

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.

- ☐ A ☐ B ☐ C ☐ D
- ☐ A ☐ B ☐ C ☐ D
- ☐ A ☐ B ☐ C ☐ D
- ☐ A ☐ B ☐ C ☐ D
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- ☐ A ☐ B ☐ C ☐ D
- ☐ A ☐ B ☐ C ☐ D
- ☐ 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.

3

The time in a moving frame (relativistic)

speed of light) appears to be slower to a stationary observer.

(b) $t_s = t_r$ t_s = time observed by stationary observer

$$t_s = \frac{t_r}{\sqrt{1 - \frac{v^2}{c^2}}} \quad t_s = 2.2 \quad \frac{2.2}{\sqrt{1 - 0.992}} = 0.140(73) \quad 15.6 \mu s$$

distance observed = $15.6 \times 10^{-6} \times 3 \times 10^8$

(Speed of light)

= $4680 m$ (4.7 km)

4630 m

next page

(92.2)

2

Marks

Question 17 (6 marks)

(a) Using $r^3/T^2 = \frac{GM}{4\pi^2}$ where $M = \text{mass of Mars}$
 $T = 7k39m = 2.754 \times 10^4 s$ $\therefore M = \frac{4\pi^2 r^3}{GT^2}$
 $M = \frac{4\pi^2 \times (9.5 \times 10^6)^3}{6.67 \times 10^{-11} \times (2.754 \times 10^4)^2} = 6.7 \times 10^{23} \text{ kg}$ ✓

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

Question 18 (3 marks)

Three 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 transceiving and return flight.
- Communications difficulties (weak signal)
- Hazards from radiation & perhaps asteroids.

3

Marks

Question 19 (4 marks)

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

$\therefore t = \frac{80 \sin 30}{9.8} = 4.1 \text{ s}$

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

$\therefore$ Total height above sea level = 182 m

(c) Speed at max height is horizontal component of initial velocity = $80 \cos 30 = 69.3 = 69 \text{ m/s}$

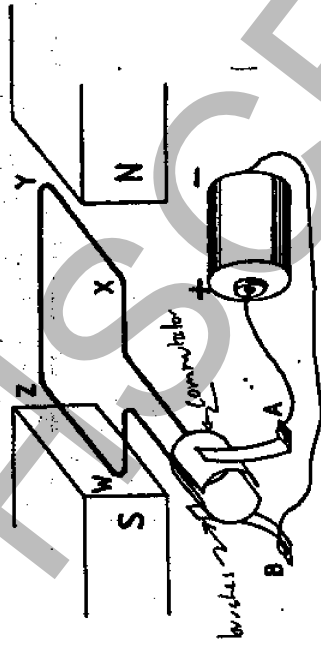
(d) Time down: $s = -182 \text{ m from max height}$
 $s = ut + \frac{1}{2}at^2$ $u_{\text{vertical}} = 0$ vertically

$-182 = 0 + \frac{1}{2}(-9.8)t^2 \Rightarrow t = \sqrt{\frac{182}{4.9}} = 6.1 \text{ s}$

$\therefore$ Total time = $6.1 + 4.1$ (time up) = 10.2 s

next page

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

$$\tau_{max} = nIAB = 20 \times 9.0 \times 0.20 \times 0.40 \times 0.32$$

$$= 4.6 \text{ Nm}$$

- (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 hairsprings to prevent it moving full circle (provide counter torque) as well as a commutator (current need 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 in the coil as it picks up speed i.e. resistance can be removed as it is not likely to burn out the coil.

Question 24 continued

(a) High voltages produced by transformers are accompanied by lower currents. This reduces the current carrying effects ② wires and losses of efficiency (energy) in transmission ①

(b) $N_1: N_2 = 500000 : 250000$

○ 10

(c) $V_p I_p = V_g I_g$
 $\therefore I_g = \frac{V_p I_p}{V_g} = \frac{25000 \times 1000}{500000} = 50A$

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

Question 24 (8 marks)

(B) $\phi - \psi = \text{const}$

$$\begin{aligned} 1.3 \times 10^{-19} &= 6.626 \times 10^{-34} \times 7 \times 10^{14} - \phi \\ (4.0382 \times 10^{-19}) & \quad 3.34 \times 10^{-19} \\ \therefore \phi &= 4.0382 \times 10^{-19} - 1.3 \times 10^{-19} = 2.7 \times 10^{-19} \end{aligned}$$

$$\phi = h f_0 \quad f_0 = \text{threshold frequency}$$

$$f_0 = \phi / h = \frac{3.34 \times 10^{-19}}{6.626 \times 10^{-34}} = 5.04 \times 10^{14} \text{ Hz}$$

Question 24 continued next page

Question 25 (4 marks)

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

Question: up the page (in the same plane of page)

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

(c) $F_{\text{avg}} = q_e E_{\text{elec}} \therefore F = \frac{F}{q} = \frac{1.6 \times 10^{-5} \cdot 9987.5 \text{ N/C}}{1.60 \times 10^{-19} \text{ C}} = 9.9875 \times 10^{14} \text{ N/C}$

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 impedance can be built very far from population centres.
- (b) Ceramic super-conductors 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 (such as a metal) 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 charged 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 (lights up) as electrons strike the screen to give an image of the signal (picture).

