**CHERRYBROOK TECHNOLOGY HIGH SCHOOL**

# AP4 TASK

# 2019

# PHYSICS
# 2 UNIT

**NAME: _____** **TEACHER: _____**

**CLASS:12PHY19_____**

**INSTRUCTIONS TO CANDIDATES:**

- Time allowed: 3 hours + 10 minutes reading time
- Students are to attempt all questions
- Non-programmable calculators may be used
- A formula list and data sheet are supplied separately
- Write answers using black pen in the spaces provided, show all working
- Use pencil for drawing graphs
- Lined pages are provided at the end of the task for planning

**TOTAL MARKS = 100**

**Section I**
**20 marks**

**Part A**
**Attempt Questions 1-20**
**Allow about 35 minutes for this part**

Use the multiple-choice answer sheet provided for Questions 1-20

**1** In one second the Sun generates $3.8 \times 10^{26}$ Joules.
About how much mass does the Sun lose to do this?

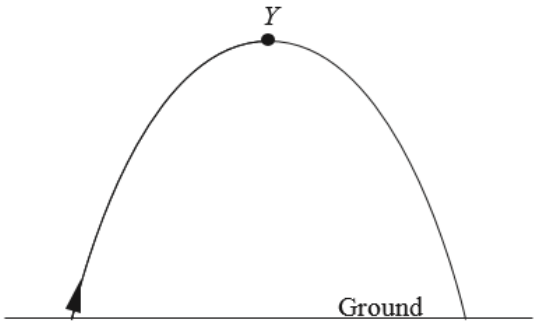
(A) 1 billion tonnes per second.

(B) 700 million tonnes per second.

(C) 6.81 million tonnes per second.

(D) 4.22 million tonnes per second

**2** Consider an object undergoing projectile motion under an acceleration of gravity as shown in the figure below.




Choose the most correct statement.

(A) The instantaneous velocity at point Y will be zero.

(B) The vertical component of the velocity is a constant.

(C) The instantaneous vertical velocity will be the same at launch as at landing at impact.

(D) The initial horizontal velocity on launch will be the same as the final horizontal velocity.

**3** Shrödinger's model of the atom differed from Bohr's model of the atom by:

(A) allowing for the existence of subshells.

(B) assuming electrons have a constant speed and constant acceleration.

(C) explaining the spectrum of the visible lines in the hydrogen spectrum.

(D) making firm predictions as to the location of the electron around the nucleus.

**4** An object travels in a circular path of radius r at a constant speed v. What happens to the object's acceleration if the speed is doubled and the radius stays unchanged?

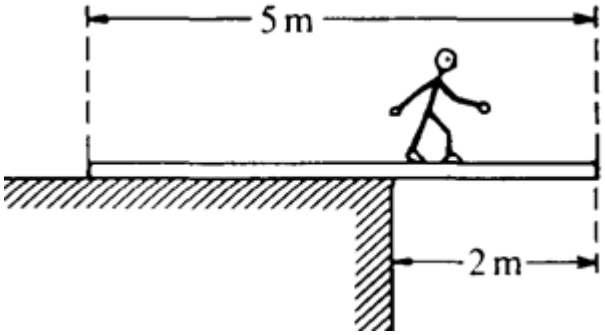
(A) Acceleration remains the same.

(B) Acceleration is halved.

(C) Acceleration is doubled.

(D) Acceleration increases by four times.

**5** A 5 metre uniform plank of mass 200 kilograms rests on the top of a building with 2 metres extended over the edge as shown in the figure. How far can a 50 kilogram person venture past the edge of the building on the plank before the plank just begins to tip?



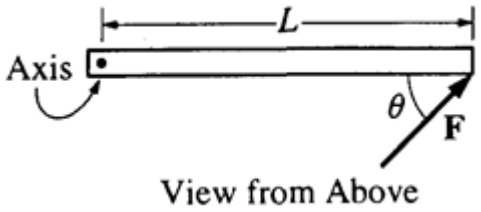

(A) 2 m

(B) 1 m

(C) 0.8 m

(D) 1.5 m

**6** A rod on a horizontal tabletop is pivoted at one end and is free to rotate without friction about a vertical axis, as shown in the figure. A force F is applied at the other end, at an angle θ to the rod. If F were to be applied perpendicular to the rod, at what distance from the axis should it be applied in order to produce the same torque?




