SYDNEY BOY HIGH SCHOOL

2008

TRIAL HSC EXAMINATION

PHYSICS

General Instructions

- Reading time – 5 minutes
- Working time – 3 hours
- Write using blue or black pen
- Draw diagrams using pencil
- Board-approved calculators may be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper
- Write your candidate number at the top of each page in Part B
- Set working out clearly as marks are allocated to working

Total marks (100)

Section 1 75 Marks

This section has two parts, Part A and Part B.

Part A = 15 marks

- Attempt questions 1-15
- Allow about 30 minutes for this part

Part B = 60 marks

- Attempt Questions 16-28
- Allow about 1 hour and 45 minutes for this part

Section II 25 marks

- Attempt Question 34 only
- Allow about 45 minutes for this section.

Part A

Total Marks (15 Marks)

Attempt Questions 1-15

Allow about 30 minutes for this Part

Use the multiple-choice Answer Sheet.

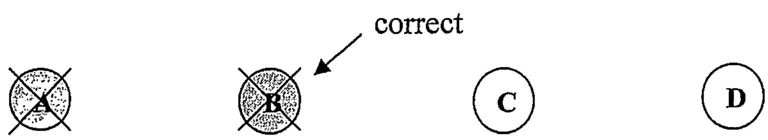
Select the alternative A, B, C OR D that best answers the question. Fill the response circle completely.

Sample 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



Use the coloured multi choice answer sheet provided with this paper.

1. An unknown planet, X, has an acceleration due to gravity of 14.0 ms^{-2} at its surface. What is the weight of a 75.0 kg astronaut on the surface of planet X?

(A) 5.17 N
(B) 75.0 N
(C) 388 N
(D) 1050 N

Questions **2, 3 and 4 refer to the following information:**

> *The following quantities describe the properties of the Hubble space telescope and its orbit around the Earth:-*
>
> - *Total mass of the telescope = $1.1x10^4$kg*
> - *Radius of telescope orbit = $7.0x10^6$m.*

2. What is the orbital speed of the telescope?

(A) $8.2 \times 10^1 ms^{-1}$
(B) $7.6 \times 10^3 ms^{-1}$
(C) $7.9 \times 10^5 ms^{-1}$
(D) $5.7 \times 10^7 ms^{-1}$

3. What is the gravitational potential energy of the telescope?

(A) -6.3×10^{11} J
(B) -6.5×10^{10} J
(C) -5.7×10^7 J
(D) -9.0×10^4 J

4. What is the gravitational force between the Earth and the telescope?

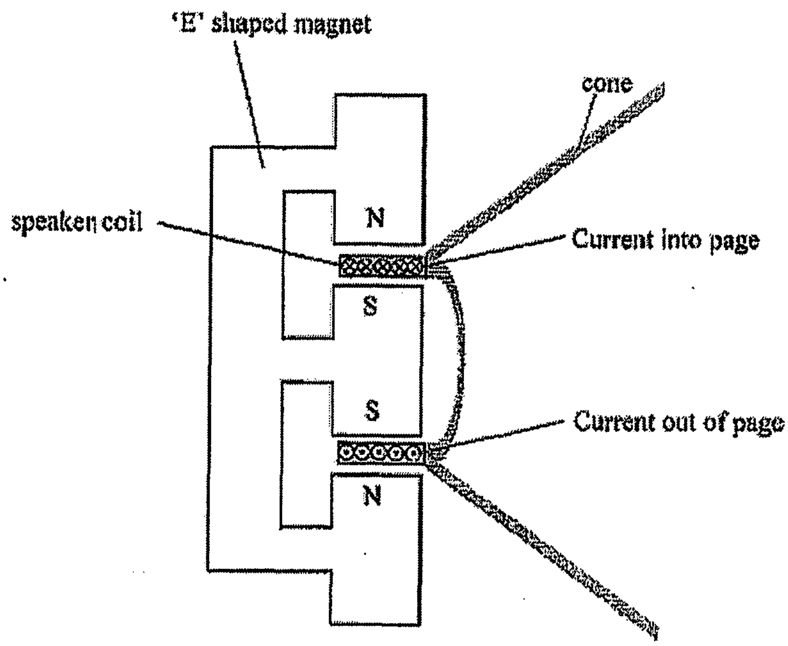
(A) 8.2×10^1 N
(B) 3.0×10^2 N
(C) 9.0×10^4 N
(D) 1.1×10^5 N

5. The star Algol is 3.67×10^{16}m away from Earth, as measured from Earth. Meanwhile, a spacecraft is travelling past earth on the way to Algol. The spacecraft measures the distance between Earth and Algol to be 2.15×10^{16}m.

