CSSA

2021
TRIAL HIGHER SCHOOL CERTIFICATE EXAMINATION

DO NOT REMOVE PAPER FROM EXAM ROOM

Centre Number

Student Number

Physics

Morning Session
Tuesday, 3 August 2021

General Instructions

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

Total marks - 100

Section I Pages 2-13
20 marks
- Attempt Questions 1-20
- Allow about 35 minutes for this section

Section II Pages 14-32
80 marks
- Attempt 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 part

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

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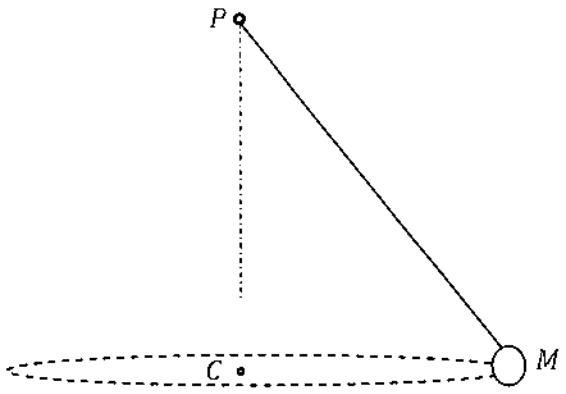
1 A conical pendulum consists of a mass, M attached by a string to a point, P. The pendulum moves in a uniform circular motion around a point C.



The direction of the total force acting on M is always

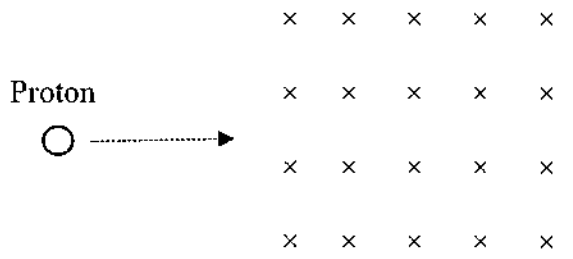
A. towards P.

B. towards C.

C. vertically downwards.

D. at a tangent to the circular motion.

2 A proton moves into a magnetic field as shown in the diagram below.



The direction of the force on the proton is

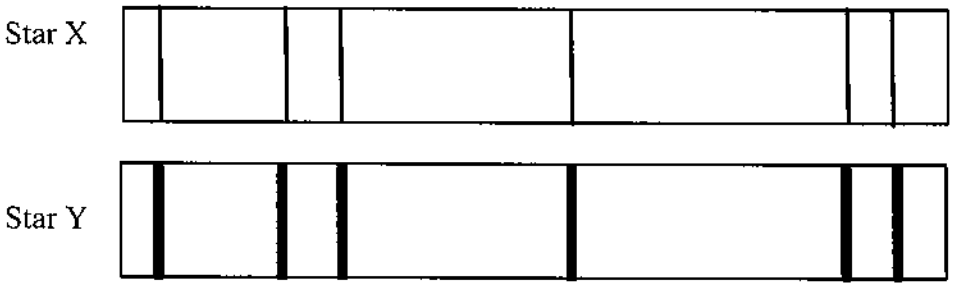
A. up the page.

B. into the page.

C. down the page.

D. out of the page.

3 The following images show the spectral lines of two stars.



Which choice below could correctly identify the stage in the stars' life cycle?

	Star X	Star Y
A.	Main sequence	Main sequence
B.	Main sequence	Red supergiant
C.	Red supergiant	Main sequence
D.	Red supergiant	Red supergiant

4 An electron bound to the nucleus of an atom may only possess certain discrete energies in what is now known as a quantum model for electron energy.

Which physical technique was the first to provide support for a quantum model of electron energy?

A. Electron diffraction

B. Emission spectroscopy

C. Radioactive decay

D. X-ray diffraction

5 An electrical substation uses a step-down transformer to convert a 13.2 kV supply to a 240 V supply for household usage. If the primary coil is 3850 turns, how many turns are in the secondary coil?

A. 70

B. 80

C. 90

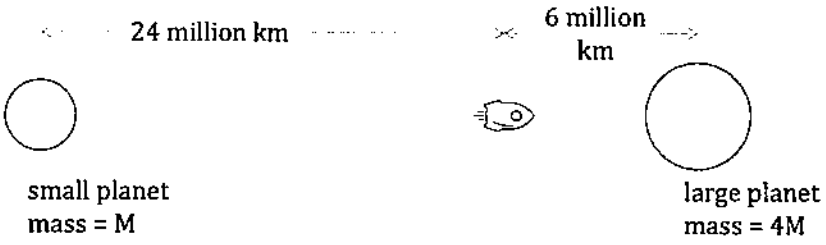
D. 210

6 A space craft is travelling between two planets of mass M and $4M$.

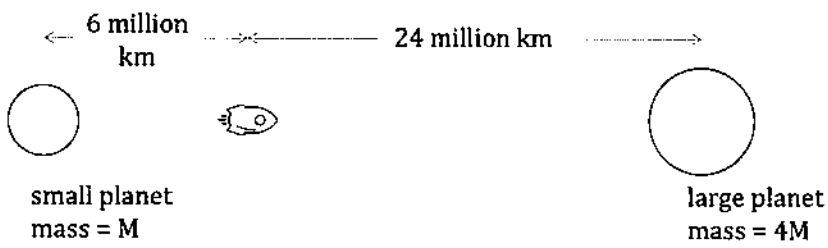
Which of the following diagrams represents the location of the space craft at which it will experience zero net gravitational force?

Diagrams are not drawn to scale.

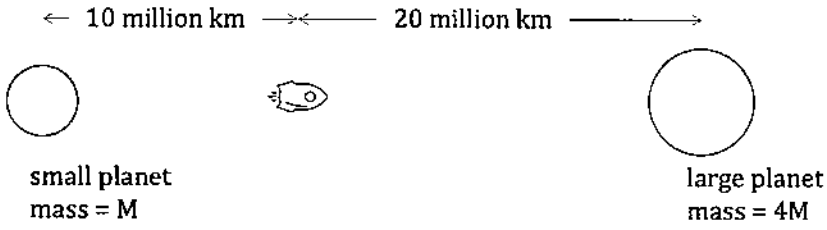
A.



