**EXAMINERS**

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## Section I
**Total marks (75)**

## Part A
**Total marks (15)**
**Attempt Questions 1 – 15**
**Allow about 30 minutes for this part**

Use the multiple-choice answer sheet provided.

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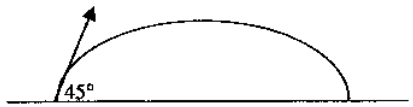
1 Examine the diagram below of an arrow fired from a bow, at ground level.

NOT TO SCALE



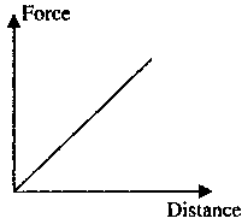

The angle to the horizontal is 45°. The initial horizontal velocity is 100 $ms^{-1}$. The initial vertical velocity of the arrow (in $ms^{-1}$) is:

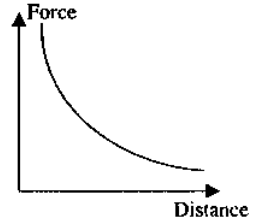
(A) 100 (B) 141.4 (C) 10 (D) 1000

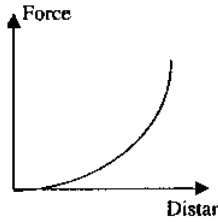
2 A space probe (on Mars) sends a signal back to earth at a microwave wavelength of 2.8 cm. If the time taken for the signal to reach Earth is 4 minutes then Mars must be at a distance of:

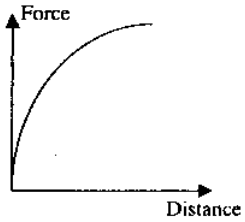
(A) $1.2 \times 10^{9}$m (B) $7.2 \times 10^{10}$m
(C) $7.2 \times 10^{7}$m (D) $1.25 \times 10^{6}$m

3 A student is attempting to perform a series of experiments to measure the gravitational field of an object. The student intends measuring the variation of the gravitational field with distance from the object. The expected graph would be similar to:

(A)



(B)



(C)



(D)


4 The table below gives values of the period and radius of orbit for a number of planets around the Sun.

| Planet | Period (years) | Radius of orbit (km) |
|---|---|---|
| Venus | 0.62 | $1.09 \times 10^{8}$ |
| Jupiter | 11.86 | $7.80 \times 10^{8}$ |
| Saturn | | $1.43 \times 10^{9}$ |
| Neptune | 164.79 | $4.51 \times 10^{9}$ |

From this table the predicted value of the period (in years) for Saturn would be:

(A) 21.7 (B) 29.4 (C) 59.1 (D) 88.3

5 Which of the following conditions must hold in order for a satellite to remain in orbit around the Earth?

(A) The period of the satellite must equal the period of the Earth's rotation.

(B) The centripetal and gravitational forces on the satellite must be equal in magnitude.

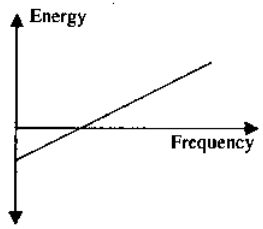
(C) There must not be any forces acting on the satellite.

(D) The satellite must remain outside the gravitational influence of the Earth.

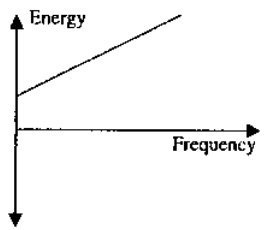


6 Select the graph below which best illustrates the relationship between the energy of electrons emitted from a metal surface and the frequency of the light illuminating the surface.

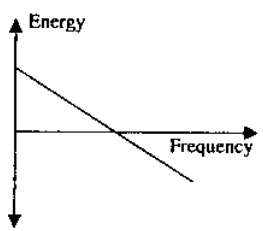
(A)



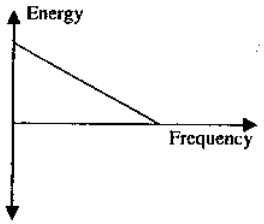

(B)




(C)




(D)




7. A rectangular coil of 100 turns has a length of 5.0 cm and a breadth of 2.0 cm. measured in the plane of the coil. The coil is placed in a magnetic field of 300 tesla with the plane of the coil parallel to the magnetic field. The coil carries a current of $I$ amperes.

