum.

Find the wavelength of the light source. Express your answer in nanometres. (3)

3 marks	calculates and uses $d\sin\theta = m\lambda$ to find λ. Converts to nm
2 marks	makes a calculation error or provides correct answer but does not convert correctly to nm
1 mark	uses a relevant equation to do some working

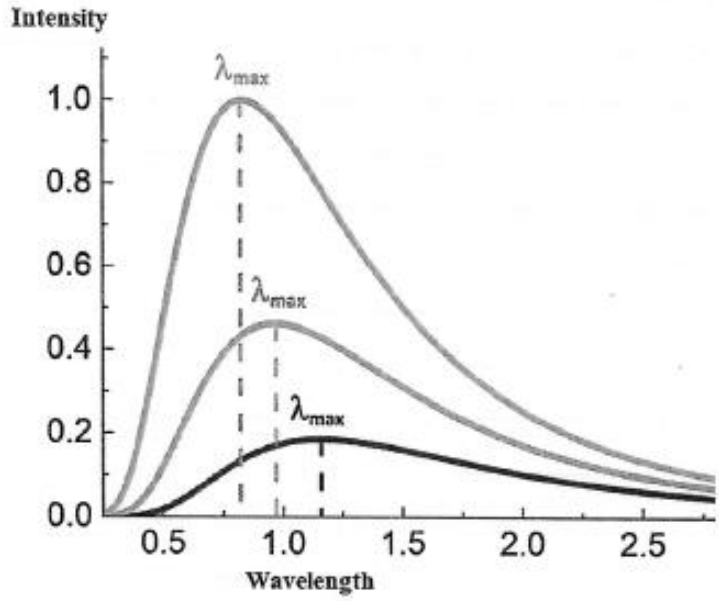


(b) If the distance D between the screen and the diffraction grating was decreased, what would happen to the distance between the maxima on the screen? (1)

1 mark – the spacing would decrease.

Question 34 (8 marks)

The graph shows the intensity vs wavelength for 3 black bodies at different temperatures.



(a) Black body radiation curves could not be explained using classical wave mechanics. What new interpretation did Max Planck introduce to explain the shape of the curves? (1)

1 mark – that the light energy is quantised

(b) Use Wien's law to estimate the temperature of the hottest of the three bodies. (3)

3 marks	selects the correct object and calculates using Wien's law
2 marks	selects an incorrect object and calculates T or selects the correct object and attempts to calculate T using Wien's law but makes an error
1 mark	attempts to calculate T

Q 34 b) shortest wavelength of peak = hottest

λ_{max} from graph $= 0.8 \times 10^{-6}$ m

$\lambda_{max} = \frac{b}{T}$

$T = \frac{b}{\lambda_{max}} = \frac{2.898 \times 10^{-3}}{0.8 \times 10^{-6}} = 3622.5$ K

$= 4000$ K (1 sig fig)

Question 34 continued on next page

(c) Describe how Einstein used Planck's interpretation to explain the existence of the threshold frequency in the photoelectric effect. (4)

4 marks	Full explanation for incident light above and below f_0, including quantization of energy (E = hf,) electron-photon interaction, work function and kinetic energy
3 marks	explanation including most of the above points
2 marks	explanation including some of the above points
1 mark	provides some relevant information

Sample answer

When light beyond the threshold frequency, f_0,is incident on a metal, photoemission occurs instantly.

Einstein explained this using Planck's idea that light was a particle (photon) with a quantum of energy E = hf

He theorized that when a photon falls on the surface of a metal, the entire photon energy is transferred to an electron.

Part of this energy is used to remove the electron from its bond to a metal atom and the rest is given to the ejected electron as kinetic energy. The minimum amount of energy required to remove an electron he called the work function.

If a photon has a frequency below f_0 it cannot give an electron enough energy to escape. If a photon has a frequency above f_0 the electron can escape and any excess energy above the work function will be expressed as the kinetic energy of the photon.