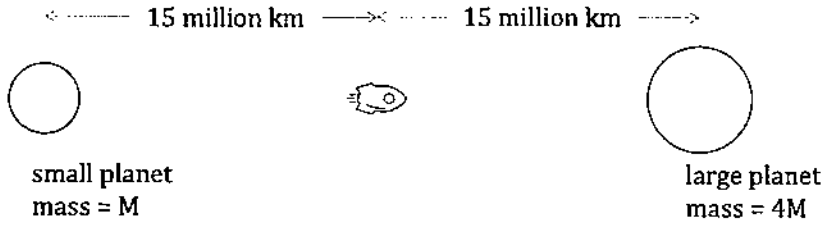
B.



C.



D.



7 Calculate the amount of energy released as a result of annihilation of an electron and positron.

A. 0.0034 MeV

B. 0.511 MeV

C. 1.023 MeV

D. 3.400×10^{-9} MeV

8 Nuclear fission is able to produce a large amount of energy because

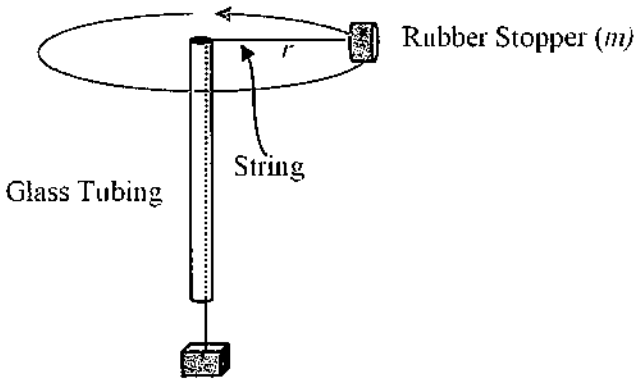
A. there is a large amount of energy required to refine uranium.

B. there is a mass defect where the mass of the products is greater than the mass of the reactants.

C. there is a mass defect where the mass of the products is less than the mass of the reactants.

D. although mass is conserved neutrinos are produced in the reaction.

9 A hanging mass of mass M is used to counteract the outward pull from a rubber stopper undergoing a horizontal circular motion as shown in the diagram. The rubber stopper has a mass m, and is travelling at a speed of v.



Assuming all friction is negligible, what expression could be used to find the hanging mass M?

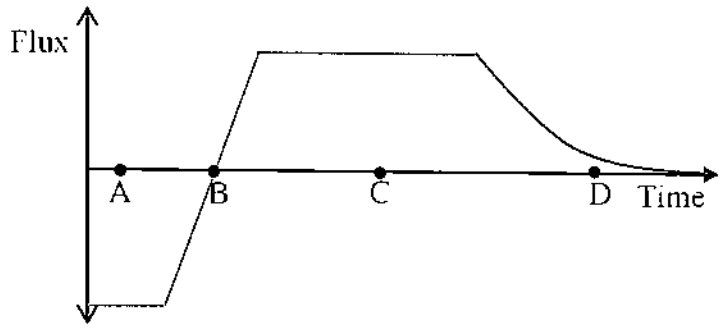
A. $\frac{mv^2}{gr}$

B. $\frac{mv}{gr}$

C. $\frac{mv^2}{r}$

D. $\frac{mv^2}{g}$

10 The graph below shows the variation of magnetic flux through a coil with time.



At which of the following times is the induced emf at a maximum?

A. A

B. B

C. C

D. D

11 An unstable nucleus has a half-life of 6.00 days when measured at rest. When moving at 0.9c relative to the observer, its half-life is equal to

A. 1.89 days.

B. 2.62 days.

C. 13.76 days.

D. 18.97 days.

12 A small sample of the radioisotope Nitrogen-13 has a half-life of 10.0 minutes.

What percentage of undecayed nuclei are expected to remain after 5.50 minutes?

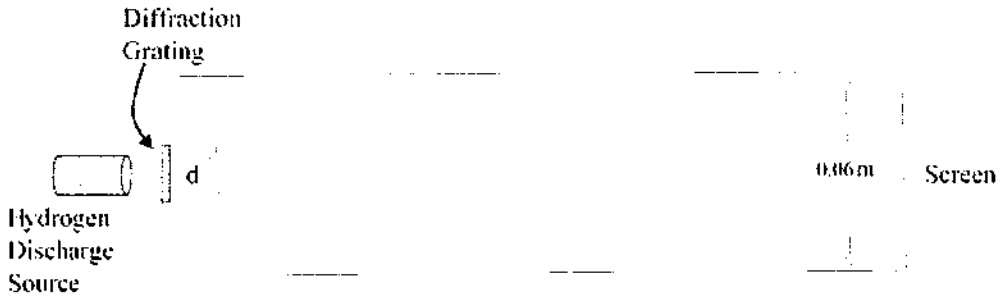
A. 32%

B. 44%

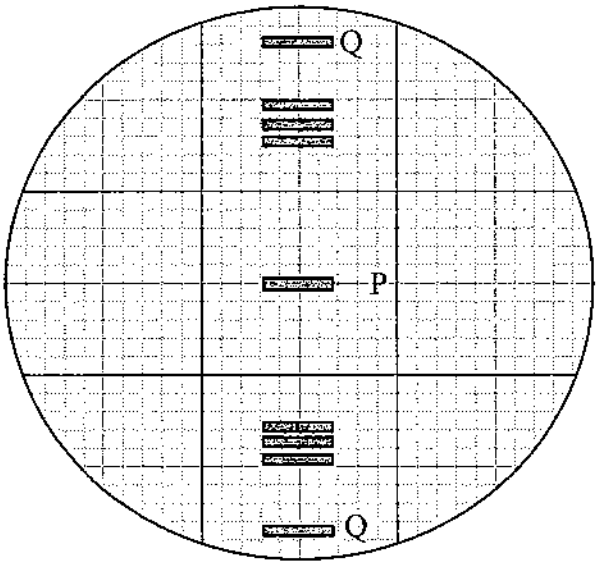
C. 56%

D. 68%

13 A student is using a spectroscope to observe the four smallest energy transitions in the Balmer Series of the hydrogen atom. A hydrogen lamp shines through a diffraction grating at one end of a tube, with a screen at the other end



The student observes the following pattern on the screen. P is the central band.