The torque on the coil (in Nm) is

(A) 0 (B) $30I$

(C) $300I$ (D) $3000I$

8. In a certain experimental arrangement, the variation in the cross-sectional area of a conductor on the drift velocity of the electrons was investigated. If the original drift velocity was $v$ ms$^{-1}$, then after doubling the cross-sectional area the new drift velocity would be expected to be:

(A) $v$ ms$^{-1}$ (B) $\frac{1}{2} v$ ms$^{-1}$

(C) $2v$ ms$^{-1}$ (D) $4v$ ms$^{-1}$

9. It is possible to cause magnets to "levitate" above materials that have become superconducting. The explanation for this is most likely to be that at temperatures below the transition temperature

(A) the magnetic effect of the current in the superconductor is reversed.

(B) the magnetic field of the magnet is dramatically increased.

(C) the superconductor excludes magnetic fields.

(D) the superconductor has a dramatic decrease in its resistance.

10. Semiconductors demonstrate improved conductivity when they are "doped" by addition of impurities. If an atom from Group III on the periodic table is used as the impurity, conductivity increases because of an

(A) increase in the number of free valence electrons.

(B) alteration to the metal lattice of the semiconductor.

(C) increase in the number of positive holes in the crystal lattice.

(D) increase in the energy of the conduction band.

11. Which of the following is correct?

(A) In a DC motor, the magnetic field is always due to a permanent magnet.

(B) A split-ring commutator reverses the current direction in the rotor coil.

(C) Brushes in an AC motor lead the current to and from the electromagnet.

(D) If a motor works with DC, that motor will not work on AC.

12. Two rectangular coils of copper wire, each of cross-sectional area 72 $cm^2$, are lying perpendicular to a uniform magnetic field of flux density $2 \times 10^{-3}$ T. Coil X consists of 200 turns of wire and Coil Y consists of 400 turns of wire. The ratio of the magnetic flux threading through Coil X to that through Coil Y is:

(A) 0.5 (B) 1.0

(C) 1.5 (D) 2.0

13. Before starting a powerful motor a large load resistor is often switched into series with the motor. The reason for this is:

(A) to limit the forward current in the motor so that the motor does not burn out.

(B) to limit the back current in the motor so that the motor does not burn out.

(C) to limit the eddy currents in the motor so that the motor does not burn out.

(D) to limit the back emf of the motor so that it does not lose energy on start-up.



14. A step-down transformer converts a primary voltage from 240 V to 12 V. The primary coil consists of 1100 turns of wire. The number of turns of wire in the secondary coil is:

(A) 22 000 (B) 13 200

(C) 55 (D) 20

15. If a 2 watt laser beam is emitting light of wavelength 600 nm, the number of photons emitted from the laser per minute will be nearest to:

(A) $6 \times 10^{12}$ (B) $6 \times 10^{18}$

(C) $6 \times 10^{36}$ (D) $6 \times 10^{43}$

**End of Section I Part A**

## Section I

### Part B

**Total marks (60)**
**Attempt questions 16 – 26**
**Allow about 1 hour and 45 minutes for this part**

Show all relevant working in questions involving calculations.

**Question 16** (5 marks) — **Marks**

(a) The OPTUS satellites occupy a geostationary orbit around the Earth. State the period of orbit for these satellite. **1**

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(b) Given that the mass of the Earth is $6 \times 10^{24}$ kg and that the radius of the Earth is 6370 km, determine the height above the Earth's surface of the orbit occupied by the OPTUS satellites. **2**

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(c) On its long voyage to Saturn, the Cassini space probe, launched in 1997, will use the so-called "slingshot effect" provided by some of the planets it passes. Describe how planets provide this slingshot effect. **2**

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**Question 17** (6 marks)

In his book "Dialogues Concerning Two New Sciences", Galileo Galilei presented his classic analysis of the motion of a projectile.

(a) Outline Galileo's contribution to our understanding of projectile motion. **2**

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(b) A scientist studying motion on Miranda, one of the moons of Uranus, launched a spherical projectile from the top of a high cliff at a speed of 15 $ms^{-1}$ horizontally. Using a special speed camera the scientist measured the magnitude of the total velocity of the projectile as it fell to the ground. **3**

Some of the data is shown in the following table:

| Time after Launch (s) | Speed (m/s) |
|---|---|
| 20 | 15.1 |
| 40 | 15.5 |
| 60 | 16.1 |
| 80 | 16.9 |

Using any pair of data values from the table, show how you would test whether this experimental data support or disagree with the present day understanding of projectile motion.

