

Answers

DIRECTIONS TO CANDIDATES:

• Write your Student Number at the top right hand corner of this page.

Section 1

PART A Multiple Choice

Select the alternative A, B, C or D that best answers the question. Fill in the response space.

1. A B C D
2. A B C D
3. A B C D
4. A B C D
5. A B C D
6. A B C D
7. A B C D
8. A B C D
9. A B C D
10. A B C D
11. A B C D
12. A B C D
13. A B C D
14. A B C D
15. A B C D

Write your answers in the spaces provided for each question.

Question 16 (7 marks)

Marks

(a) (i) The speed of light is constant and independent of the motion of the observer. 2

All inertial frames of reference are equivalent. The laws of physics are the same in all inertial frames.

(ii) The length of an object appears to decrease to an external observer when the object is moving at speeds close to the speed of light.

The time in a moving frame (celestial speed of light) appears to us slower to stationary observer.

(b) $t_s = t_o$ t_s = time observed by stationary obs

$$t_s = t_o \sqrt{1 - \frac{v^2}{c^2}}$$

$$2.2 = 2.2 \sqrt{1 - \frac{v^2}{(3 \times 10^8)^2}}$$

$$\sqrt{1 - \frac{v^2}{(3 \times 10^8)^2}} = \frac{2.2}{2.2} = 1$$

$$1 - \frac{v^2}{(3 \times 10^8)^2} = 1 - 0.992 = 0.008$$

$$\frac{v^2}{(3 \times 10^8)^2} = 0.008$$

$$v = 0.008 \times 3 \times 10^8 = 2.4 \times 10^6 \text{ m/s}$$

distance observed = $15 \cdot 6 \times 10^6 \times 3 \times 10^8$ (Speed of light)

$$= 4680 \text{ m (4.7 km)}$$

4630m

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(92.2)

2

Marks

Question 17 (6 marks)

(a) Using $r^3/T^2 = \frac{GM}{4\pi^2}$ where $M = \text{mass of Mars}$
 $T = 7 \text{ k } 39 \text{ m} = 2.754 \times 10^4 \text{ s}$ $M = \frac{4\pi^2 M}{GT^2}$
 $M = \frac{4\pi^2 \times (9.5 \times 10^{23})}{6.67 \times 10^{-11} \times (2.754 \times 10^4)^2} = 6.7 \times 10^{23} \text{ kg}$ ✓

(b) The satellites are suborbital for part of their orbit around the Earth.

• Due to appreciable air resistance they lose their orbital velocity and spiral down to Earth (many burn up on re-entry)

(c) $r^3/T^2 = \frac{GM}{4\pi^2} \Rightarrow r^3 = \frac{GM T^2}{4\pi^2}$
 $T = 2.5 \text{ hours} = 24 \times 60 \times 60$
 $r = \sqrt[3]{\frac{6.67 \times 10^{-11} \times 6 \times 10^{24} \times (24 \times 60 \times 60)^2}{4\pi^2}} = 4.23 \times 10^4 \text{ m}$

Question 18 (3 marks)

These issues discussed from one of the following:

- Distance and time of travel (one issue)
- Speed required (linked to above - one issue)
- Fuel to be carried for man, servicing and return flight.
- Communications difficulties (weak signal)
- Hazards from radiation & perhaps asteroids.

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3

Marks

Question 19 (4 marks)

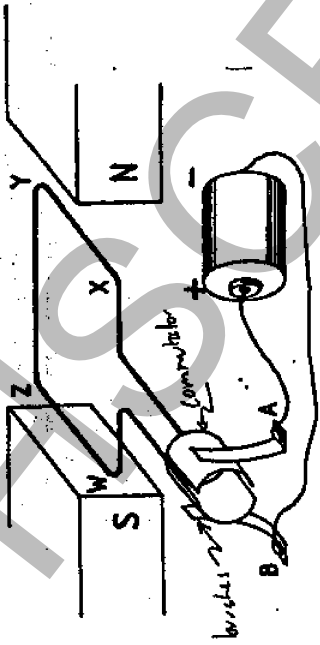
(a) $v_{\text{max height}} = 0$ $v = u + at$ $a = -9.8 \text{ m/s}^2$
 $0 = 80 \sin 30 + (-9.8)t$