What does the wavelength of light for bands Q represent?

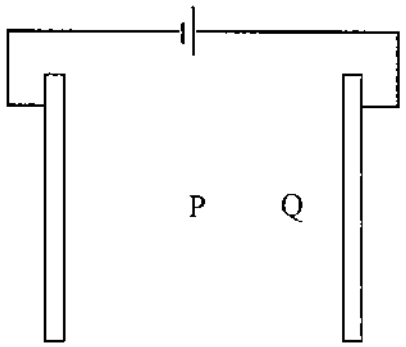
A. The jump from 3 to 2.

B. The jump from 4 to 2.

C. The jump from 5 to 2.

D. The jump from 6 to 2.

14 Two metal plates are placed vertically in a vacuum aligned as shown below. Point P is midway between the plates. An electron is moving between the plates when the power is off.



Which of the following options will result in the greatest particle acceleration when the potential difference between the plates is now switched on?

A. An electron moving downwards from P

B. An electron moving to the left from P

C. An electron moving downwards from Q

D. All the choices result in the same acceleration

15 Technetium-99 is a medical radionuclide needed during certain bone scanning procedures. It is the result of parent radionuclide undergoing a single beta minus decay.

What is the name of the parent radionuclide?

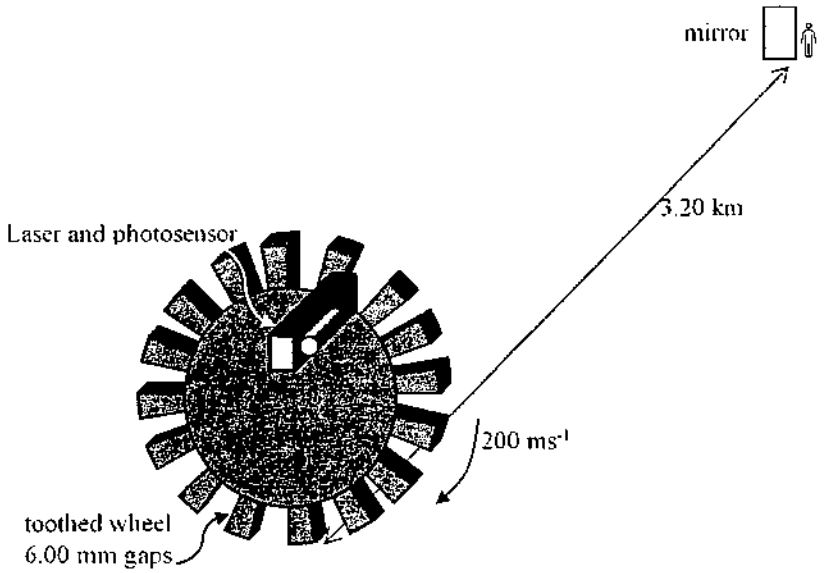
A. molybdenum-99

B. molybdenum-97

C. ruthenium-99

D. ruthenium-97

16 A student is carrying out an experiment similar to Fizeau's experiment to measure the speed of light. He sets up a mirror on one headland and a laser and photosensor on another, 3.20 km away, positioned behind a toothed wheel, as shown. The laser light reflects off the mirror, passes between the teeth of the wheel and reaches the photosensor. The gaps between the teeth on the wheel are 6.00 mm wide.



During the night, the angular velocity of the toothed wheel is gradually increased from zero until the photosensor records no light. The student measures the speed of the teeth on the wheel to be 200 ms^{-1} at this point. Using this information, what should the student calculate the velocity of light to be?

A. 1.06×10^5 ms^{-1}

B. 2.13×10^5 ms^{-1}

C. 1.06×10^8 ms^{-1}

D. 2.13×10^8 ms^{-1}

17 A student investigates the current flowing in a DC motor. Firstly, the power is switched on for one minute and the average current flowing through the coil is calculated. Secondly the power is continuously switched on and off for one minute. The student finds the average current in the first test was lower than the average current in the second test.

The best explanation is:

A. The motor in test 2 is experiencing more friction as it speeds up and down. So more current is needed.

B. The motor in test 1 heats up more, this lowers the resistance in the coil of the motor. So less current is needed.

C. The motor in test 1 runs more smoothly and so experiences less changes in flux. This makes the current lower.

D. The motor in test 1 has a higher average angular speed and so experiences a greater change in flux. This makes the current lower.

18 A black body is heated to 5700 K and emits electromagnetic radiation. Determine the energy of the emitted photons of radiation with the wavelength of maximum intensity.

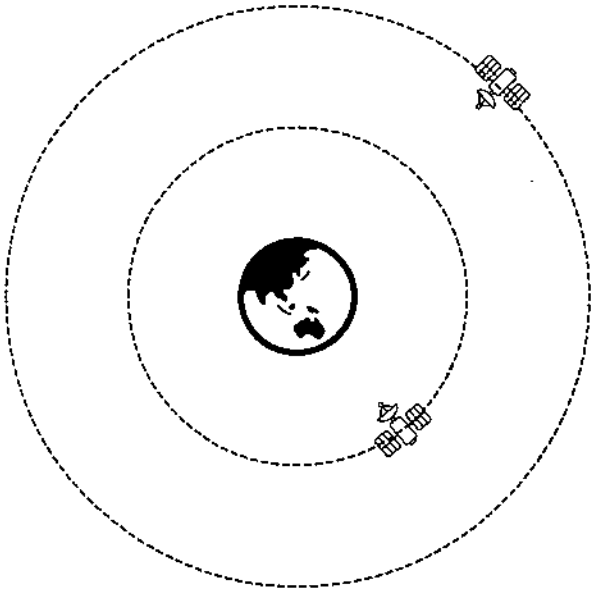
A. 3.78×10^{-30} J

B. 3.91×10^{-19} J

C. 5.08×10^{-7} J

D. 5.90×10^{14} J

19 Two satellites, A and B, orbit the same planet with orbital periods T_A and T_B, respectively.



If the ratio of their orbital periods is given by:

$$\frac{T_A}{T_B} = 64$$

What is the ratio of the satellites' radii, $\frac{r_A}{r_B}$?