Question 29 (7 marks)

Marks

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

$$Bqv = qE$$

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

(b) $F_{\text{mag}} = F_{\text{elec}} \Rightarrow m = \frac{Bqv}{v} \text{ (or use momentum)}$

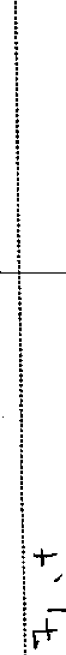
$$Bqv = m\frac{v}{r} \Rightarrow m = \frac{Bqvr}{v} \text{ (or use momentum)}$$

(c) line 1 From (b) above $q = \frac{mv}{Br}$ and $m = \frac{Bqvr}{v}$

$$\therefore m \propto r \therefore m \propto Zm_1$$

$\therefore q \propto \frac{1}{r}$ and $m \propto r$

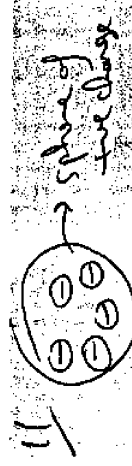
$\therefore$ small mass, large charge binds most



next page

Question 30 (7 marks)

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

for gold foil. 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 change 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: "if intercept

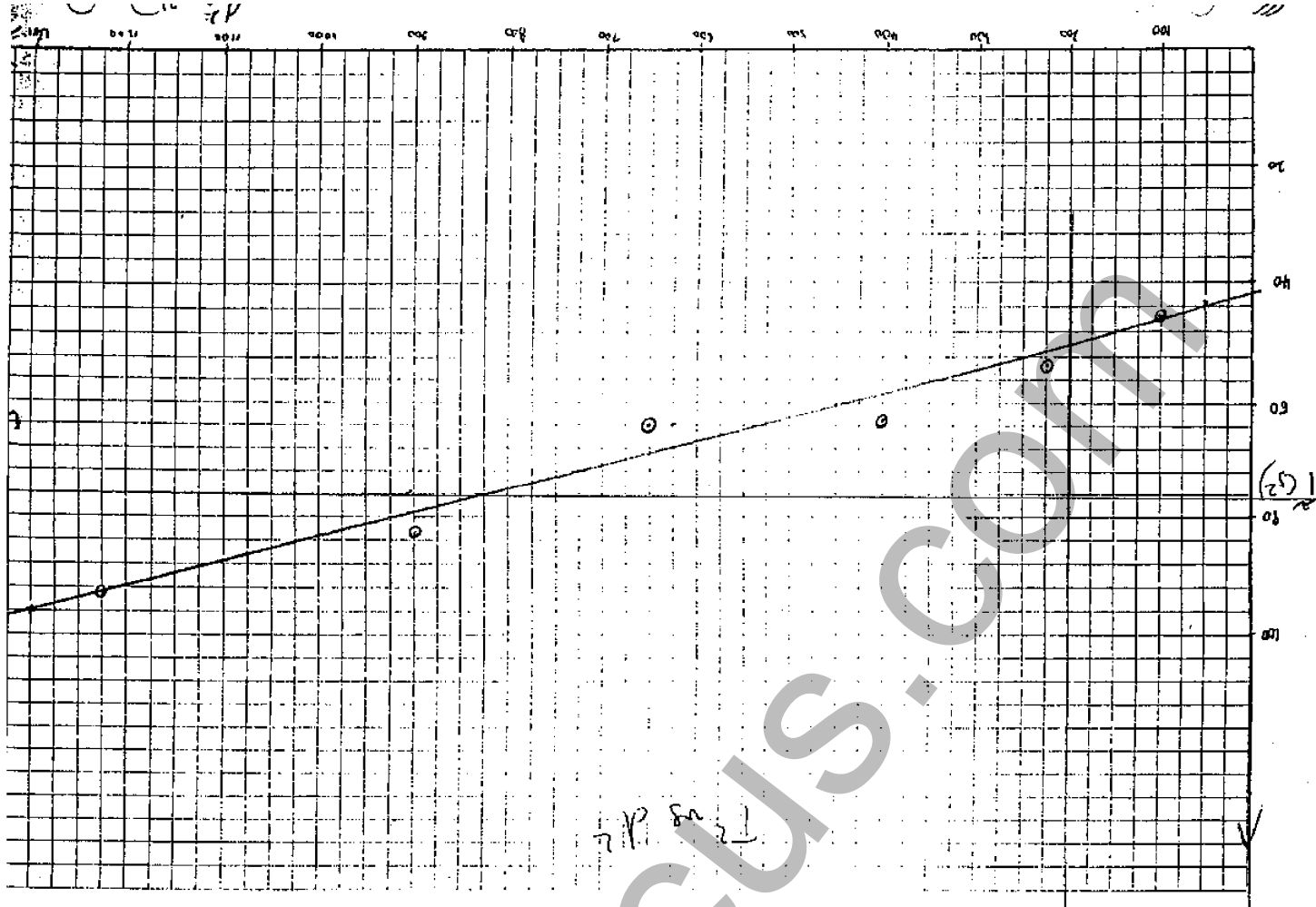
$$A = 42.9$$

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

(d) A: represent the (period)² when the two masses are both

at the same part of the cycle (minimum (quiescent))

Experimentally it can be measured by placing the masses at the same point.



Marks