What is the speed of the spacecraft, relative to Earth?

(A) 0.810c
(B) 0.657c
(C) 0.414c
(D) 0.235c

6. The following diagram shows a cross-section of a loudspeaker.



At the instant shown, when the current in the coil is flowing into the page at the top of the coil, which of the following statements describes the motion of the coil (and the attached cone)?

(A) It is oscillating.
(B) It is rotating.
(C) It is accelerating to the right of the page.
(D) It is accelerating to the left of the page.

7. The unit of magnetic flux is the weber, where 1.0 Wb is equivalent to which of the following units?

(A) 1 Am^2
(B) 1 Am^{-2}
(C) 1Tm^2
(D) 1Tm^{-2}

8. An electric motor driven from a constant voltage supply is used to move a load. If the magnitude of the load is decreased, which one of the following sets of changes occurs?

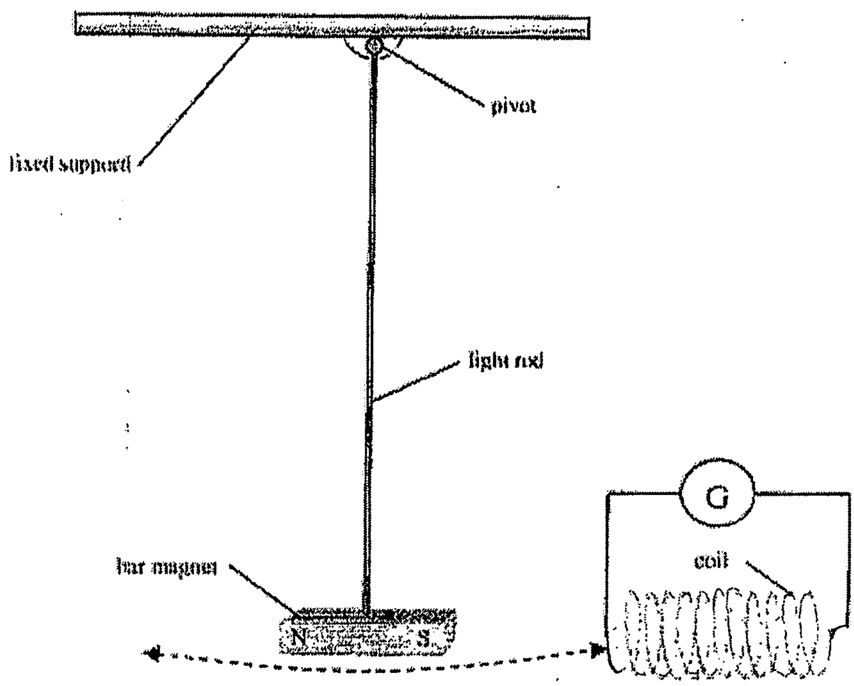
	Speed of rotation	**Induced emf in coil (back emf)**	**Current in the coil**
(A)	increases	increases	decreases
(B)	decreases	decreases	increases
(C)	increases	increases	increases
(D)	decreases	increases	decreases

9. There are 200 turns in the primary coil of an ideal transformer and its secondary coil has 50 turns. If the current in the secondary coil is 40.0 A, what is the current in the primary coil?

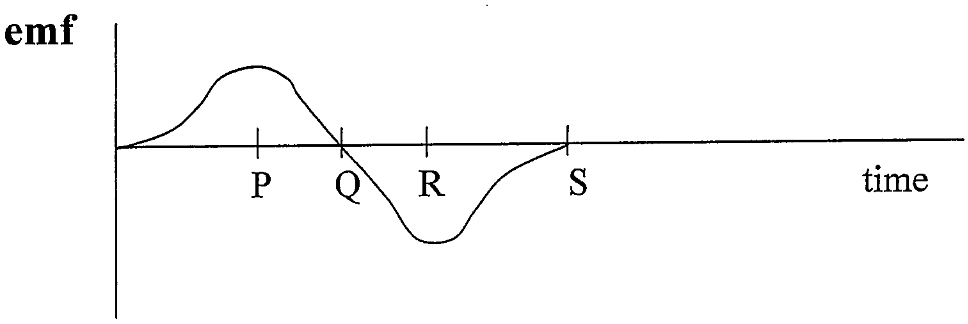
(A) 160 A
(B) 80.0 A
(C) 40.0 A
(D) 10.0 A

PART A CONTINUED NEXT PAGE

10. The diagram below represents a magnet mounted on a light rod which oscillates as a simple pendulum. At the end of the swing, the magnet approaches a coil connected to a sensitive galvanometer.