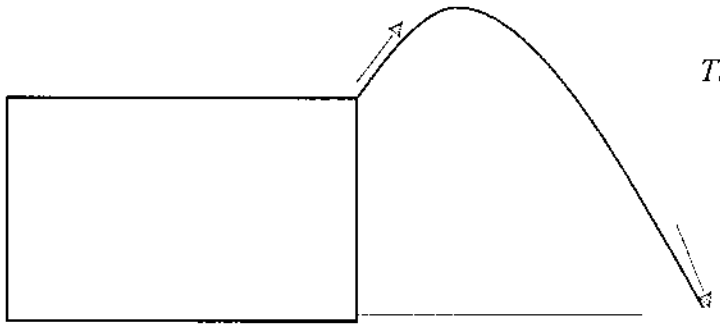
A. $\frac{1}{16}$

B. $\frac{1}{4}$

C. 4

D. 16

20 A spear is launched at 45° to the horizontal from a high cliff. The spear lands at 60° to the horizontal below the cliff. The spear reaches a maximum height after 1.5 seconds.



This diagram is not to scale.

The total time of flight for the spear is

A. 1.5 s.

B. 3.0 s.

C. 4.1 s.

D. 4.7 s.

Section II

80 marks
Attempt Questions 21 - 34
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.
- Section II extra writing space is provided on pages 33-34. If you use this space, clearly indicate which question you are answering.
- SEPARATE writing booklets are available if required. If you use a SEPARATE writing booklet, clearly indicate which question you are answering by writing the question number before beginning the response.

Question 21 (3 marks)

A space probe is in orbit around Mars at an altitude of 1200 km. To move to a higher orbit, small rocket engines are used to provide the energy required.

(a) Compare the kinetic energy of the space probe in the lower and higher orbit. **1**

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(b) Explain why energy is required to move the space probe from a lower to a higher orbit. In your answer refer to the total energy of the satellite. **2**

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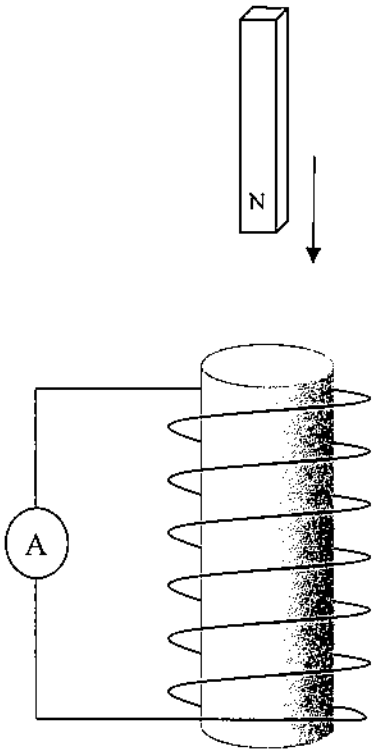
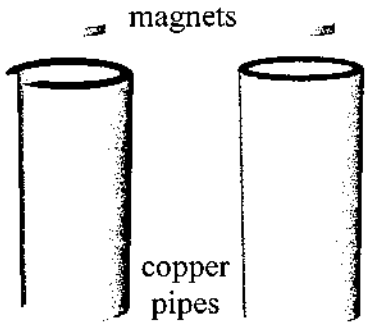
Question 22 (5 marks)

(a) A bar magnet enters a solenoid as shown in the figure below. **2**



Draw arrows on the diagram above to show the direction of the current induced in the coil **AND** the magnetic field produced as the magnet approaches.

(b) A cylindrical magnet is dropped through two copper pipes, one with a vertical slit, as shown in the diagram below. Describe and explain the difference in the motion of the TWO magnets. **3**



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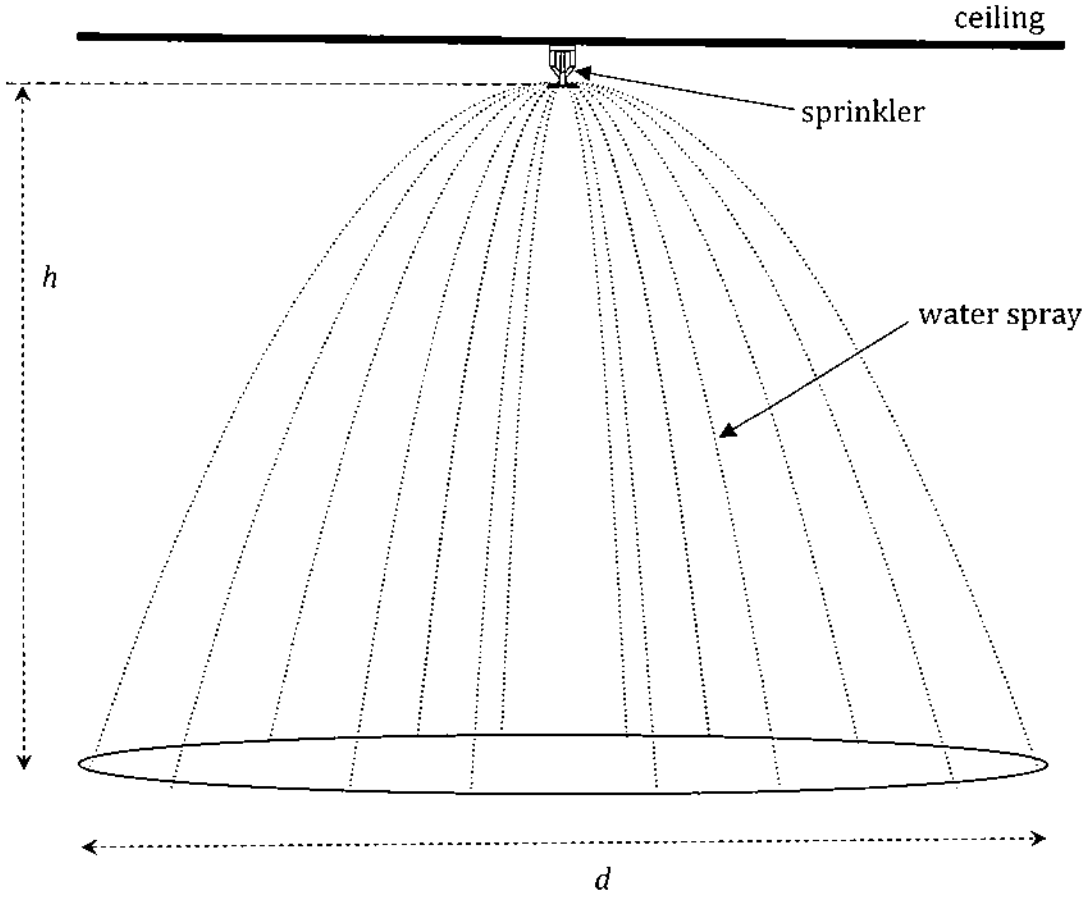
Question 23 (7 marks)

A sprinkler is used to spray water over a fire to stop it from spreading. The fire sprinkler has a spray pattern that covers a circular section of diameter d on the floor. The sprinkler is mounted at height h above the floor as shown below.