(A) L sin θ

(B) L cos θ

(C) L tan θ

(D) 2 L sin θ

**7** If the angular velocity of a second hand of a clock is 0.105 rad $s^{-1}$ and length of hand is 1.8 cm, then speed of tip of the second hand **is:**

(A) 0.189 cm $s^{-1}$

(B) 1 cm $s^{-1}$

(C) 0.189 m $s^{-1}$

(D) 2 m $s^{-1}$

**8** The mass of Titan as estimated from a point on its surface that is 2575 km from Titan's centre where it has gravitational field strength of 1.35 N $kg^{-1}$ is about:

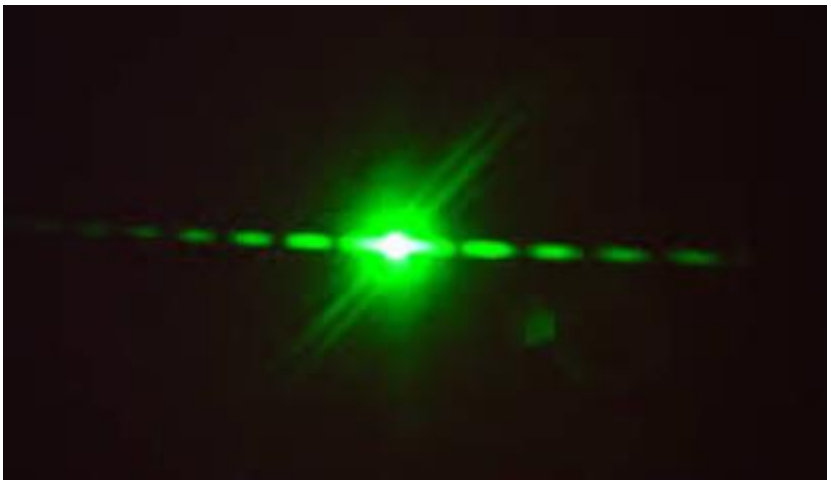
(A) $6.0 \times 10^{23}$ kg

(B) $1.35 \times 10^{23}$ kg

(C) $40 \times 10^{9}$ kg

(D) $9 \times 10^{24}$ kg

**9** A student passed a single beam of laser light through a single narrow slit and got an image on a screen in a darkened room shown below.



What phenomena is responsible for the pattern shown?

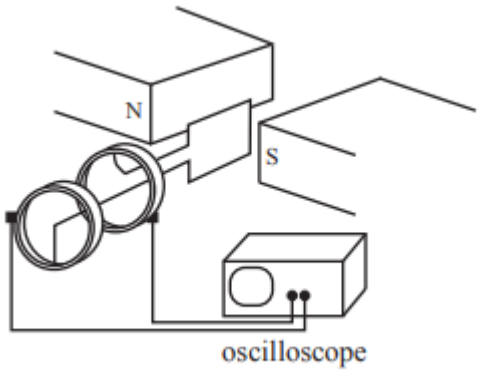
(A) Refraction.

(B) Reflection.

(C) Coherence.

(D) Diffraction.

**10** **A** square coil of side length 16 cm has 200 turns and sits within a magnetic field of strength 0.05 T as shown in the figure. A cathode ray oscilloscope is used to measure the emf.




What size emf is produced when it turns at a rate of 46.8 rotation $s^{-1}$?

(A) 12 V

(B) 24 V

(C) 60V

(D) 0.12 V

**11** A positive charged particle q is accelerated in a uniform electric field E starting from rest. If $v_0$ is the velocity of the particle at the end of distance d, what is the velocity of the particle at distance 2d in the same electric field?

(A) $2\ v_0$

(B) $4\ v_0$

(C) $8\ v_0$

(D) $\sqrt{2}v_0$

**12** The gap across a spark plug's electrodes is 0.4 mm. If the voltage between the electrodes is 16000 V what is the electric field in the gap?




(A) 0.64 $NC^{-1}$

(B) 10 000 000 $NC^{-1}$

(C) 4 000 000 $NC^{-1}$

(D) 40 000 000 $NC^{-1}$

**13** The work done to move a charge of 2 μC from a point B to a point A that is at a higher potential is $2.4\times10^{-5}$ J. What is the potential difference between the two points?

(A) 12 V

(B) 1.2 V

(C) 120 V

(D) 1200 V

**14** A transformer has 3000 primary turns and 150 secondary turns. It is connected to a 240 V power supply and outputs 15 A. What is the secondary voltage and the primary current?

(A) 18 V, 1 A

(B) 20 V, 1 A

(C) 12 V, 0.75 A

(D) 0.75 V, 12 A

**15** Two straight current carrying wires exert a force of F newtons per metre. If the separation distance is doubled the force per length will be:

(A) 2F

(B) F/2

(C) F/4

(D) 4F

**16** Millikan's oil drop experiment was important because:

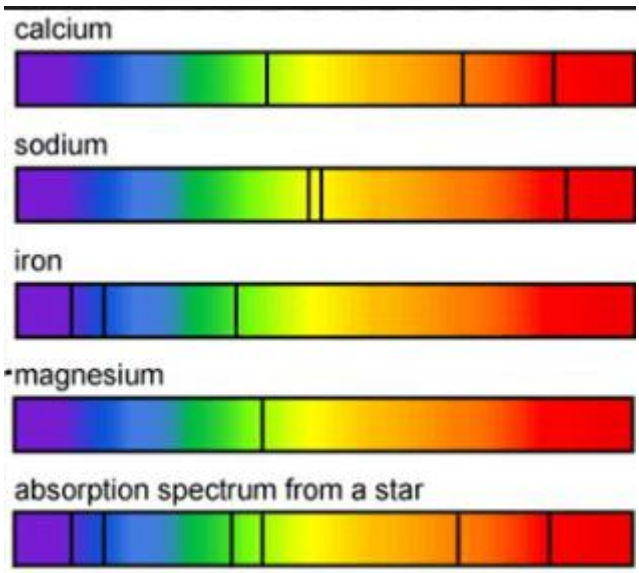
(A) it quantified the charge on an electron.