$\therefore t = \frac{80 \sin 30}{9.8} = 4.1 \text{ s}$
 $v^2 = u^2 + 2as \Rightarrow 0 = (80 \sin 30)^2 + 2(-9.8)s$
 $s = \frac{40^2}{19.6} = 81.6 \text{ m (82 m)}$

\therefore Total height above sea level = 182 m
 Speed at max height is horizontal component of initial velocity = $80 \cos 30 = 69.3 = 69 \text{ m/s}$

(d) Time down: $s = -182 \text{ m}$ from max height
 $s = ut + \frac{1}{2}at^2$ $u_{\text{vertical}} = 0$ vertically
 $-182 = 0 + \frac{1}{2}(-9.8)t^2 \Rightarrow t = \sqrt{\frac{182}{4.9}} = 6.1 \text{ s}$
 \therefore Total time = $6.1 + 4.1$ (time up) = 10.2 s

Question 20 (7 marks)



(a) Commutator: allows the current in the coil to change direction every

1/2 revolution so coil turns in constant direction.

Brushes: allow current to conduct to coil without affecting the rotation of the coil

$$T_{max} = nIAB = 20 \times 9.0 \times 0.20 \times 0.40 \times 0.37 = 4.6 \text{ Nm}$$

(c) (i) multiple coils ensure that active coil is always aligned to field lines for maximum torque. Allows smooth torque + maximum torque

(ii) curved faces provide a radial field so that coil is always aligned with field lines. Smooth strong torque

(iii) laminations reduce eddy current build up in rotor reducing heating in rotor and energy loss

Question 21 (2 marks)

Similarity: both contain coils in magnetic fields, respond to a current passing

movement of the coil

Difference: The galvanometer has hair springs to prevent it moving full circle (provide counter torque) as well as a commutator (current field to move full circle)

Question 22 (2 marks)

Motors act as generators producing current in them as they turn in a magnetic field. The current opposes the change that caused it (Lenz's law) and leads to back emf. The net current drops as the coil as it picks up speed i.e. resistance can be removed as it is not likely to burn out the coil.

Marks

5

Marks

7

Marks

9

24

10

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Question 23 (6 marks)

(a) High voltages produced by transformers are accompanied by lower currents. This reduces current heating effects in wires and losses of efficiency (energy) in transmission.

(b) $N_s I_s = 500000 \cdot 25000$

(c) $V_p I_p = V_s I_s$
 $I_s = \frac{V_p I_p}{V_s} = \frac{25000 \cdot 1000}{500000} = 50 \text{ A}$

(d) The transformer consists of a laminated core about which wires are wound. This reduces eddy current and is energy losses due to heating are reduced.

Question 24 (8 marks)

(a) $E_{\text{max}} = hf - \phi$
 $1.3 \times 10^{-19} = 6.626 \times 10^{-34} \times f \times 10^{14} - \phi$
 $\therefore \phi = 4.882 \times 10^{-19} - 1.3 \times 10^{-19} = 3.582 \times 10^{-19}$
 $\phi = hf_0$ $f_0 = \text{threshold frequency}$
 $f_0 = \frac{\phi}{h} = \frac{3.582 \times 10^{-19}}{6.626 \times 10^{-34}} = 5.4 \times 10^{14} \text{ Hz}$

Question 24 continued next page

Question 24 continued

(b) Intensity: No effect on the maximum KE of electrons as max KE depends on the frequency. ϕ increases the value of photoelectric current as more electrons are released.
 Frequency: Emission is frequency dependent below the threshold frequency no emission occurs as the minimum energy depends on a min frequency.

(c) Classical theory predicted that emission is independent of frequency and that the KE of photoelectrons would increase with light intensity.