(a) Assuming the water is initially directed horizontally, explain how the diameter of the spray pattern, d, changes with the speed of the water leaving the sprinkler. **3**

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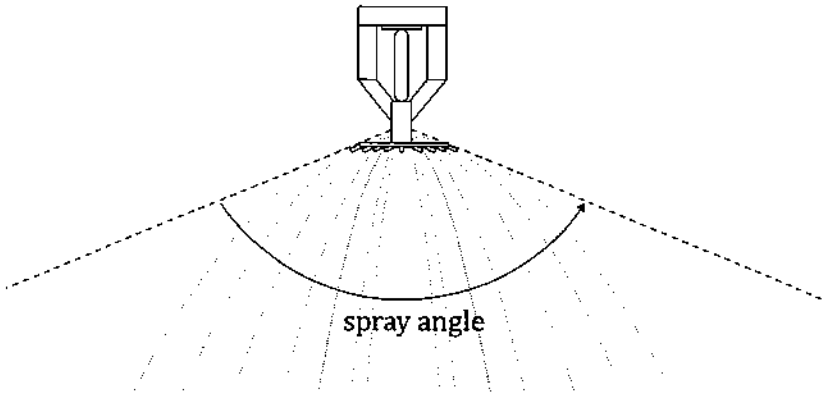
(b) The sprinkler design can be modified to direct more water to a fire. This is done by reducing the spray angle of the sprinkler. **4**



A sprinkler system is designed for a room where $h = 3.0$ m and $d = 4.0$ m. Water takes 0.65s to fall 3.0m to the floor while producing a spray pattern with a diameter of 4.0m.

Find the spray angle of the sprinkler for this design.

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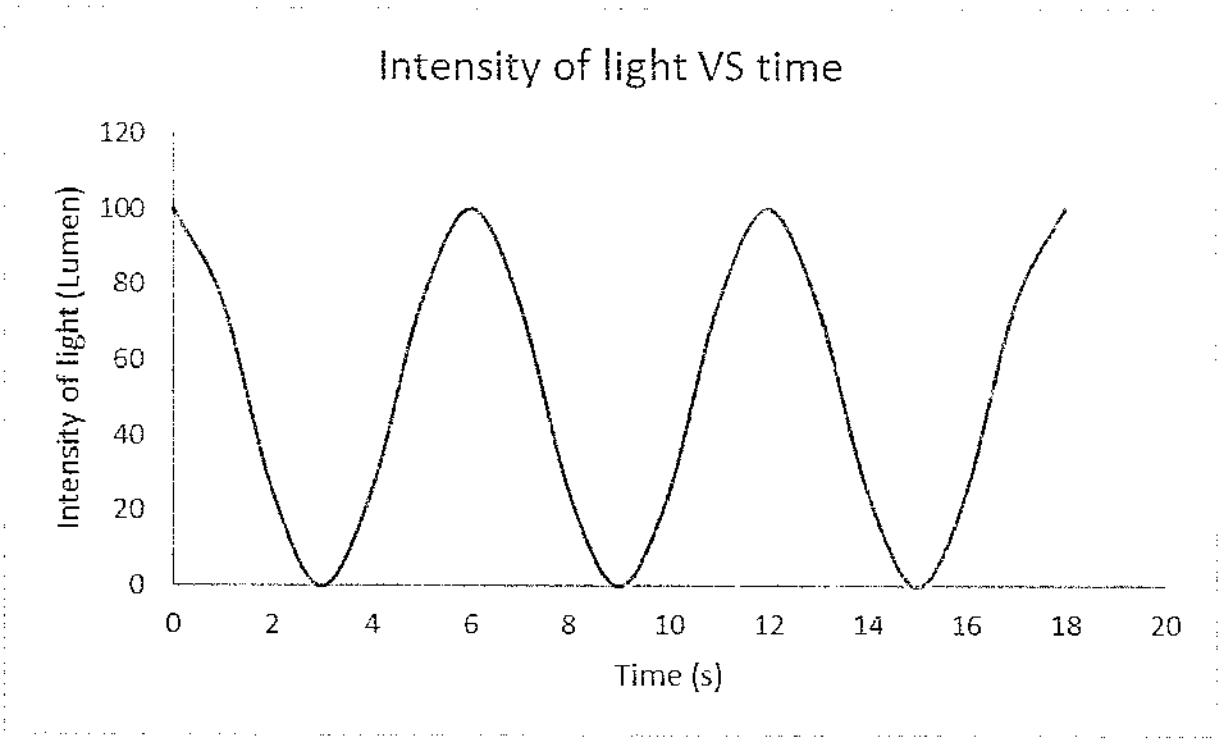
Question 24 (4 marks)

A group of students shone a plane polarised beam of light on a polarising filter which was rotating at angular velocity of 30 degrees/s. They measured the intensity of light passing through the filter and showed their results on the graph below.



(a) Explain the change in intensity of light shown on the graph. **3**

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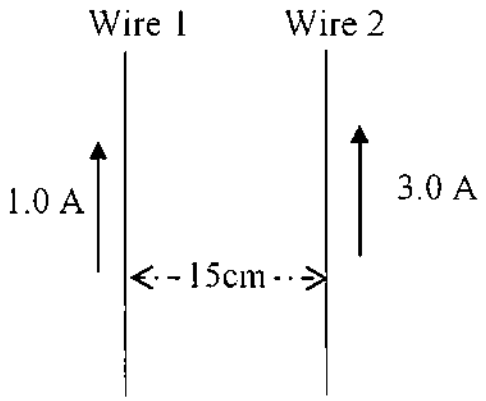
(b) Sketch on the graph above how the intensity will change with time if the plane polarised light is replaced with an unpolarised light source of equal intensity. **1**

Question 25 (5 marks)

Two parallel wires of length 1m are set up such that both currents are travelling in the same direction and are separated by a distance of 15cm.



