Section A: Multiple Choice

Select the best response.
Attempt all questions, Answer on the separate bubble sheet.

1. What was the key piece of evidence in Rutherford's Gold foil experiment that led to a revision of the atomic model?

A a few alpha particles passed through unhindered

B most alpha particles were scattered through angles from 15° to 30°

C most alpha particles were deflected at angles greater than 90°

D a few alpha particles were deflected at angles greater than 90°

2. What will be produced when white light is passed through a gaseous sample of an element and examined with a spectrometer?

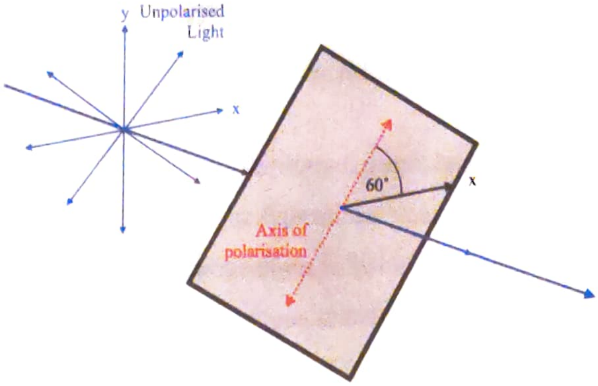
A An absorption spectrum that is shown as a series of dark lines on a coloured background

B An emission spectrum that is shown as a series of coloured lines on a dark background

C An absorption spectrum that is shown as a series of coloured lines on a dark background

D An emission spectrum that is shown as a series of dark lines on a coloured background

3. Unpolarised light with an intensity of 10 L passes through a polarising filter as shown below. What is the intensity after the filter?



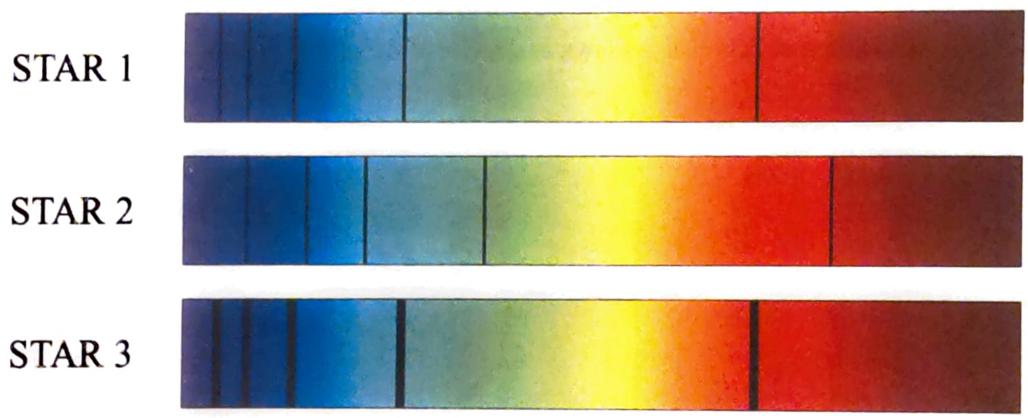
A 2.5 L

B 5.0 L

C 7.5 L

D 8.0 L

4. Below are the Hydrogen absorption spectrums from three different stars.



Which statement about the spectrums is most likely correct?

A Star 2 is closer to the Earth than star 3

B Star 1 has a faster rotational velocity than star 3

C Star 2 has a higher temperature than star 1

D Star 3 has a similar translational velocity to star 1

5. Barnard's star is $\boxed{5.963}$ light years from Earth. If a spacecraft was to travel this distance at 0.35 c, calculate the time of travel from the astronaut's perspective.

A 17.0 years

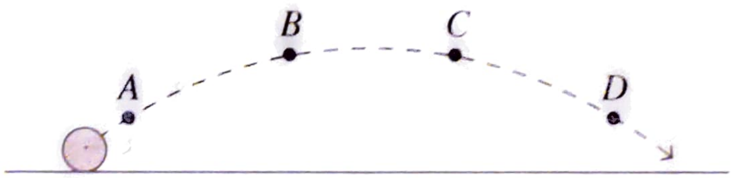
B 16.0 years

C 13.7 years

D 5.96 years

6. A field hockey player scoops the ball up and over opposing players to pass to their teammate further up the field. The ball moves from position *A* to position *D*, as shown in the diagram. At all labelled points the ball is not in contact with any object and drag is to be ignored.

At which point[s] is the ball accelerating downwards?



A D only

B C and D only

C B, C, D only

D A, B, C and D

7. A National Aeronautics and Space Administration (NASA) scientist uses a simulator to model the surface gravity of four different bodies in the Solar System. The surface gravity of each body is shown in the table.

Body	*Surface gravity ($m\ s^{-2}$)*
Ceres	5.55
Icarus	0.38
Hermes	4.97
Pallas	2.49

In the first simulation, the scientist throws a small cube with a mass of 450 g upwards. The cube initially travels at a speed of 6.5 m s^{-1} and reaches a maximum height of 8.5 m above the point of release.

Which body is the scientist simulating?