Question 35 (6 marks)

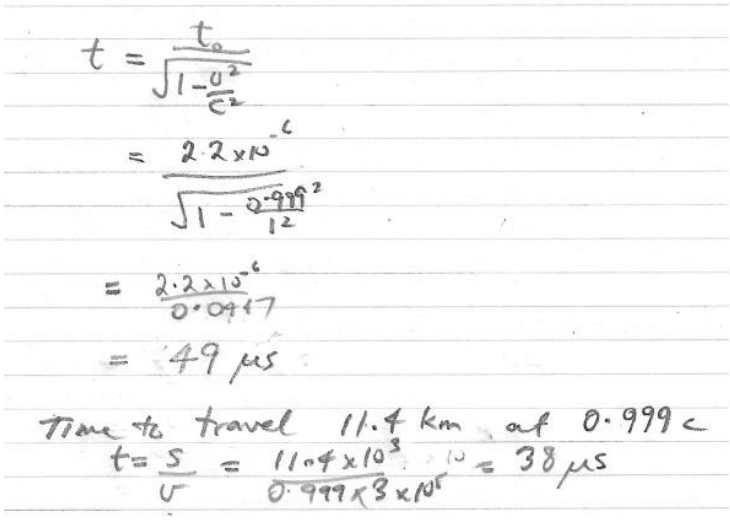
Muons are unstable subatomic particles that decay into electrons and neutrinos with a mean lifetime of 2.2 μs. They are produced when cosmic rays bombard the upper atmosphere about 11.4 km above the earth's surface, and they travel very close to the speed of light relative to the earth.

Explain how observations of these muons can be used as evidence to support Einstein's Special Theory of Relativity of both length contraction and time dilation.

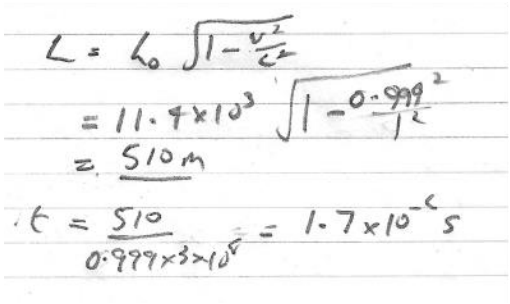
6 marks	Uses a full quantitative analysis from both frames of reference to show evidence for both length contraction and time dilation
5 marks	Uses a partially quantitative analysis from both frames of reference to show evidence for both length contraction and time dilation
4 marks	Uses a **qualitative** analysis from **both** frames of reference to show evidence for both length contraction and time dilation or Uses a full quantitative analysis from **one** frame of reference to show evidence for length contraction or time dilation
3 marks	Uses a qualitative analysis from one frames of reference to show evidence for length contraction or time dilation or Uses a partially quantitative analysis from one frame of reference to show evidence for length contraction or time dilation
2 marks	Uses information from the question to show some evidence for length contraction or time dilation
1 mark	provides some relevant information

Many more muons arrive on the surface of the earth than would be expected if time dilation did not occur. Travelling at close the speed of light, say 0.999 c, muons with a life span of 2.2 and 10^{-6} s would travel only $s = vt = 0.999 \times 3.0 \times 10^8 \times 2.2 \times 10^{-6} = 660$ m into the atmosphere before decaying if relativistic effects did not occur.

However, from the earth frame of reference, the lifetime of the muon is significantly dilated due to their relativistic speeds. Using the time dilation formula, it can be shown that the muons will have a longer life span in the earths frame of reference and therefore many will not have decayed by the time the reach the earth surface.



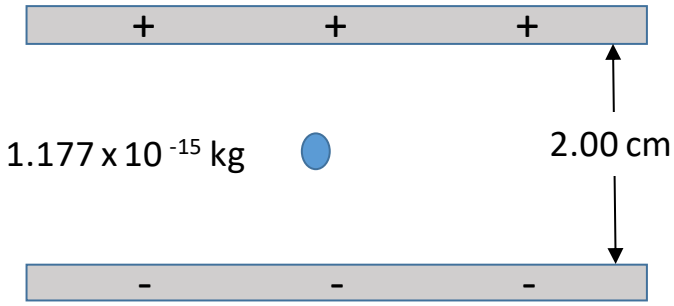
This can also be explained from the muon frame of reference by length contraction. The distance from the upper atmosphere of the ground of 11.4 kilometres is contracted according to the length contraction formula.



From the muon frame it only needs to cover 510m which would take 1.7 μs which it can do before it decays.