You may assume that the acceleration due to gravity on Miranda is constant over the height involved and has a value of 0.096 $ms^{-2}$.

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(c) If the mass of the projectile in part (b) is 2 kg, calculate its weight on the surface of Miranda. **1**

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**Question 18** (5 marks)

(a) Difficulties are sometimes experienced when earth-based satellite monitoring stations attempt to communicate with satellites in earth orbit. **1**

Name ONE common cause of such communications difficulties.

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(b) Compare the use of microwave and radiowave technology as effective communication strategies for space travel. 2

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(c) Human beings travelling to the stars is a common feature of science fiction. Voyager 2, one of the fastest travelling man-made objects, is now making its way towards the stars at around $1.08 \times 10^5$ km/hr. Imagine that this space probe was to travel straight towards our nearest star, Alpha-Centauri, a distance of $4.10 \times 10^{13}$ km away.

(i) Determine how long in years it would take to reach Alpha-Centauri at its current speed. 1

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(ii) Comment on what your answer implies for the future of long-distance space travel. 1

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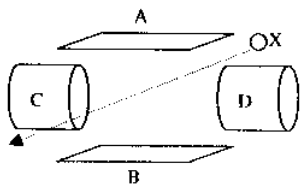
**Question 19** (6 marks)

Consider the experimental arrangement below, in which a pair of horizontal parallel plates (A and B) provides an electric field, and the magnetic deflection coils (C and D) provide a magnetic field at right angles to the electric field.

Electrons are emitted from a source X, travelling in a direction out of the page and perpendicular to the plane of the page and to the electric and magnetic fields.






(a) If the distance between the plates is 2.5 mm and there is a potential difference of +100V from plate A to plate B (positive plate), calculate the strength and direction of the electric field vector. 2

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(b) Describe the direction of the magnetic field vector if an electron travelling in a straight line is to pass through the pair of fields and remain undeflected. 1

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(c) Derive an expression for the velocity of the electrons in an undeflected beam in terms of the magnetic and electric field strengths. 1

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(d) If the strength of the magnetic field is 200μT, calculate the kinetic energy of the individual electrons within the beam. 2

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**Question 20** (5 marks)

(a) Define the term "spacetime". 1

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(b) Suppose a spacecraft has a measured length of 30 m when it is stationary on the launch pad on Earth. When it is accelerated to a speed of $\frac{c}{2}$, what would its length be as measured by ..

(i) Lorena, an observer travelling in the spacecraft? 1

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(ii) Katherine, an observer on Earth? 1

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(c) Describe two other consequences of the Theory of Special Relativity for the spacecraft mentioned above. 2

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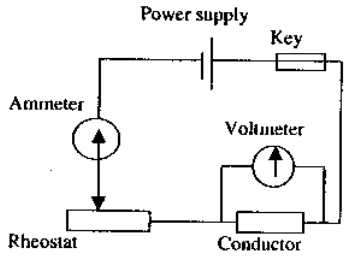
**Question 21** (6 marks)

(a) Two students, X and Y, each set out to determine the resistance of a conductor. Each student constructs the circuit shown below. 2




The two conductors do not necessarily have the same resistance. Each power supply has a selector switch which is labelled from 2V → 12V so that the electromotive force applied to the circuit can be varied.

By manipulating the power supply and the rheostat, student X sets the potential differential across the conductor successively at 2V, 3V..... 6V and reads each corresponding current from the ammeter.

Identify which quantities constitute the independent variable, the dependent variable and the constant quantity.

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(b) Photoelectrons are emitted by the surface of a certain metal when the surface is illuminated by green light of wavelength 550 nm. The same surface emits photoelectrons when it is illuminated by violet light of wavelength 400 nm. 2

Explain any difference between the photoelectrons emitted using green light and those emitted using violet light.