Question 25 (4 marks)

(a) $F = Bqv = 0.1 \times 1.602 \times 10^{-19} \times 1 \times 10^5 = 1.6 \times 10^{-15} \text{ N}$

Direction: up the page (in the same sense of page)

(b) $F = ma \therefore a = \frac{F}{m} = \frac{1.6 \times 10^{-15}}{9.109 \times 10^{-31}} = 1.8 \times 10^{15} \text{ m/s}^2$

(c) $F_{\text{mag}} = F_{\text{elec}} \therefore F = \frac{F}{q} = \frac{1.6 \times 10^{-15}}{1.60 \times 10^{-19}} = 1 \times 10^{14} \text{ V/C}$

Question 26 (4 marks)

- (a) Energy losses in wires due to resistance would be greatly reduced saving large amounts of energy which would be used as electrical energy and reducing costs and environmental problems. Also low voltage can be built very far from population centres.
- (b) Ceramic superconductors are too brittle and difficult to make into wires for transmission.
- They are chemically unstable in some environments
 - Costly and difficult to manufacture

Question 27 (4 marks)

- (a) In a metal the increase in temperature increases the increased vibrations of lattice ions increases the probability of collisions with conduction electrons.
- In semiconductors the increase in temperature provides the energy to promote conduction electrons into the conduction band - jumping the forbidden gap thus lowering resistance.
- (b) Thermionic emission: emission of electrons from surfaces when a material is heated.
- Solid state devices are compact resulting in miniaturisation.
- OR They waste less energy in heating effects than thermionic devices.
- OR cheaper to manufacture.
- OR long start-up time while they heat up.

Question 28 (3 marks)

- (a) There are two charges and accelerate the electrons emitted by the cathode.
- (b) Deflect the electron beam and have two time bases for vertical and horizontal deflection.
- (c) The coating fluoresces (light up) as electrons strike the screen to give an image of the signal (picture).

Question 29 (7 marks)

(a) $F_{mag} = F_{elec}$ on charged particles

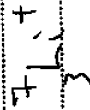
$Bqv = qE$
 $\therefore v = \frac{E}{B}$

(b) $F_{mag} = F_{elec}$
 $Bqv = m\frac{v^2}{r} \Rightarrow m = \frac{Bqr}{v}$ (or use conservation)

$\therefore m \propto r \therefore m_2 = Zm_1$
 From (b) above $q = \frac{mv}{Br}$ and $m = \frac{Bqr}{v}$
 $\therefore q \propto \frac{1}{r}$ and $m \propto r$

\therefore small mass, large charge binds most

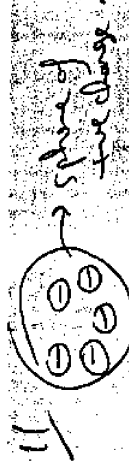
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line 3

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Question 30 (7 marks)



(a) A sphere of positive charge with electrons embedded in it.

(b) Alpha particles were fired at gold foil and the deviation of the α -particles was detected by using a scintillating screen of a phosphor on the gold foil.

(c)(i) The deviation of the α -particles after passing through the gold foil would be very small.

(ii) Most of the α -particles passed through with small deviations but a small number showed large deviations (scattering).

(iii) The size charge in the atom must be concentrated in a very small volume and that the atom was largely empty space.

(The mass of the atom is concentrated in the nucleus as it was known that most of the charged [protons] is larger than that of electrons.)

d (cm)	Period, T (s)	d ² (cm ²)	T ² (s ²)
10	6.78	100	46.0
15	7.18	225	51.6
20	7.70	400	59.3
25	8.00	625	64.0
30	9.10	900	82.8
35	9.68	1225	93.7