As it swings, the magnet induces an emf (voltage) in the coil. A graph of induced emf plotted against time for the coil is shown below. Times P, Q, R and S are marked on the graph for one complete period of oscillation.



At which of the times P, Q, R and S is the magnet closest to the coil?

(A) Time P
(B) Time Q
(C) Time R
(D) Time S

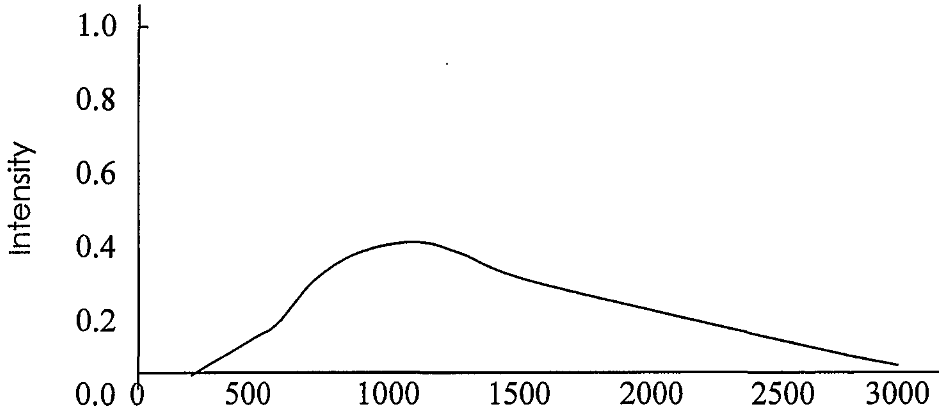
11. Red light from a laser was tested in a laboratory and found to have a wavelength of 635 nm. What is the energy of an individual photon of this light?

(A) 1.04×10^{-36} J
(B) 1.04×10^{-27} J
(C) 3.13×10^{-28} J
(D) 3.13×10^{-19} J

12. In the context of experiments conducted in the nineteenth century, which of the following properties of cathode rays supports **both** the theory that cathode rays are composed of waves **and** the theory that they are particles?

(A) Cathode rays can be deflected by electric fields.
(B) Cathode rays can be deflected by magnetic fields.
(C) A metal object in the path of the cathode rays will cast a sharp shadow.
(D) Cathode rays have a definite charge to mass ratio.

13. The following graph shows intensity of light, at different wavelengths, emitted by a white-hot metal filament in a light bulb at a temperature of 2500 K.



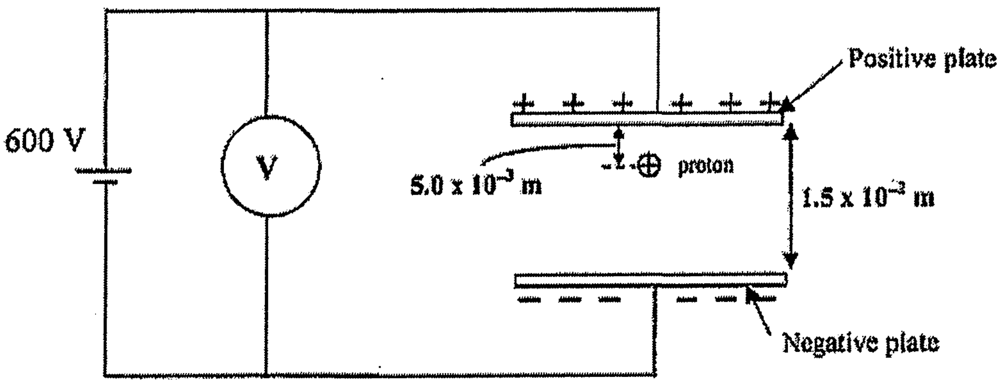
What was Planck's hypothesis to explain this intensity distribution for a black body radiator?

(A) Light emitted and absorbed by black body radiators is in the form of a wave.
(B) Light emitted and absorbed by black body radiators is quantised.
(C) Light emitted and absorbed by black body radiators is a function of the temperature.
(D) Only light above a threshold frequency can be emitted or absorbed by black body radiators.