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(c) Calculate the photon energy of the violet light mentioned in (b) above. 2

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**Question 22** (5 marks)

(a) Explain what is the essential condition for a substance to be a semiconductor. 2

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(b) Explain why negative electrons and positive holes move through a semiconductor when the potential difference of a battery is applied across the semiconductor. 2

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(c) Name three semiconductor materials. 1

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**Question 23** (5 marks)

(a) Describe one aspect of the motion of electrons in a metal conductor when the conductor is carrying a current. 1

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(b) Describe and account for the motion that constitutes the current. 2

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(c) Bragg's Law predicts the conditions under which diffracted X-ray beams from a crystal are possible. The conditions are expressed by the equation 2

$$2d \sin\theta_m = m\lambda$$

where $m$ is an integer (1,2,3,...)
$\lambda$ is the wavelength of the X-rays,
$d$ is the spacing of the planes of the crystal,
$\theta$ is the angle between the direction of the incident X-ray and the surface of the crystal.

X-rays of wavelength 0.110 nm are directed onto the surface of a crystal of sodium chloride with the angle $\theta$ starting at 0° and increasing to 90°. The separation of the planes in a sodium chloride crystal is 0.252 nm.

Determine the angles at which constructive interference will occur in the emergent X-rays.

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**Question 24** (5 marks)

(a) Sketch the output voltage produced by a DC generator with a single coil. 1

(b) Explain the function of a split-ring commutator in a single-coil DC generator. 1

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(c) Outline how an AC generator produces a current. 2

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(d) Give one reason AC generators rather then DC generators are used in power stations. 1

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**Question 25** (5 marks)

(a) A straight piece of wire is moved perpendicularly to the Earth's magnetic field. List two factors which would affect the size of the potential difference that develops between the ends of the wire. 2

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(b) A loop of wire laying on a table top is connected to a sensitive galvanometer to form a complete circuit. The magnetic flux passing through the loop is $3.2 \times 10^{-5}$ Tm$^2$. The loop is quickly turned over in a time of 0.2 seconds.

(i) Explain the difference between magnetic flux and magnetic flux density. 1

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(ii) Calculate the rate of change of magnetic flux through the coil when it is turned over. 2

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**Question 26** (6 marks)

(a) The distance from the main farm transformer (415 volts AC) to the shearing shed is 500 metres. The farmer needs to run this power to his shed via a power line. Given the resistance of the wire is 1 ohm per 20 metres, calculate the power line loss. 2

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(b) The farmer has several items in his work shed that are designed to operate on a 240 V AC supply. Ignoring the power line loss calculated in part (a), determine the relationship between the number of turns in the coils of a transformer that would be needed to step the voltage down from 415 V AC to 240 V AC. 2

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(c) (i) Explain why large transformers need oil to circulate around the core of the transformer. 2

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(ii) How do transformers overcome the problem of eddy currents developing within the core of the transformer.

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**End of Section I Part B**



## Section II – Options

**Total marks (25)**
**Attempt ONE question from Questions 27 - 31**
**Allow about 45 minutes for this section**

Answer the question in the writing booklet provided.

Show all relevant working in questions involving calculations

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**Question 30 – Quantum to Quarks** (25 marks)

**Marks**

(a) i) The atomic mass of sodium $^{23}_{11}Na$ is 22.98985122. Determine the binding energy of $^{23}_{11}Na$ **3**

ii) A hydrogen atom at rest emits a photon of energy when an electron moves from the excited state of $n_i = 6$ to the ground state of $n_f = 1$. Determine the recoil velocity of the hydrogen atom. **3**

(b) i) Explain why the discovery of radiation by Becquerel in 1896 had important implications for the path physics research followed. **2**

ii) α. State Bohr's third postulate. **1**

β. Show how de Broglie's "matter waves" confirmed this postulate. **2**

iii) α. Explain what is meant by the Zeeman effect. **1**

β. State the two normal appearances of the Zeeman effect. **2**

γ. State which phenomenon was discovered as a result of research into the Zeeman effect. **1**

(c) In the "Compton scattering" experiment,

i) What did Compton actually do? **1**

ii) What happened to the electrons involved? **1**

iii) What happened to the incident x-ray photons? **1**

iv) State which law(s) of physics must be applied to analyse this experiment. **2**

(d) State the essential features of a thermal fission reactor and give one example of the material which may constitute each feature. **5**

**END OF OPTION QUESTION**