(B) it established the charge to mass ratio of the electron.

(C) it used a simple apparatus to equate gravity and electrostatic charge.

(D) it enabled the calculation of the mass of an proton when combined with previous data from JJ Thomson.

**17** The absorption emission spectral lines for a number of elements are shown in the figure below along with the absorption spectral emission from a star.




The elements the star contains are:

(A) calcium, sodium and iron.

(B) calcium, iron and magnesium.

(C) calcium, sodium and magnesium.

(D) calcium, sodium, iron and magnesium.

**18** The photoelectric effect experimental evidence that did **not** support the wave nature of light was:

(A) a heated filament emits electrons in a vacuum.

(B) as the intensity of light increases the number of electrons emitted from the surface increases.

(C) monochromatic light of high intensity doesn't always cause electron emission from all metals.

(D) the maximum energy of the emitted electrons increases linearly with the frequency of the light but is independent of its intensity.

**19** $^{14}C_6$ has a half-life of 5730 years how many grams of a 4.0 g sample would be left after 3.5 half-lives?.

(A) 1 g

(B) 0.5 g

(C) 0.375 g

(D) 0.35 g

**20** The four images below represent the double slit interference patterns obtained using the same source of monochromatic light. In each case the distance to the screen was the same. Which one represents the smallest slit separation?

(A) 

(B) 

(C) 

(D) 

## Section II - 80 marks
## Physics

**Attempt Questions 21-37**
**Allow about 2 hours and 25 minutes for this part**

Answer the questions in the spaces provided. These spaces provide guidance for the expected length of response.
Extra writing space is provided on pages 29 and 30. If you use this space, clearly indicate which question you are answering.

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**Question 21** (3 marks)

Early scientists made exhaustive efforts to accurately measure the speed of light. Explain how it is that now, the speed of light is used to define the measure of distance. **3**

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**Question 22** (3 marks)

In an early type of particle accelerator, the nuclei of hydrogen isotopes of deuterium stripped of its electron called deuterons (one proton and one neutron) were made to move in a circular path within a toroidal tube (a hollow ring) of diameter 1 m. **3**
Calculate the magnetic field required to constrain a deuteron ($q_p = + 1.602 \times 10^{-19}$ C) within the toroidal tube at a velocity of $9 \times 10^6$ m $s^{-1}$.

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**Question 23** (3 marks)

A manufacturer of solar cells wanted to determine the work function of silicon under low levels of artificial light. To test the solar cells, the manufacturer used a light source which emitted photons with a wavelength of 510.6 nm.
Under these conditions the photoelectrons emitted were found to have a maximum kinetic energy of $5.36 \times 10^{-20}$ J.

(a) Determine the maximum energy in joules of the highest energy incident photons. **2**

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(b) Calculate the work function of the silicon in joules. **1**

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**Question 24** (3 marks)

The International Space Station orbits $4.00 \times 10^{2}$ km above Earth's surface in a circular orbit. Calculate the orbital speed of the International Space Station. **3**

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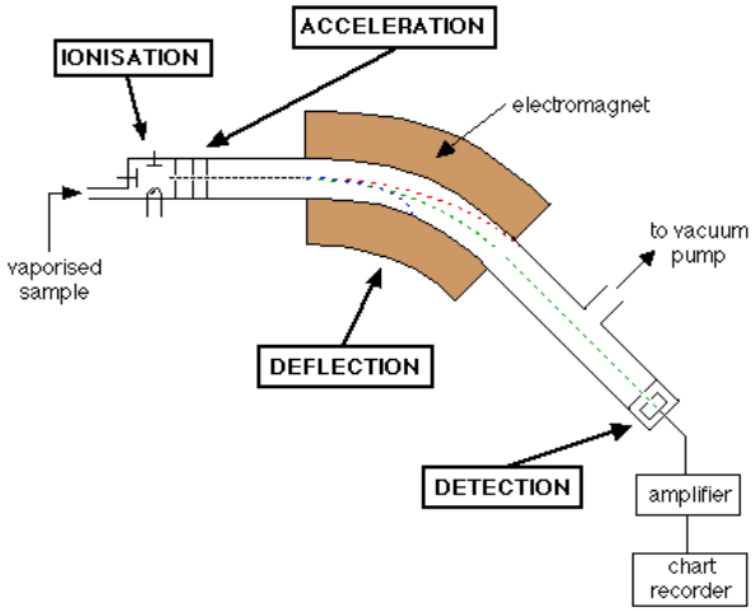
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**Question 25** (3 marks)