(a) Determine the magnitude and direction of the magnetic force acting on both Wire 1 and Wire 2. **3**

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(b) What is the direction and strength of the magnetic field midway between the wires? **2**

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Question 26 (5 marks)

A DC motor is being designed to drive a winch which is lifting an elevator. Explain the factors affecting the rotational speed of a DC motor. Use mathematical models to support your answer. **5**

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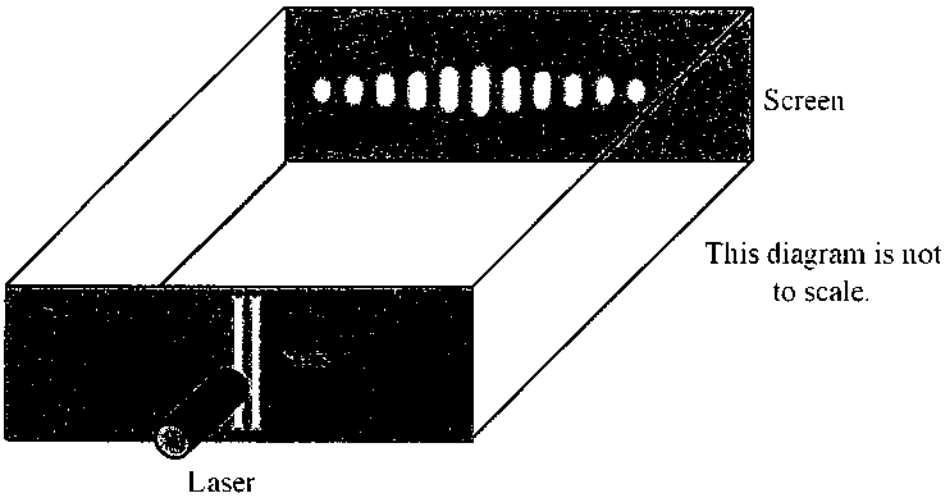
Question 27 (7 marks)

A laser beam of coherent monochromatic light with the wavelength of 700 nm was shone on double slits shown below:



The distance between two slits is 1.50 mm and the distance of the slits to the screen is 2.00 m

(a) Circle both fifth order maxima on the diagram above and explain why there is a bright band of light at these positions. **3**

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(b) Calculate the angle of diffraction for the fifth order maxima. **2**

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(c) Describe how the pattern above will be altered if the air between the slits and the screen is replaced by glass with a refractive index of 1.50. Justify your answer. **2**

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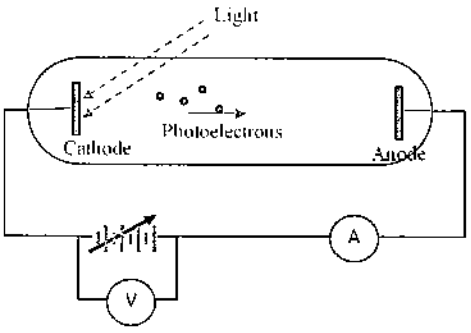
Question 28 (7 marks)

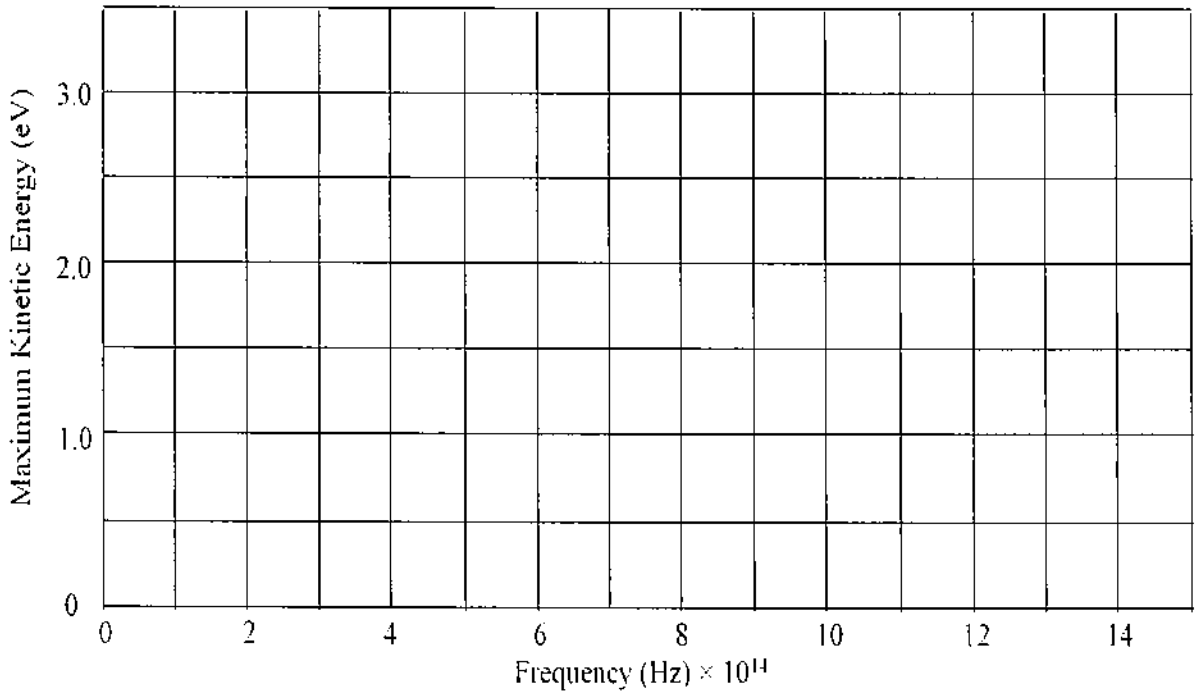
A group of students performed an investigation on the photoelectric effect using the following set-up.