$0 = 6.5^2 + 2a(8.5)$

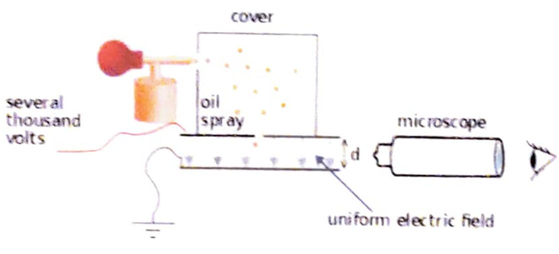
A Ceres

B Icarus

C Hermes

D Pallas

8. Millikan's oil drop experiment was designed to find the charge on an electron.



Some drops were observed to be stationary. Which two quantities would be in balance (equal but opposite) for this to occur?

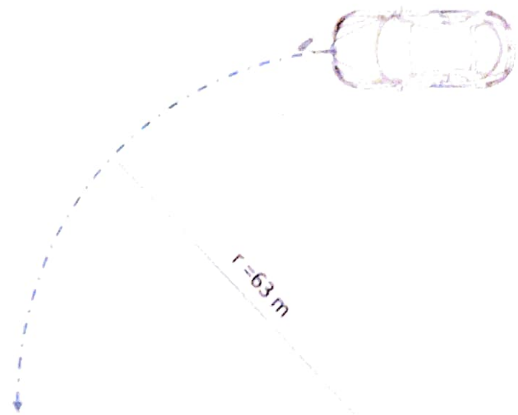
A weight force (mg) and electrostatic force (qE)

B weight force (mg) and electromagnetic force (qvBsinθ)

C mass (m) and electrostatic force (qvBsinθ)

D gravitational field (g) and electric field (E)

9. A car is approaching a curve at 60 kmh^{-1} .



Calculate the magnitude of the centripetal acceleration required for the car to navigate this corner at this speed.

A 0.95 ms^{-2}

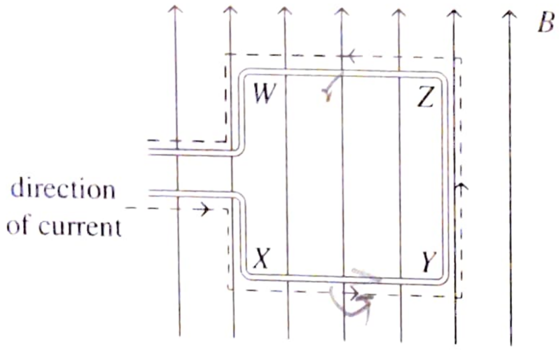
B 57.1 ms^{-2}

C 4.4 ms^{-2}

D 0.26 ms^{-2}

$a_c = \frac{v^2}{r} =$

10. Consider the current-carrying loop.



How is torque created in the current-carrying loop?

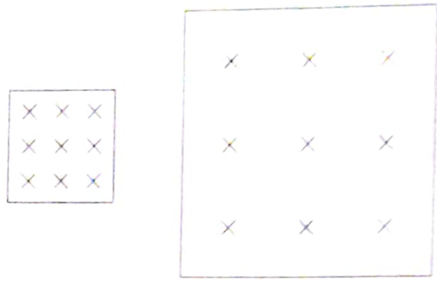
A There is a force on WZ out of the page and a force on XY into the page

B There is a force on WZ into the page and a force on XY out of the page

C There is a force on WZ out of the page and a force on XY out of the page

D There is a force on WZ into the page and a force on XY into the page

11. A Physics teacher drew two magnetic fields and asked their students to explain the difference. The two magnetic fields are shown in the diagram.



A the two magnetic fields show the same amount of flux, and the smaller magnetic field shows less flux density

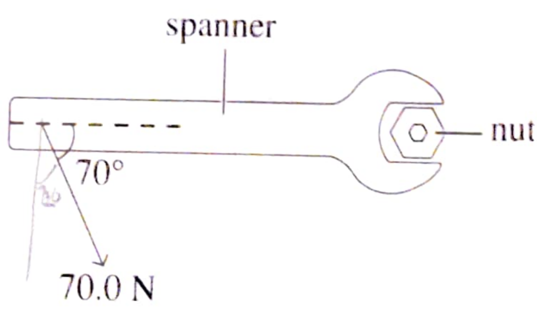
B the two magnetic fields show different amounts of flux, and the smaller magnetic field shows less flux density

C the two magnetic fields show different amounts of flux, and the smaller magnetic field shows greater flux density

D the two magnetic fields show the same amount of flux, and the smaller magnetic field shows greater flux density

12. In cycling, it is important for the nuts on bike seats to be tightened appropriately so they do not come loose during a race. Before a race, a cyclist tightened the nuts with a 50.0 cm spanner and applied a force of 70.0 N at an angle of 70° to the spanner, as shown in the diagram.

76cos(20)



What magnitude of torque has the cyclist applied to the nut?

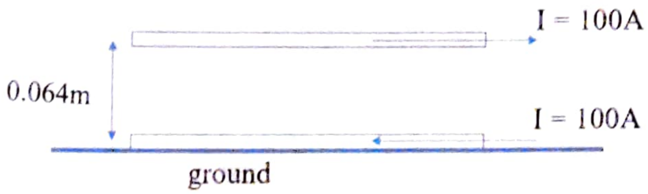
A 11.97 N m

B 32.89 N m

C 1197 N m

D 3289 N m

13. Two current-carrying rods are set up as shown. The upper rod is fully suspended by the electromagnetic force from the lower rod.