The operational process of a mass spectrometer shown on the figure below is divided into four basic stages:

- Ionisation: The atom is ionised by knocking one or more electrons off to give a positive ion. Mass spectrometers always work with positive ions.
- Acceleration: The ions are accelerated so that they all have the same kinetic energy.
- Deflection: The ions are deflected by a magnetic field according to their masses. The lighter they are, the more they are deflected. The amount of deflection also depends on the number of positive charges on the ion. The more the ion is charged, the more it gets deflected.
- Detection: The beam of ions passing through the machine is detected electrically.




Describe how the principles that determine the behaviour of charged particles in fields enable the operation of a mass spectrometer. **3**

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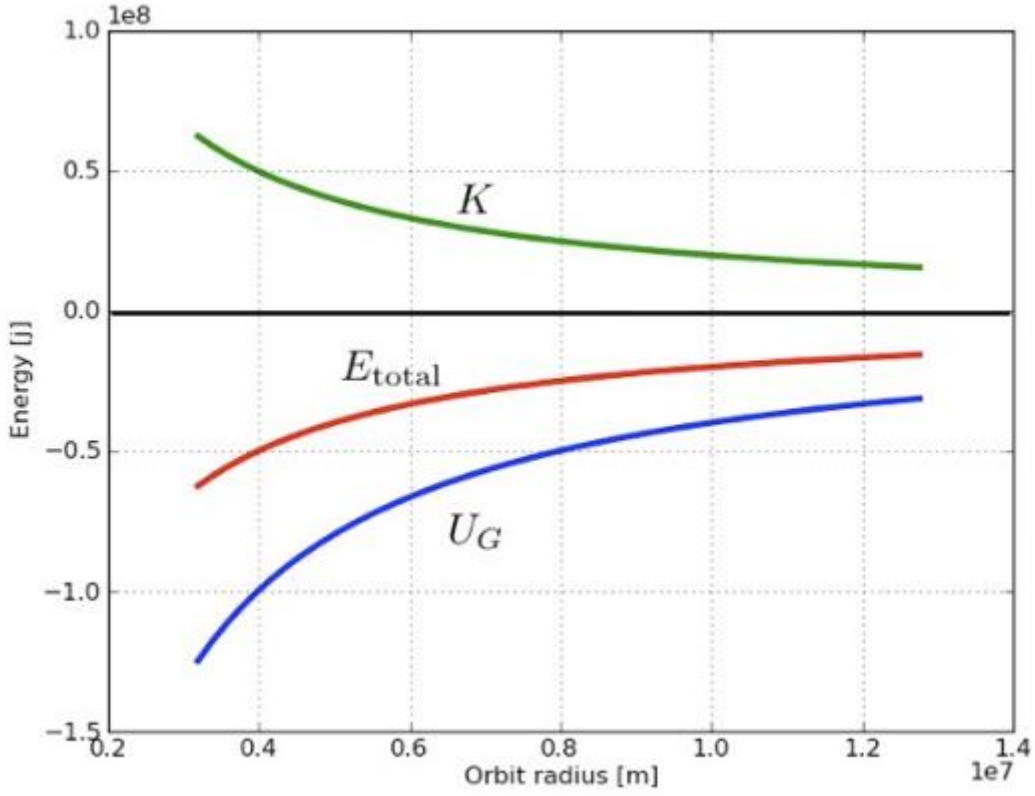
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**Question 26** (3 marks)




The graph shows the energy changes that occur when a space craft moves between stable circular orbits at different altitudes.
Docking or joining spacecraft together is a common occurrence. The time to successfully do so takes from 2 days to 6 hours. Spacecraft often move from a higher orbit to a lower orbit in order to do this efficiently. Describe the sequence of forces that would need to be applied to move a spacecraft in a higher stable circular orbit to a lower stable orbit in order to dock safely with another spacecraft. **3**

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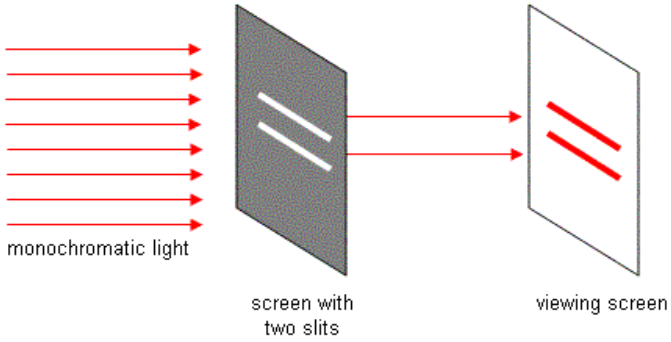
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**Question 27** (3 marks)

As part of an investigation of light a yellow light of wavelength 5.7 x $10^{-7}$ m from a sodium lamp is used as a monochromatic source. This is then aimed at a double slit engraved into a black slide and the interference pattern it produces is observed on a screen at a distance 20cm from the slits. **3**




A student measures a distance of 3.89 mm between the centres of each of five consecutive interference fringes. Calculate the slit separation distance on the slide and justify the method of slit separation determination.