When light is shone onto cathode, the photoelectrons produced set up a current which is recorded on the ammeter. The variable power supply is then increased from zero until the current is reduced to zero and the voltage is recorded. This voltage is called the stopping voltage and used to calculate the maximum energy of the photoelectrons released from the cathode. 1 volt of stopping voltage indicates 1eV of kinetic energy. The students varied the colour of light that was used to illuminate the cathode and recorded the stopping voltage in the table below:

Frequency of light (Hz) × 10^{14}	Stopping voltage (V)
6.67	-0. 33
7.50	-0.72
8.57	-1.18
10.0	-1.79
12.0	-2.62

(a) Use the above data to draw a graph of maximum kinetic energy versus frequency. **2**



(b) Use the graph in part (a) to determine the threshold frequency. **1**

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(c) Use the graph in part (a) to calculate Planck's constant. Show your calculation process clearly. **2**

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(d) Explain how the law of conservation of energy applies in the photoelectric effect to produce the straight-line graph you have plotted. **2**

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Question 29 (6 marks)

When a Uranium-235 nucleus absorbs a neutron in a nuclear reactor, Krypton-92, Barium-141 and several neutrons are common products of the reaction.

(a) Name this type of nuclear reaction. **1**

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(b) Write a nuclear equation for this reaction. **2**

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(c) With reference to this process, justify the use of a moderator like graphite in nuclear reactors that produce these radioisotopes. **3**

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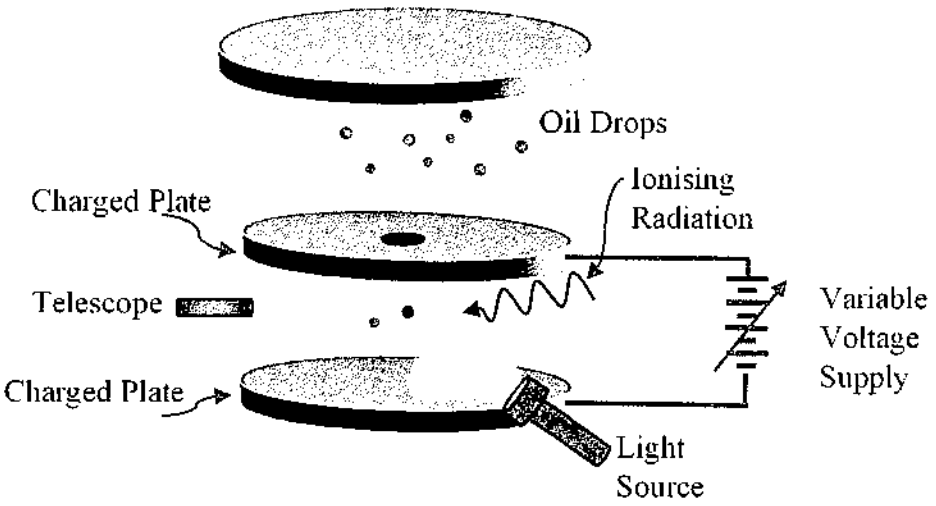
Question 30 (6 marks)

Between 1909 and 1910 the American physicist Robert Millikan conducted a series of experiments with charged oil drops. By comparing the applied electric force to the weight of each oil drop, he was able to determine the electric charge on each oil drop.

The apparatus Millikan used is shown below.



(a) Why was the radius of the observed oil drops measured? **1**

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(b) Outline how Millikan determined the electric charge on the oil drops he observed. **2**

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(c) It was known at the time that electric charge was a quantum property of matter. **3**
How did Millikan use this assumption to determine the charge on a single electron?

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Question 31 (6 marks)

A plank of wood is fixed to a wall using a hinge.

When the angle between the plank and the wall is 45°, a spring is attached to the wood 25cm from the hinge and fixed to the wall so that it is horizontal (Diagram A).

The wood is then pushed downwards until it is perpendicular to the wall (Diagram B).

Diagram A

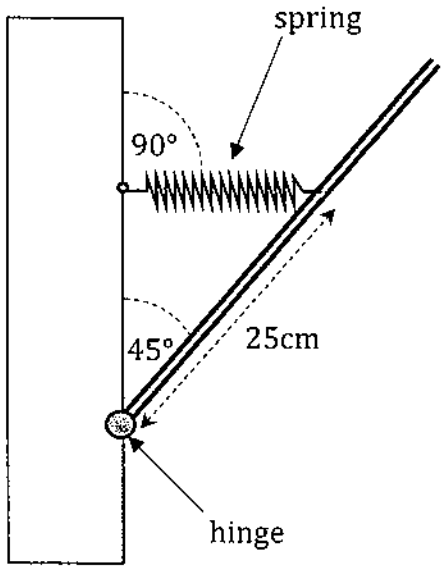
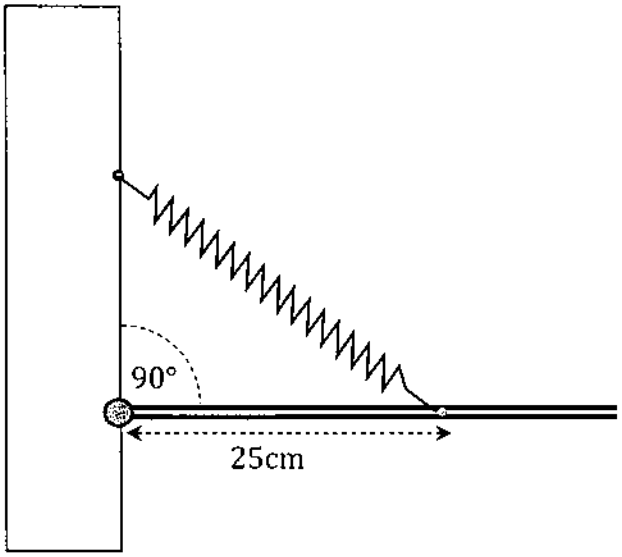
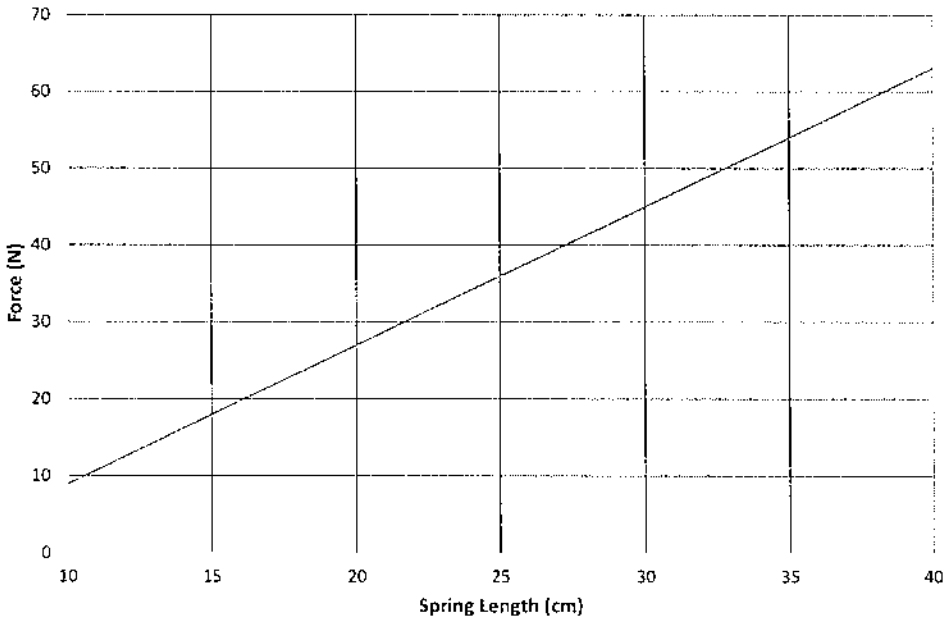