Calculate the mass per unit length of the upper rod

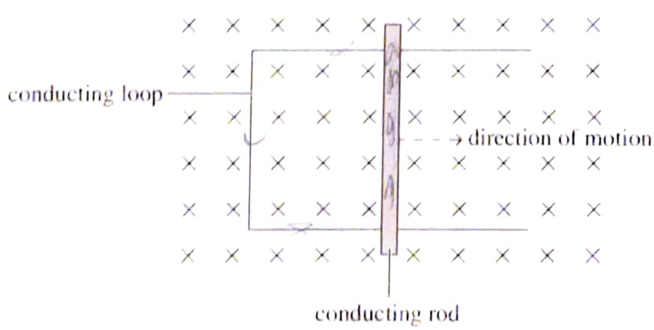
A 3.2×10^{-3} kg m^{-1}

B 3.2×10^{-2} kg m^{-1}

C 6.5×10^{-5} kg m^{-1}

D 6.5×10^{-4} kg m^{-1}

14. A conducting rod slides along a metal conducting loop, as shown in the diagram.



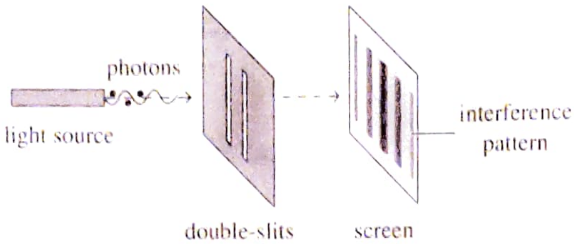
Which option correctly identifies the three variables?

	Direction of electromagnetic force on the conducting rod	*Direction of induced current in the rod*
A	to the left	up the rod
B	to the left	down the rod
C	to the right	up the rod
D	to the right	down the rod

15. Young performed an experiment where photons were beamed through a double-slit onto a screen, as shown in the diagram.

The following changes were made separately, one at a time.

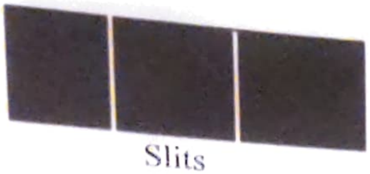
Change 1: The slit separation is increased.
Change 2: The distance between the double-slit and the screen is increased.



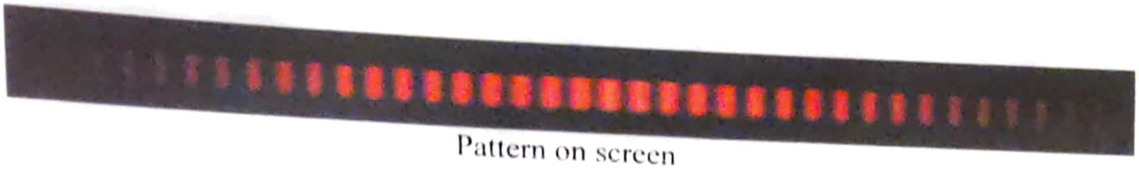
Which row of the table identifies what will occur after each change?

	Change 1	*Change 2*
A	If the slit separation increases, the spacing between the bright bands decreases	The spacing between the bright bands decreases
B	If the slit separation increases, the spacing between the bright bands decreases	The spacing between the bright bands increases
C	If the slit separation increases, the spacing between the bright bands increases	The spacing between the bright bands increases
D	If the slit separation increases, the spacing between the bright bands decreases	The spacing between the bright bands decreases

16. Monochromatic light was passed through two slits and formed the interference pattern on a distant screen shown in the diagram.

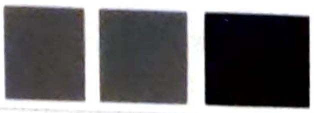


Slits



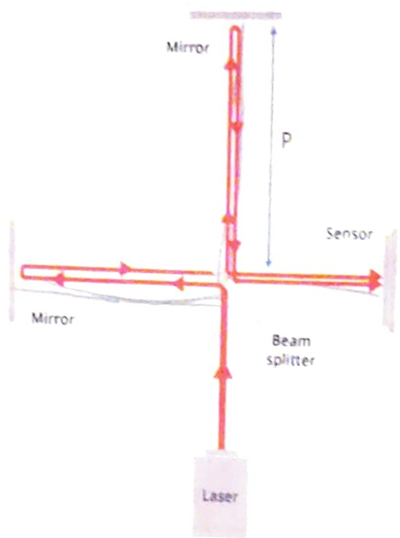
Pattern on screen

Which single change in the set-up of this experiment would generate the following pattern?

A	B	C	D
Change of slits to 	Change of slits to 	Change of slits to 	Halving the wavelength of the light.

17. In a modern repeat of the famous Michelson Morley experiment, a monochromatic laser produced light with a wavelength of 560 nm was used. This light took the paths shown in the diagram below.

The apparatus allowed for an adjustment in the path length, **P**, as shown below.



The apparatus was adjusted so that maximum intensity was recorded at the centre of the sensor.

P was then increased by 280 nm. What effect would this have on the observed intensity?

A The intensity would reduce during the change and end up very low.

B The intensity would reduce while the change is being made, but then increase again, ending up at approximately the same intensity as before the change.

C The intensity would undergo several decreases and increases in intensity until ending up greatly reduced.

D no change would be observed either during or at the end of the change.

18. Two objects are launched into space from the ground so that they will just escape Earth's gravitational field forever, by being given an initial velocity.