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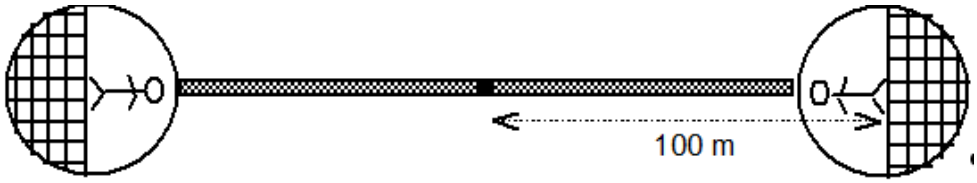
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**Question 28** (3 marks)

(a) A space station has the shape of a doughnut. The distance from the centre of the hole to the centre of the ring of "dough" is 100 m. With what speed must it be made to rotate so that a spaceman living in the "dough" experiences the same magnitude acceleration as on the surface of the Earth? **2**




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(b) If the angular velocity of the space station is changed to $0.3\ rad\ s^{-1}$ will the inhabitants have an apparent weight gain or loss? Justify your answer. **1**

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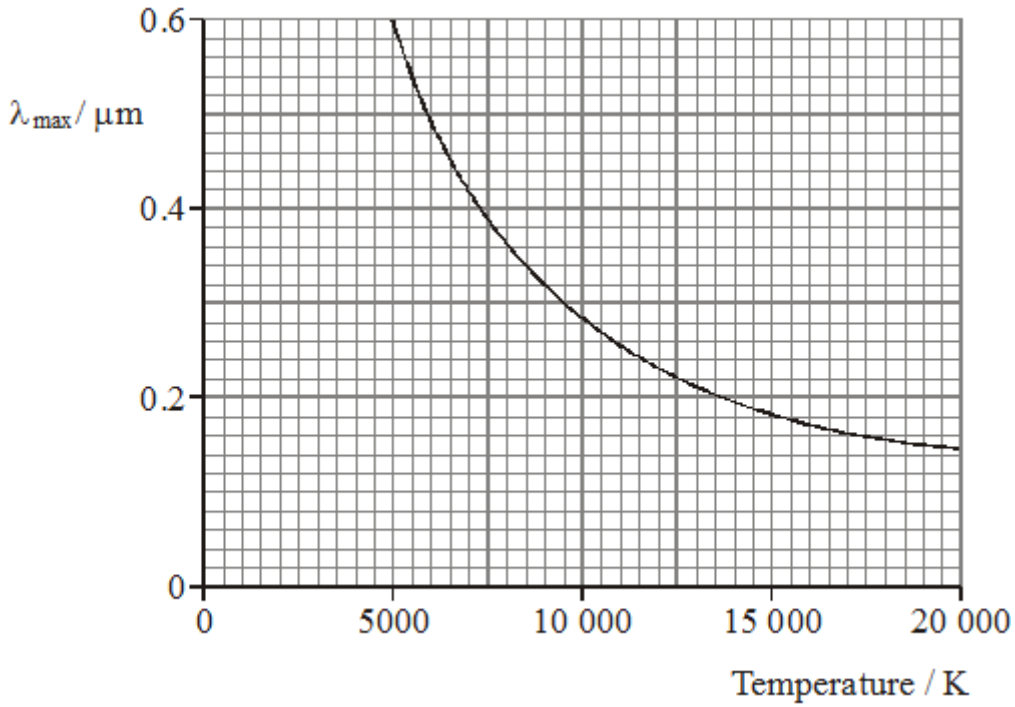
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**Question 29** (5 marks)

The graph shows how $\lambda_{max}$ (the wavelength of the peak of the radiation spectrum) for a range of stars varies with the surface temperatures of the stars.




(a) Use the graph to estimate the surface temperature of a star whose intensity peaks at a wavelength of 0.4 μm. **1**

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(b) Using data from the graph, perform appropriate calculations that would support the data from the graph reflecting Wien's Law. **4**

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**Question 30** (5 marks)

(a) Discuss the importance of James Clerk Maxwell's contribution to the classical theory of electromagnetism. **3**

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(b) Describe two supporting observations that provided confirmation of Maxwell's contribution to understanding electromagnetic waves. **2**