Diagram B



The force exerted by the spring, depends on its length. As the spring stretches, the force it exerts increases. A graph showing this relationship is below.



Question 30 continues on the next page

(a) Calculate the length of the spring in Diagrams A and B. **2**

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(b) Calculate the torque produced by the spring on the plank of wood around the hinge in both Diagrams A and B and compare the values. **4**

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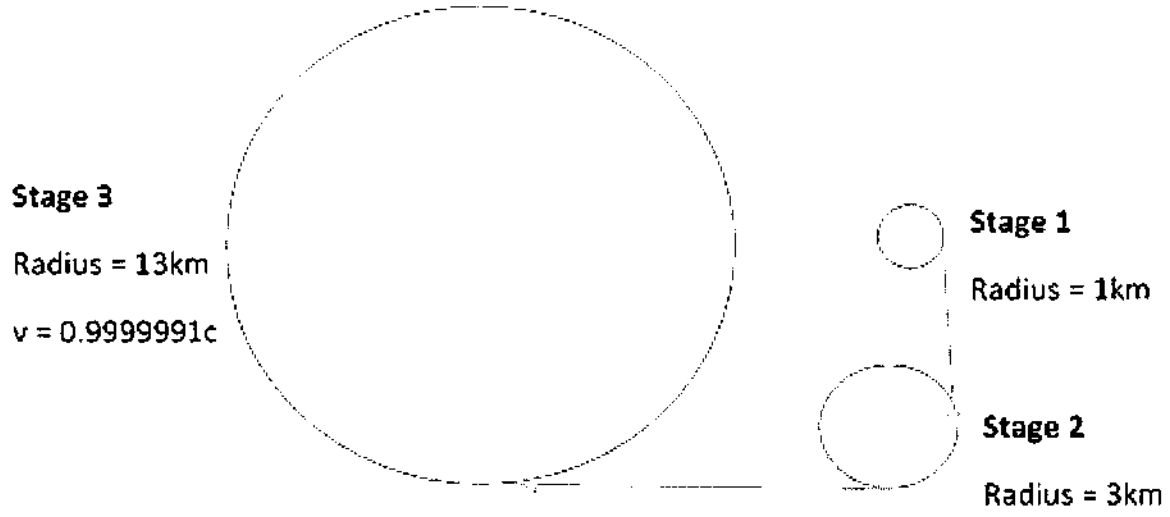
Question 32 (4 marks)

When the Bohr model of the atom was proposed in 1913, some atomic properties could not be fully explained using classical mechanics alone. **4**

Explain how subsequent contributions to our understanding of atomic structure from Louis de Broglie supported the establishment of an improved quantum-mechanical model for the atom.

Question 33 (9 marks)

A particle accelerator is being proposed. It will consist of three stages of circular rings containing proton beams. The protons will be accelerated by electric fields and directed by powerful magnetic fields. The protons will reach relativistic speeds at Stage 3. Each stage will have an identical magnetic field and protons will travel in a clockwise direction.



(a) Justify the use of particle accelerators in investigating the Standard Model of matter. **3**

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Question 33 continues on the next page

(b) Explain why the THREE rings have different radii. **3**

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(c) Calculate the magnitude and direction of the magnetic field in Stage 3 where the protons reach a velocity of 0.9999991c. **3**

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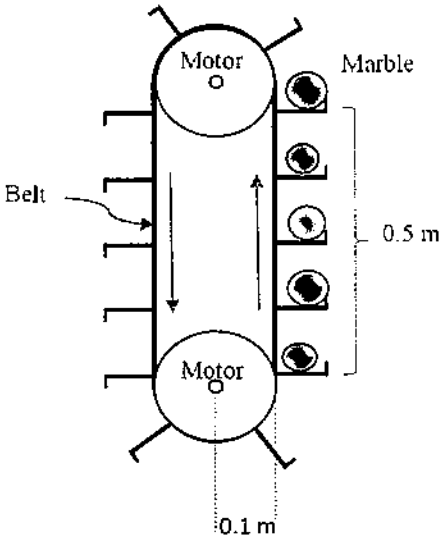
Question 34 (6 marks)

A toy engineer is designing an elevator to lift a maximum of five marbles over a height of 0.50 m. It consists of two identical motors. The coil of each motor has 100 turns, a 0.50 T magnetic field and a coil area of 1×10^{-4} m^2. The motors are connected to a pulley with a radius of 0.10 m and connected via a belt with platforms of negligible mass.
The engineer adds one marble at a time and measures the smallest current passing through each motor that allows the marbles to be stationary. The following data is recorded:



Number of marbles	Current in each motor (A)
1	0.64
2	1.27
3	1.91
4	2.55
5	3.19

(a) Explain how the engineer can calculate the torque exerted by a marble mass m. **2**

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(b) Calculate the average mass of the marbles used. **4**

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End of examination

Section II extra writing space

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Section II extra writing space

If you use this space, clearly indicate which question you are answering by writing the question number before beginning the response.

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