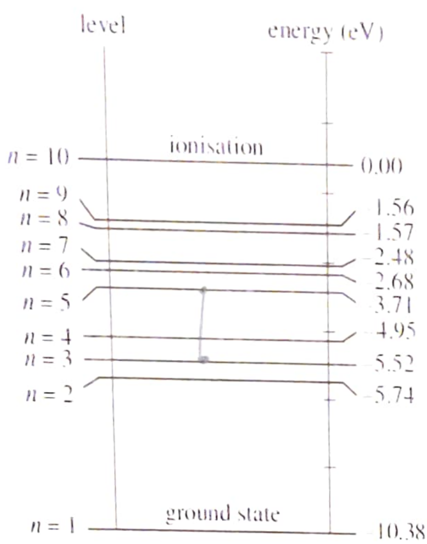
Object **A** had a mass of 10 kg, while object **B** had a mass of 100 kg.

$\frac{1}{2}mv^2 = \frac{GMm}{r}$

Which alternative is correct?

	Objects' initial speed	Objects' initial kinetic energy
A	equal	equal
B	equal	**B** is 10 times greater than **A**
C	equal	**B** is 100 times greater than **A**
D	**B** is 10 times greater than **A**	**B** is 100 times greater than **A**

19. The energy level diagram for mercury is shown.



3.71 - 5.52 =

What frequency of light would be emitted as an electron falls from the $n = 5$ state to the $n = 3$ state?

A 1.8×10^{9} Hz

B 2.89×10^{-19} Hz

C 4.4×10^{14} Hz

D 2.3×10^{14} Hz

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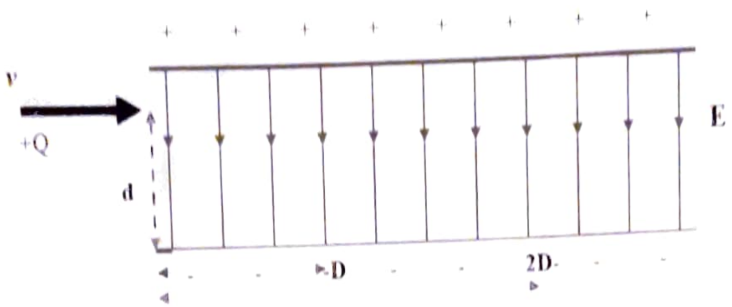
20. A charged particle (+Q) enters a region of uniform electric field E between two parallel plates, as shown. The particle's velocity before entering is *v*.

The apparatus is in a vacuum and the experiment is being performed in weightless conditions. The charged particle travels a horizontal distance **D** before striking the charged plate.



Which of the following would cause the particle to strike the plate at a distance of **2D**?

A halving the mass of the particle

B halving the electric field strength

C doubling the initial velocity to **2*v***

D halving the vertical distance, **d**, the particle must move

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

$\vec{E}$

$s = ut + \frac{1}{2}\frac{qE}{m}(t)^2$

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SECTION B

Answer all questions in the space provided. Marks awarded for working out.

Question 21. (3 marks)
A canon ball is fired from ground level as shown below. Calculate its range across level ground.

3

Time of flight:

- let vertical distance/range = y
- Horizontal range = x

so

y = 0 at range x,

$0 = u_y t + \frac{1}{2}at^2$

$-u_y t = \frac{1}{2}at^2$

$u_y = 28\sin(23)$

$u_y = 10.94\,ms^{-1}$

~~0 = 10.94~~

$10.94\cancel{t} = \frac{1}{2}(9.8)t^{2}$ (cancel time)

$10.94 = 4.9t$

$t = 2.2326...$

so

$x = t\cos 23 \times 28$

$x = 57.5\,m$

23

Question 22 (4 marks)

Two projectiles are launched with the same initial speeds and angles to the horizontal. Projectile **A** has a mass of **m**, while projectile **B** has a mass of **2m**.

a) Explain why the two projectiles will have the same range.

as the rang is independent of mass and rather dependent on ~~vertical~~ time of flight which is dependent on vertical velocity and horizontal velocity, the two sharing vertical and horizontal velocity mean they will have the same range.

2

Both projectiles were launched again, this time with the same angles to the horizontal but with different initial speeds. → mmmmm

Projectile **B** remains in flight for twice as long as projectile **A** over level ground.

b) Demonstrate that projectile **B** travels twice the distance compared to projectile **A**.

if $t_B = 2t_a$, then as $x_A = u_A \cos\theta \times t_A$, then assuming B has the same the initial horizontal velocity ($u_A \cos\theta = u_B \cos\theta$) then

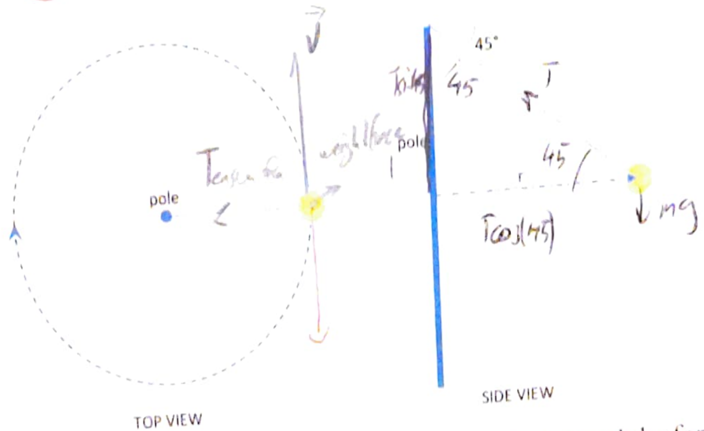
2

$x_B = 2t_a \times \cos\theta \times u_B$

$= 2t_a \times \cos\theta \times u_A$ (as $u_A = u_B$)

$x_B = 2x_a$

Question 23. (6 marks)
The diagrams show a totem tennis set-up from top and side views. A tennis ball is tied to a pole with a cord so that it moves in a clockwise, circular motion around the centre pole.



a) ON THE top view (LEFT) DIAGRAM, Label the velocity of the ball and the force[s] acting on it at the point shown.