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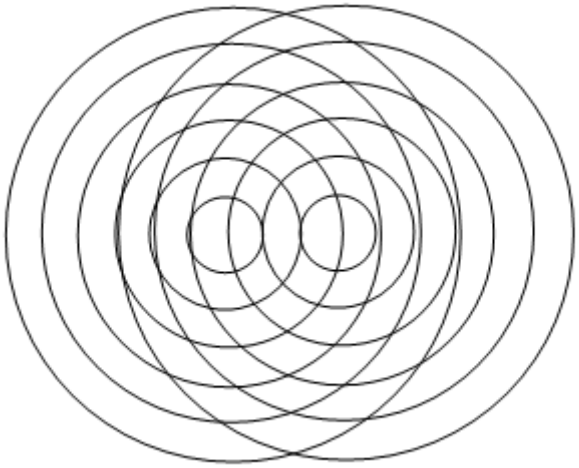
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**Question 31** (5 marks)

One of the most famous experiments that supported the wave model of light was Young's double slit experiment. This experiment enables the observation of one of light's wave properties (interference) and the collection of quantitative data about light.

(a) The diagram below shows two sources separated by exactly 3 wavelengths emitting waves in phase. Clearly indicate on the diagram with a heavy dot the zones of maximum reinforcement, where the path difference between the waves is $2\lambda$. **2**



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(b) Outline three safety concerns addressed during your quantitative investigation using a double slit apparatus. **3**

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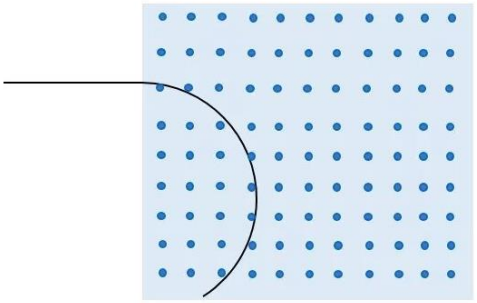
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**Question 32** (5 marks)

The path followed by a positive ion entering a uniform magnetic field is shown in the figure below.



Positive ions travelling with the same velocity enter a uniform magnetic field initially at right angles to the field.

(a) If two of the ions have equal masses but different charges, identify whether the ion with a smaller or larger positive charge will move in a path with a larger radius. Justify your identification**.** **3**

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(b) If a positive ion is travelling with a velocity of $5.0 \times 10^7$ m $s^{-1}$ and the magnetic field is of intensity $3.5 \times 10^{-3}$ T, determine the magnitude of the force per unit charge acting on the ion. **2**

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**Question 33** (6 marks)

(a) If friction is not able to provide any of the force for the centripetal acceleration of a car on a banked curve, show with the aid of a labelled diagram that the banking angle θ for a radius of curvature R and speed v is independent of the mass of the vehicle and is given by

$$tan\Theta = \frac{v^2}{Rg}$$ **3**

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(b) Discuss the implications of the relationship $tan\Theta = \frac{v^2}{Rg}$ on road design. **3**

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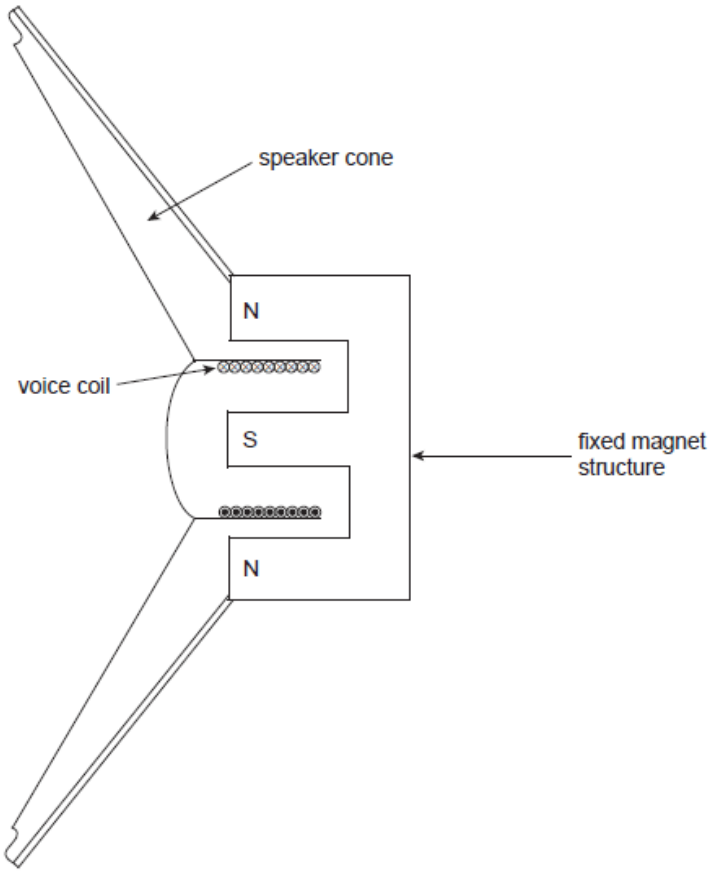
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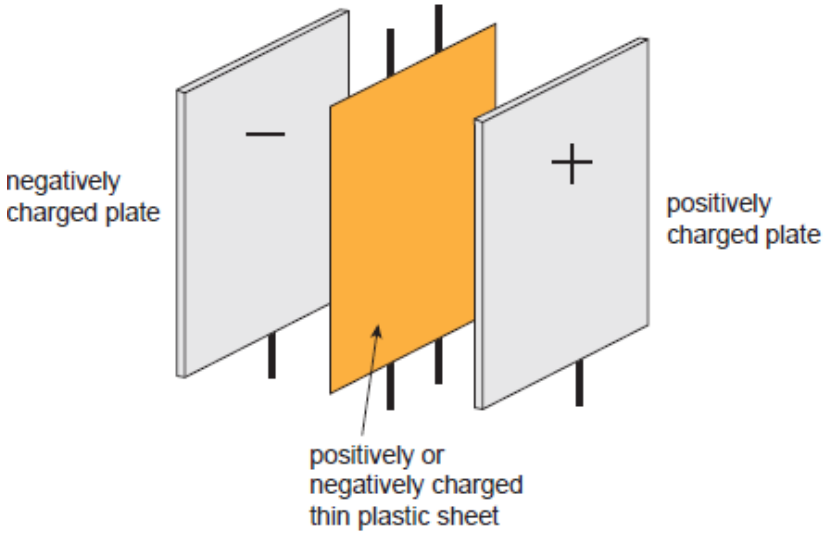
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**Question 34** (6 marks)