(b) Graph paper

(c) A: "y" intercept

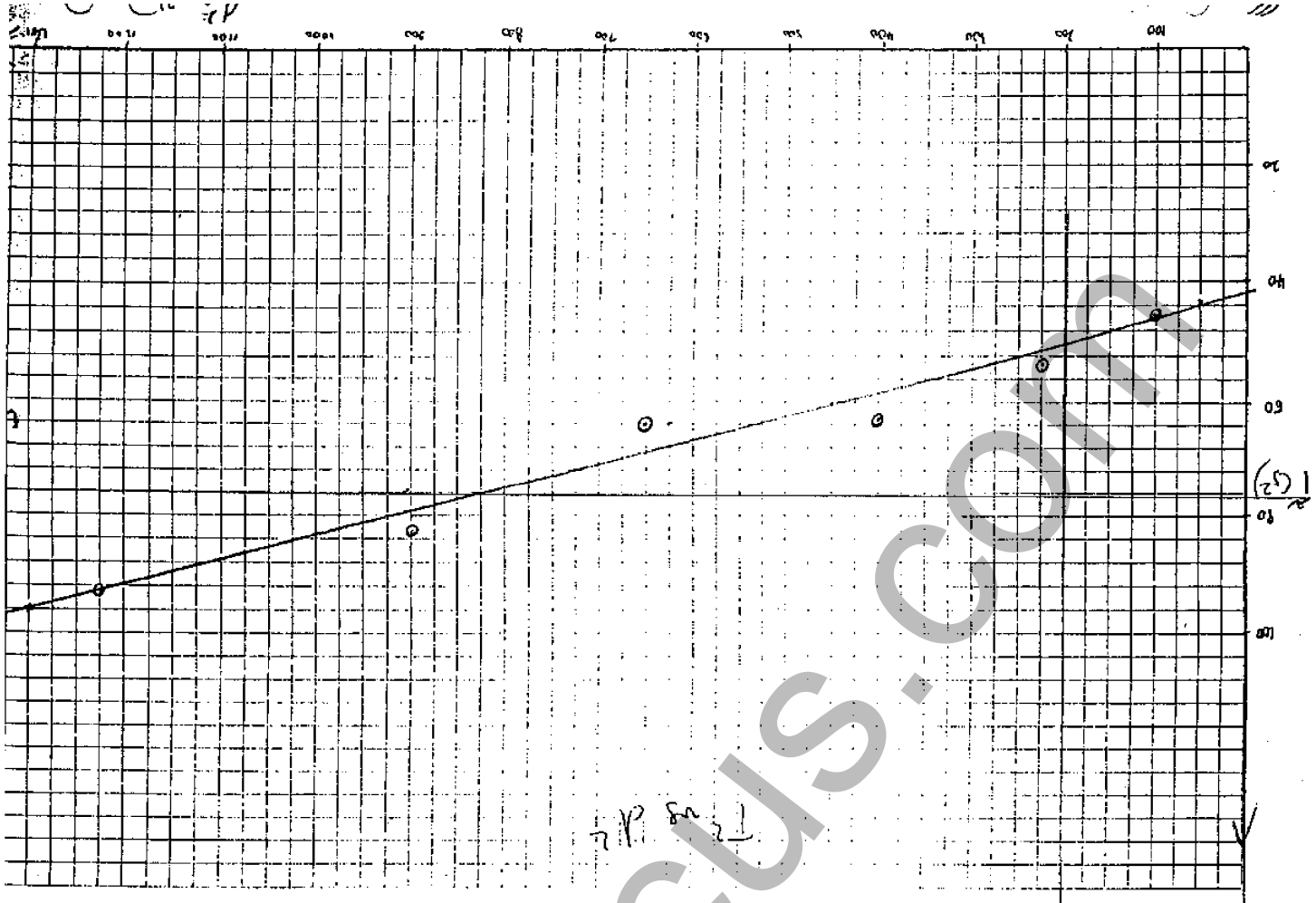
$$A = 4.2 \text{ s}^2$$

$$B: \text{gradient} = \frac{96 - 44}{1300 - 50} = 0.042 \text{ s}^2 \text{ cm}^{-2}$$

(d) A: represent the (period)² value. The two masses are half.

At the same part of the table (minimum (period))

Experimentally it can be observed by plotting the mass at the same part.



Marks

(a)