2 1

The ball has a mass of 60.0 g and the cord is 1.80 m long. The ball rotates around the centre pole at an angle of 45° to the pole.

b) Calculate the radius of the ball's circular path

$T\sin 45 = T\cos 45 = mg$

$mg = \frac{mv^2}{r}$ → $\frac{v^2}{g} = r$ → $r = 1.8 \times \sin(45) = 1.27\text{m}$ 1

c) Determine the magnitude of the net force acting on the ball at the point shown. Explain your reasoning.

Tension [vertically] and weight force must be equal for uniform circular motion to occur and so only horizontal tension will occur which will also effectively be the centripetal force. ~~3~~ 2

$T\sin 45 = T\cos 45 = mg$ (as established earlier, because $\sin 45 = \cos 45$), so horizontal, vertical tension and weight will be equal)

$T\sin 45 = mg = F_c$ → $T\cos 45$ ∴ Net force $= T\cos(45)$ but $T\cos 45 = T\sin 45$,

so Net force $= mg$

∴ Net force $= 0.588$ N

~~$T\cos 45$~~ $mg = \frac{mv^2}{r}$

~~$T\sin 45$~~ $mg = \frac{v^2}{r}$

1

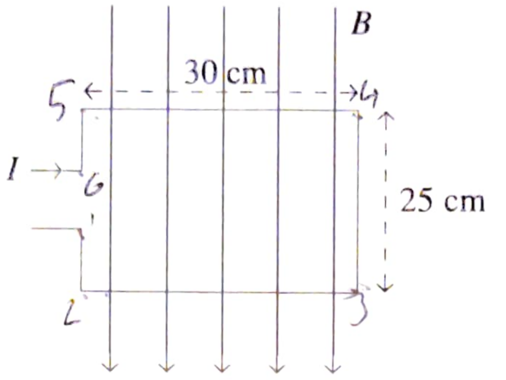
Tomsic Examination Number: 600 (23)

SECTION C

Answer all questions in the space provided. Marks awarded for working out.

Question 24. (2 marks)

The diagram shows the wire loop of a motor in a magnetic field. The loop carries a current of 8 A and the magnetic field intensity is 0.025 T.



Calculate the torque experienced by the wire loop. 2

$I = 8$, $B = 0.025$, $A = 0.3 \times 0.25 = 0.075$,

$m =$

$\tau = F \times r$

$F = B \times l \times I$

$\tau = B \times l \times I \times r$ → $A = l \times r$

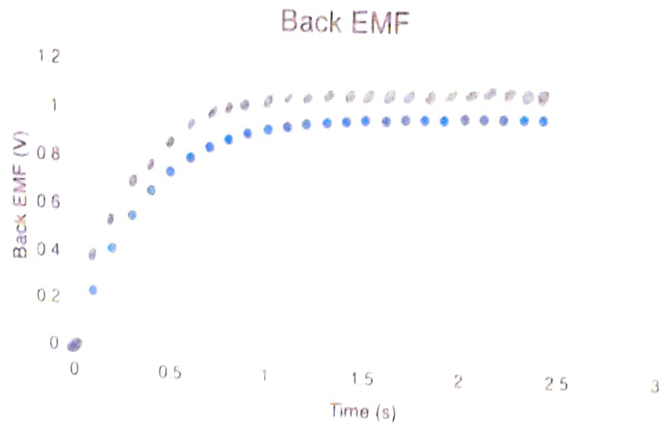
$\tau = B I A \times n$ → $n = 6$

$\tau = B I A \times 6$

$\tau = 0.09\ Nm^{-1}$

Question 25. (11 marks)

A DC electric motor was connected to a 1.2 V DC battery and allowed to gain angular velocity.
The back EMF in the motor was measured over a time interval of 2.4s and graphed below.



a) Explain the shape of the curve. Refer to appropriate laws and physics models. 3

See writing Booklet One

2

b) The above motor was connected in series with an ammeter and the current was measured over the same time interval. On the same axes above, sketch the curve of the measured current. Quantitative values (numbers) are not required on your sketch. 2

$\mathcal{E}_{net} = \mathcal{E} - \mathcal{E}_{back}$

0

Question 25 continues on the next page

on 25 (continued)

c) Compare the structural features and physics principles that are involved in DC motors and AC induction motors to explain how the motor effect is used in both motors.