A loudspeaker shown in the figure below uses a fixed magnet and a moveable alternating current carrying coil to produce sound.




An electrostatic speaker shown in the figure below utilises an electric field across two fixed outer plates and a varying charged central sheet that is free to vibrate to produce sound.



(a) Compare and describe the physical principles that enable the operation of the magnetic and electrostatic loudspeaker. **3**

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(b) Contrast the physical principle of operation of a loudspeaker with the operation of an induction motor. **3**

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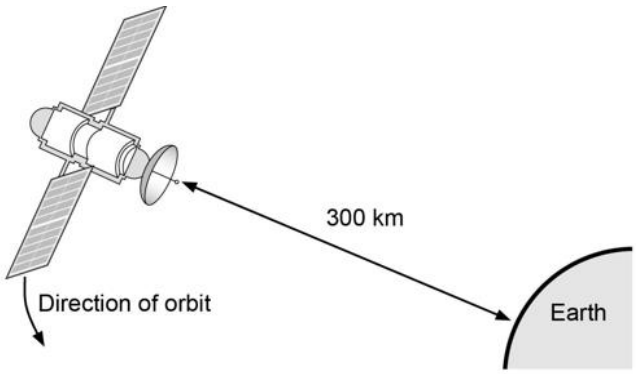
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**Question 35** (7 marks)

A 10 kg satellite is placed into an orbit at an altitude of 300 km.




(a) Identify the nature of that orbit. **1**

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(b) Calculate the orbital period of the satellite. **2**

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(c) Describe the properties of the orbit of this satellite that would make it useful for identified potential applications. **4**

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**Question 36** (8 marks)

The CERN physics program uses powerful accelerators and detectors to study fundamental particles. The laboratory has had to innovate to keep up with electrical demands as CERN uses 1.3 terawatt hours of electricity annually, enough power to fuel 300,000 homes for a year. Much of that power is consumed when the accelerator is in operation accelerating protons. Each proton in the Large Hadron Collider has around $7 \times 10^{12}$ eV of kinetic energy and is smashed into another proton travelling in the opposite direction with the same energy.

(a) Determine the total momentum of two colliding protons with energies of $7 \times 10^{12}$ eV in the LHC? Justify your answer. **2**

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(b) Calculate the relativistic momentum of a proton travelling at 0.999999991c. **2**

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(c) The Large Hadron Collider at CERN has a radius of 26 659 m. If a proton has a maximum energy of $7 \times 10^{12}$ eV this results in 11245 revolutions around the CERN ring per second. Determine the angular velocity of the protons. **2**

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(d) The large hadron collider seeks among other things, to give clarity to aspects of the Standard Model of matter. Part of that model includes quarks and the quark composition hadrons. Describe the relationship between quarks and the quark composition hadron, the proton, in the Standard Model. **2**

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**Question 37** (9 marks)

As part of a depth study an investigation was conducted to determine a value for Planck's constant. The experiment involved setting up five individual, single frequency light emitting diodes (LEDs). Each LED only emits one frequency of light when a turn on voltage ($V_0$) above a certain threshold value is applied across its terminals.
The relationship between the frequency of the emitted light and the voltage ($V_0$) is given by the equation below.
$E = hf = q_e(V_0 + k)$ where
h is Planck's constant, f is the frequency of light emitted by the diode, $q_e$ is the charge on an electron, $V_0$ is the turn on voltage, k is the threshold voltage that is a constant dependent on the material.