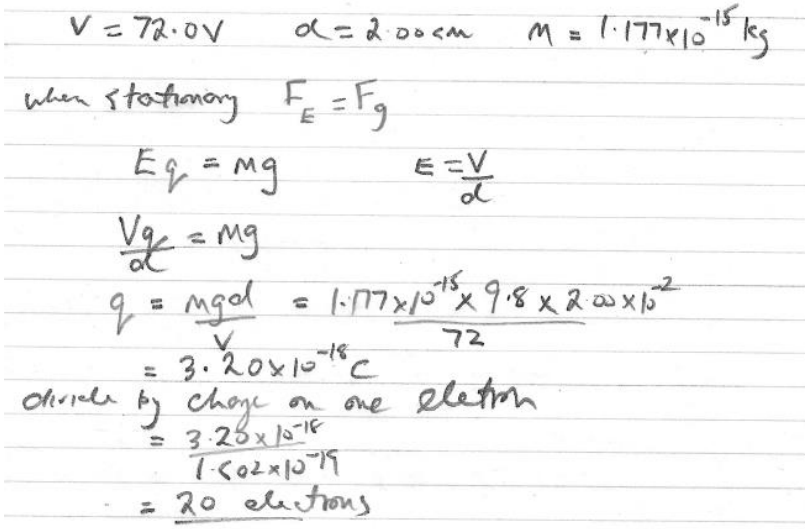
Question36 (4 marks)

An oil drop of mass 1.177×10^{-15} kg falls vertically into the evacuated space between two parallel charged plates, which are 2.00 cm apart. The oil drop is negatively charged.



(a) The voltage is altered so that it slows the oil drop until it is stationary. When the potential difference between the plates is 72.0 V, the oil drop stops moving. How many excess electrons are on the oil drop? **3**

3 marks	full working to get correct answer
2 marks	full working to get correct answer for charge, but incorrect number of electrons or full working to get correct answer for charge but no attempt to find number of electrons or full working to get find for charge and number of electrons but makes a calculation error eg not converting cm to m
1 mark	uses a relevant equation to do some working

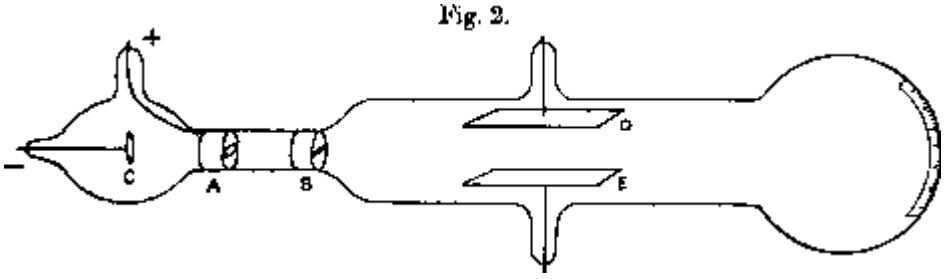


(b) An experiment with a similar approach was used by Robert Millikan. What did he conclude from his investigation? **1**

1 mark – the fundamental charge on an electron

Question 37 (5 marks)

In 1889, JJ Thomson performed an investigation that determined the charge to mass ratio of the electron using the apparatus shown below.



Outline his procedure and how he derived the relationship $\frac{q}{m} = \frac{E}{rB^2}$

5 marks	outlines all main steps and show full derivation of q/m
4 marks	outlines most of the main steps and show full derivation of q/m or outlines all the main steps and shows a partial derivation of q/m
3 marks	outlines some of the main steps and shows a partial derivation of q/m or shows a full derivation of q/m ratio only
2 marks	outlines some of the main steps and attempts a derivation of q/m ration
1 mark	provides some relevant information

Thomson applied a high potential between the anode A and the cathode B to produce a beam of electrons which could be observed on a screen coated with phosphors.

He used a coil with a current applied to it to produce a magnetic field in the region of D and E that deflected the beam. The radius of deflection, r, was determined from where the beam now hit the screen.

He then applied an electric field between D and E to counteract the magnetic field and straighten the beam so $F_E = F_B$

From the known parameters of B, E and r he could determine the q/m ratio.