6

4

Question 26. (2 marks)

Supertankers are large cargo ships that often transport oil. The supertankers TI Europe and TI ... each has mass of 5.00×10^8 kg. They float with their centres 100.00 m apart and. Calculate the gravitational force between the two supertankers.

$$F = \frac{GMm}{r^2} = \frac{(5\times10^8)^2 \times G}{(100)^2} = 1667.5N$$

$$= 1.67 \times 10^3 N$$

2 2

Question 27. (3 marks)

The James Webb telescope discovered a new solar system and estimated that a planet at radius 8.9 x 10^8 m had a period or orbit of 2000 earth-days around the central star.

a) Starting with Newton's law of universal gravitation and the laws of circular motion, derive an equation for the mass of the central star in terms of r and T.

kepler's

$$F = \frac{GMm}{r^2} = \frac{mv^2}{r}$$

& $v = \frac{2\pi r}{T}$

so

$$F = \frac{GM}{r} = \frac{4\pi^2 r^2}{T^2}$$

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

$$M = \frac{4\pi^2 r^3}{T^2 G}$$

2 2

b) Find the mass of the central star.

$T = 172.8 \times 10^6 s$, $r = 8.10^8$

so

$$M = \frac{4\pi^2 r^3}{T^2 G}$$

$$M = 5.9 \times 10^{13} kg$$

0 1

stion 28. (3 marks)

Demonstrate that gravitational force is insignificant compared to electrostatic force when considering the attraction between an electron and the nucleus. Use the Bohr model of the Hydrogen atom with electrons in uniform circular motion at r = 5.3 x 10^{-11} m.

3

Force due to attraction:

$F_g = \frac{GMm}{r^2}$

as hydrogen has one proton & one electron:

$F_g = \frac{G \times M_e \times M_p}{(5.3 \times 10^{-11})^2}$ where M_p = mass of proton

M_e = mass of electron

?

$F_g = 3.62 \times 10^{-47}$ inwards

Force due to electrostatics:

$F_E = \frac{1}{4\pi\epsilon_0} \times \frac{q_e \times q_p}{r^2}$ where q_e is electrons charge & q_p is protons charge

$F_E = 8.21 \times 10^{-8}$ N

as F_E is 39 x greater in magnitude than F_g, F_g is quite insignificant when compared to F_E so gravitational force is insignificant.

11

Question 29. (~~12~~ marks)

The apparatus below allows for investigations related to photoelectric effect. The device allows for light of different wavelengths to be incident on a photoelectric material and the stopping EMF (voltage) to be recorded.

In a particular investigation, light of different wavelengths was incident onto a photoelectric material and the stopping EMF (voltage) was recorded.

a) Identify the independent variable in this investigation. 1

wavelength, or incident light

1

A filter was used so that red light was incident and the voltage adjusted until the current just stopped. The intensity of the light was then increased, but this did not result in a current flow.

b) Explain this result and propose ONE change which would result in a current flowing. 3

See writing Booklet

2

Question 29 continues on the following page

on 29 (continued)

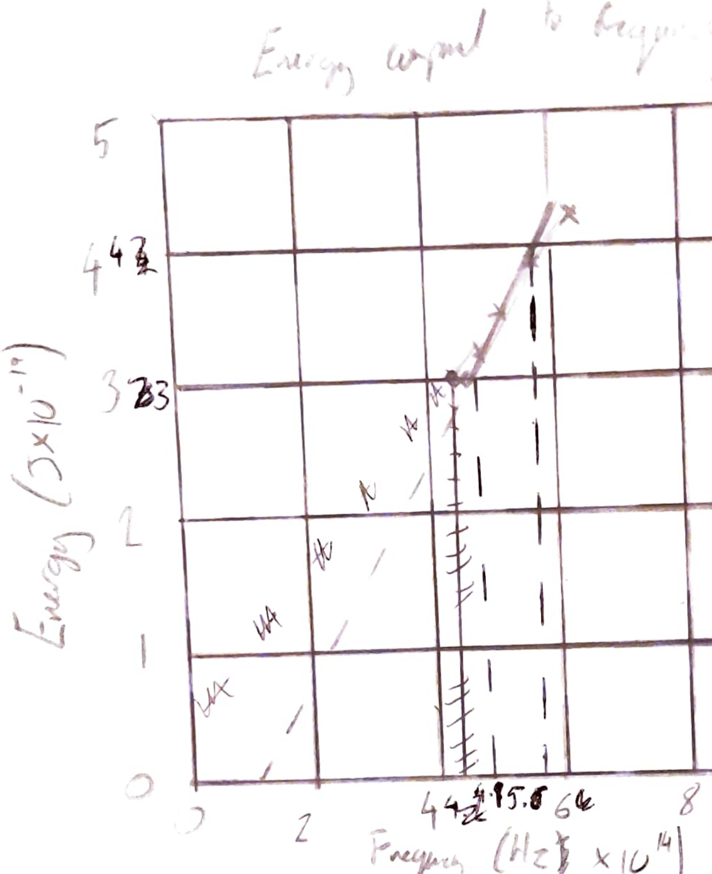
The following data was obtained.