Questions 14 and 15 refer to the following information:

The diagram below shows a proton between two parallel, charged metal plates. The potential difference between the plates is 600 V and they are 1.5×10^{-2} m apart.

The proton is at a position 5.0×10^{-3} m from the positive (top) plate. The electric charge on a proton is $+1.6 \times 10^{-19}$ C.



14. What is the force on the proton due to the electric field between the plates?

(A) 6.4×10^{-15} N
(B) 6.4×10^{-13} N
(C) 4.0×10^{2} N
(D) 4.0×10^{4} N

15. What is the potential difference between the position of the proton and the negative plate?

(A) 600 V
(B) 400 V
(C) 200 V
(D) 100 V

Part B

Total Marks – 60

Attempt Questions 16-28

Allow about 1 hour and 45 minutes for Part B

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

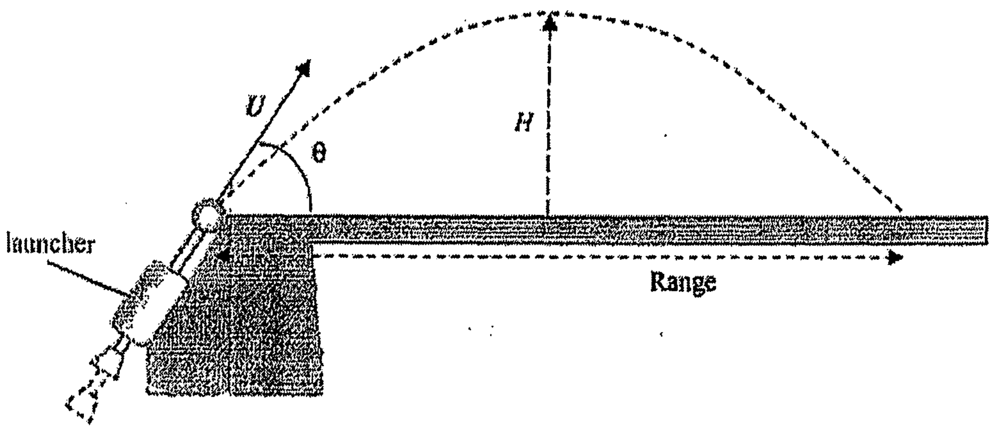
Question 16 (2 Marks) **Marks**

The modern definition of the metre is "the distance travelled by light in a vacuum during 1/299,792,458 of a second." 2

Explain why the modern metre is defined in this way.

Question 17 (6 marks) **Marks**

A boy performs an experiment with the simple projectile launcher shown below, which launches steel balls on a flat surface.



By pulling the spring in the launcher to a fixed distance, the boy gives the ball an initial velocity.

In one test run of the launcher, the boy makes a number of observations about the trajectory of the ball. These are shown in the table below as Test Run A.

Result Table Test Run A

Angle of Launch, θ	30°
Maximum Height, H	0.26 m
Range of Ball	1.80 m

(a) For Test Run A, calculate the magnitude of the initial vertical velocity of the ball. **2**

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(b) For Test Run A, calculate the total time the ball is in the air. **2**

(c) For Test Run A, calculate the magnitude of the initial horizontal velocity of the ball. **2**

Question 18 (6 marks)

The following information was included in a NASA press release of 13 June 2005:

> **Astronomers Announce the Most Earth-Like Planet Yet Found Outside the Solar System.**
>
> Taking a major step forward in the search for Earth-like planets beyond our own solar system, a team of astronomers has announced the discovery of the smallest extra-solar planet yet detected. "We keep pushing the limits of what we can detect and we're getting closer and closer to finding Earths," said team member Steven Vogt, a Professor of astronomy and astrophysics at the University of California, Santa Cruz.
>
> The newly discovered "Super Earth" orbits the star Gliese 876, located just 15 light years away in the direction of the constellation Aquarius. The team measured the mass of the planet to be 5.9 Earth masses, and its radius to be 2.2 times that of the Earth. It orbits Gliese 876 with a period of 1.94 days at a distance of 3.15×10^9 m.