The experiment produced the following results.

| LED colour | Maximum wavelength (λ) (nm) | Turn on voltage($V_0$) | 1/λ ($m^{-1}$) |
|---|---|---|---|
| Blue | 450 | 2.53 | |
| Green | 550 | 2.04 | |
| Yellow | 570 | 1.88 | |
| Red | 690 | 1.37 | |
| Infra-red | 890 | 0.88 | |

(a) Complete the table above for calculated values of 1/λ. **2**

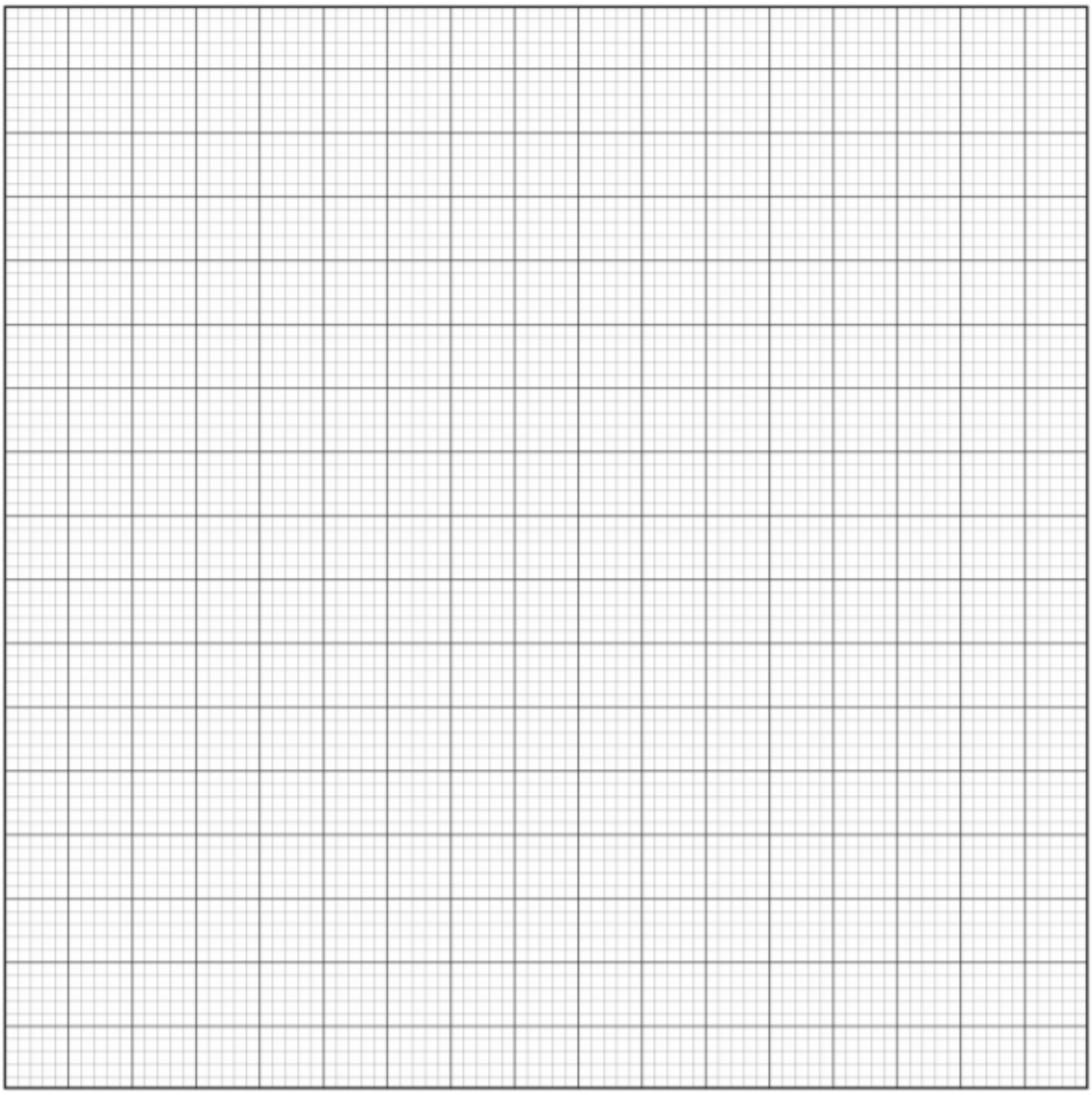
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(b) Plot a graph of voltage against $1/\lambda$, and draw the line of best fit. **2**



(c) Use the graph to calculate the gradient of the line of best fit. **2**
Show all construction lines.

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(d) Use the calculated gradient and the provided equation ($E = hf = q_e(V_0 + k)$ ) to calculate a value for Planck's constant and comment on the accuracy of the procedure.. **3**

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## Section II extra writing space

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**If you use this space, clearly indicate which question you are answering.**