Filter colour	Stopping Voltage (V)	K.E. of electrons (J)	Wavelength of light (nm)	Frequency (Hz)
Blue	2.6	4.2×10^{-19}	480	6.3×10^{14}
Green	2.41	3.9×10^{-19}	522	5.7×10^{14}
Yellow	2.12	3.4×10^{-19}	583	5.1×10^{14}
Orange	1.99	3.2×10^{-19}	613	4.9×10^{14}
Red	1.89	3.0×10^{-19}	660	4.5×10^{14}

c) Complete the final column in the table above. 1

d) Graph Energy vs Frequency on the axes below 4

3



e) Determine Planck's constant using your graph. 2

gradient $= \frac{(4-3)\times10^{-19}}{(5.6-4.1)\times10^{14}}$

$h = 6.67\times10^{-34}$

$h = 6.67\times10^{-34}$ Js

h (Plancks constant) $= \frac{\text{Energy}}{\text{Frequency}}$ = gradient

2

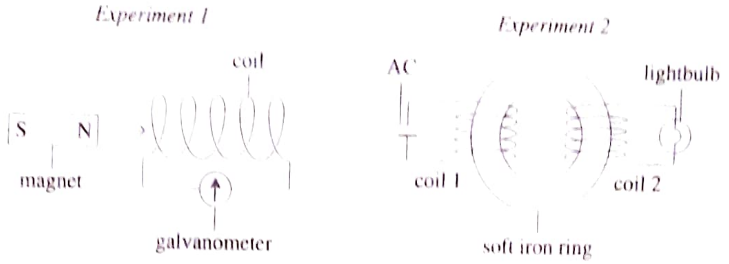
Examination Number:

SECTION D

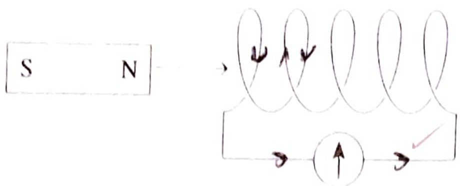
Answer all questions in the space provided. Marks awarded for working out.

Question 30 (6 marks)

Scientists including Faraday and Lenz investigated the relationship between electricity and magnetism through a series of experiments. The diagram shows the set-up of Faraday's first and second experiments.



a) Label the diagram below to show the direction of current and induced magnetic field in experiment 1. 2



1

b) Assess the contribution of Faraday and Lenz to our understanding of how magnetic fields and induced emfs are related in terms of the Law of Conservation of Energy. Refer to the diagrams in your response. 4

BOOKLET

3

Question 31 (4 marks)
When electricity is transmitted over large distances, transformers are used.

Two transmissions take place using identical transmission lines.

- In transmission A, 64kW of power is transmitted at 28 kV AC.
- In transmission B, 64kW of power is transmitted at 280 kV AC.

Compare the power losses that occur in transmissions A and B. Include relevant equations and calculations in your response.

4

~~$P_{loss} = I^2R = \frac{V^2}{R}$ ... $= VI$~~

~~· In transmission A:~~

~~$28 \times 10^3 = V$, $I = 2.29A$, $R = $~~

~~$P_{loss} =$~~

4

~~In transmission B:~~

$P_{loss} = I^2R$ ~~$= \frac{V^2}{R}$~~, ~~R~~ The original power loss in A & B is equal, however; as Powerloss is proportional to current^2, ~~not~~, more so than voltage (so a decrease in current leads to a decrease in powerloss), this means that as voltage increases, powerloss decreases, so Transmission B will have less powerloss as the power is transmitted at a greater voltage. This can be seen using the powerloss formula as R for both is the same, yet the current in A = 2.3A whilst in B it is 0.23, so A will lose 98 times more power than B ~~it has~~ due to its greater current.

Question 32 (9 marks)

'Prior to the twentieth century, physicists developed theories and models under the banner of classical physics that were able to make predictions. However, developments in the twentieth century saw these models and theories being challenged by quantum physics.' Analyse this statement with reference to the photoelectric effect and the work of Bohr, de Broglie and Schrödinger.

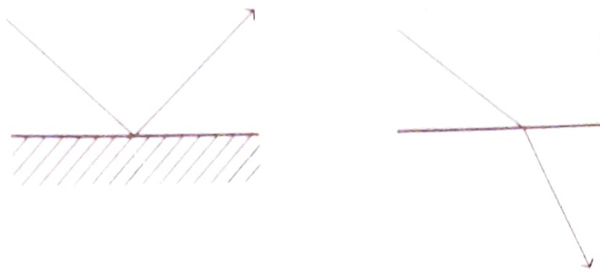
9

9

Writing space for Question 32 continues on the next page

Question 33 (4 marks)

Two theories of light were proposed by Newton and Huygens in in the seventeenth century: the corpuscular theory and the wave theory. Two properties of light are depicted in the diagrams.



Analyse the evidence, including the determination of the speed of light, that supported or challenged the competing models. In your response, refer to the properties shown in the diagrams.

Newton: Newton's model was corpuscular, i.e it involved particles of light that had little to no mass. This model of light was supported by reflection as the particles bounced [illegible] as seen in 4

3

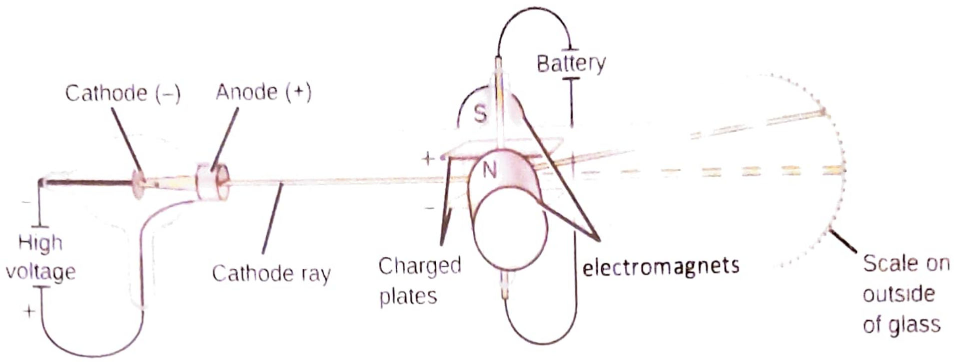
the second diagram the bending towards the normal according to Newton was due to the particles having an attraction force in the denser medium causing bending them ~~towards~~ away from the normal. ~~[illegible]~~ When the speed of light in water using Hippolyte Fizeau's method was measured, it was found slower than in the air and using Snell's law this could not be right so Newton's theory was not supported by the data.

Huygens: Christiaan Huygens ~~[illegible]~~ model ~~[illegible]~~ involved a longitudinal self propagating wave where the wavelets combined to form the wave front (see below). This explained diagram 1 as it also just bounced, but explained the second by saying that the wave propagation slowed down, which bent the light away from the medium. This was supported by Fizeau which found that light moved slower in denser medium supporting Huygens wave theory of light.

12

Question 34 (7 marks)

Thomson's experiment to measure the charge:mass ratio of cathode rays (electrons) is shown below.



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a) Explain how the left-hand end of the device acted as a particle accelerator. Support your explanation with reference to relevant laws.

The anode acted as a ~~...~~ collimator and so as the electrons jumped from the cathode to the anode they would enter an electric field between the top bit and bottom bit of the anode (as it had a gap) that would accelerate the particles, which is supported by the law of electrostatics where a ~~positive~~ negative charge is attracted by positive charges. 2

b) In the first part of Thomson's experiment, the electric field generated by the charged plates and the magnetic field generated by the electromagnets were adjusted so that the net force on an electron was zero. Demonstrate how this revealed the velocity of the electrons.

as $F = q$ (charge) V (velocity) B (magnetic field strength) : qE, charge (q) E (electric field strength)

[where E is electricity, $F = q\vec{E}$, the angle. 2]

by equating $F = qvB = qE$, we could cancel the q's and get that $\cancel{V = \frac{B}{E}}$ with $V = \frac{E}{B}$ which E & B were measurable constants.

2

Question 34 continues on the next page

Question 34 (continued)

c) Outline the significance of Thomson's empirical research (above) on the emerging models of the atom. In your answer, refer to relevant models of the atom.

3

Thomson's experiment measured the charge to mass ratio of electrons. This grounded the plum pudding model as through his experiment he predicted that the atom was made up of a ~~to~~ positive core with small negative charges inside. While wrong, ~~this~~ ~~model~~ his calculations later were used by Millikan to gain the charge and mass of electrons and ~~Rutherford~~ Further his finding of the charge to mass ratio ~~[illegible]~~ through the ~~[illegible]~~ also contributed to later models when they had to account for the orbital stability due to the electrostatic force.

2

Question 35 (5 marks)

Physicists are planning a new 32 km long linear (straight line) particle accelerator, the International Linear Accelerator. They intend to fire a pulse of laser light at a metal cathode to eject electrons, then accelerate the ejected electrons. The cathode has a work function of 4.5 eV.

a) Calculate the minimum frequency of laser light required for this apparatus to eject electrons. 1

$E = hf - \phi$

$E \geq 0$

$hf \geq \phi$

2.80

$7.209 \times 10^{-19} \geq hf$

$1.097... \times 10^{15}\ Hz \geq f$

$1.1 \times 10^{15}\ Hz \geq f$

1

b) Calculate the length of the accelerator from the perspective of electrons moving at 0.998 c. 2

$L = 32000 \times \sqrt{1 - \left(\frac{0.998c}{c}\right)^2}$

$L = 2.02\ km$

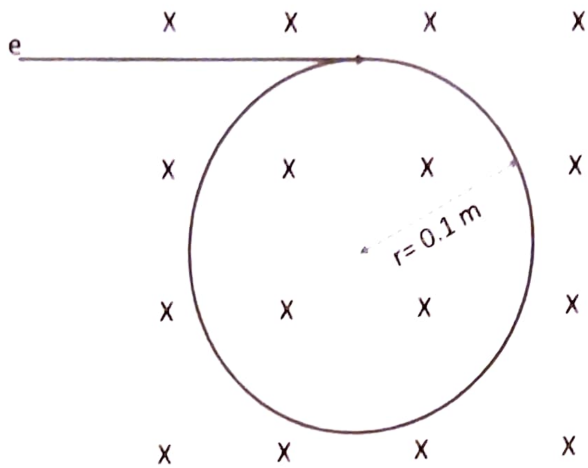
2

3

Question 35 continues on the next page

Question 35 (continued)

Once the electrons were travelling at 0.998 c (2.994×10^8 m s) they entered a perpendicular magnetic field and followed a circular path as measured by a stationary observer and shown below.



c) The magnetic field strength can be found using $B = \frac{mv}{qr}$. Demonstrate how ignoring relativistic effects would result in an under-estimation of B. 2

as mass dilates due to relativity by a factor of $\frac{1}{\sqrt{1-(\frac{v}{c})^2}}$, the B value would by ib taking the B by $\frac{mv}{qr}$, $\frac{1}{\sqrt{1-(\frac{v}{c})^2}}$ off as mass is assumed to be constant which is not, so using this, B would be using $\frac{mv}{qr}$ = 0.02 T when as accounting for relativity it would ~~be~~ be: ~~0.26~~ 0.27T.

2

END OF EXAM