Use the information contained in the passage above to answer the following questions:

(a) Calculate the acceleration due to gravity at the surface of the planet. **2**

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(b) Compare the escape velocity of the planet to that of the Earth. **2**

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(c) Calculate the mass of the star, Gliese 876. **2**

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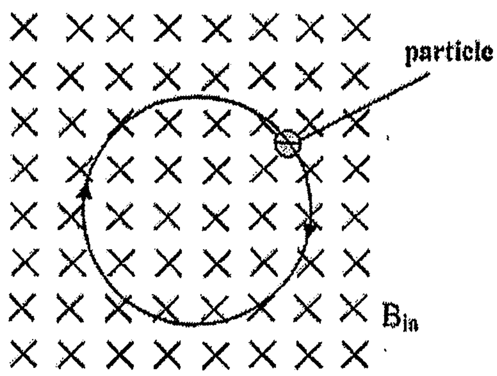
Question 19 (6 marks) **6**

The Michelson-Morley experiment attempted to measure the velocity of the Earth through the aether. Describe the procedure used and evaluate the reliability of the result.

Question 20 (4 marks)

The diagram below illustrates the path of a negatively charged particle moving in a magnetic field. The magnetic field is directed into the page.

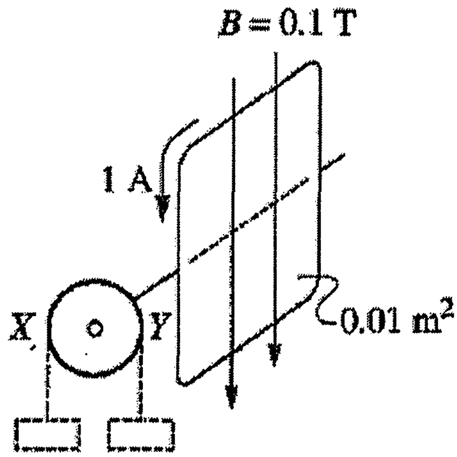


(a) Explain why the path of the particle is circular. **2**

(b) Explain what would happen to the radius of the path if a negatively charged particle of the same mass and speed, but twice the charge is travelling in the same magnetic field. **2**

Question 21 (4 marks) **Marks**

A simple motor consists of a flat rectangular coil with *n* turns in a magnetic field *B* as shown. 4



The coil has an area of 0.01 m^2 and carries a current of 1 A. The motor drives a pulley of diameter 20cm and weights can be hung from either side of the pulley at point X or point Y.

(a) In order to prevent rotation, should a weight be hung at point X or at point Y? Justify your answer. 1

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(b) What is the magnitude of the torque provided by a mass of 0.2kg suspended from either point X or point Y? 2

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(c) If the motor is just stopped by a mass of 0.2kg how many turns does the coil have? 1

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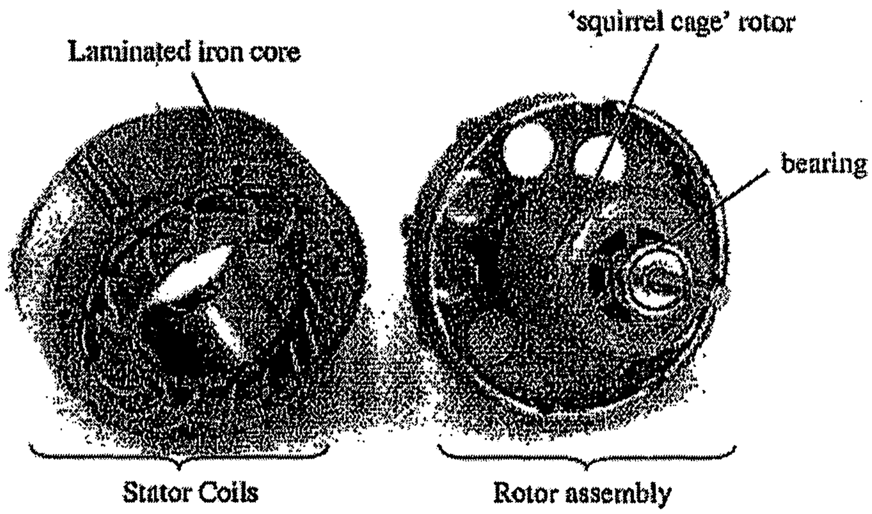
Question 22 (3 marks)

An electricity transmission line consists of two wires separated by 4.0 metres and the towers supporting the wires are 200 metres apart. Each wire is carrying a current of 1.78×10^2 A. The currents are flowing in opposite directions.

Determine the magnitude and direction of the force per metre exerted by each current on the other. **3**

Question 23 (5 marks) **Marks**

The photograph below shows the parts of an AC electric motor.



(a) Outline the function of the stator coils in this motor. **2**

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(b) Describe the principle of operation of the type of motor illustrated above. **3**

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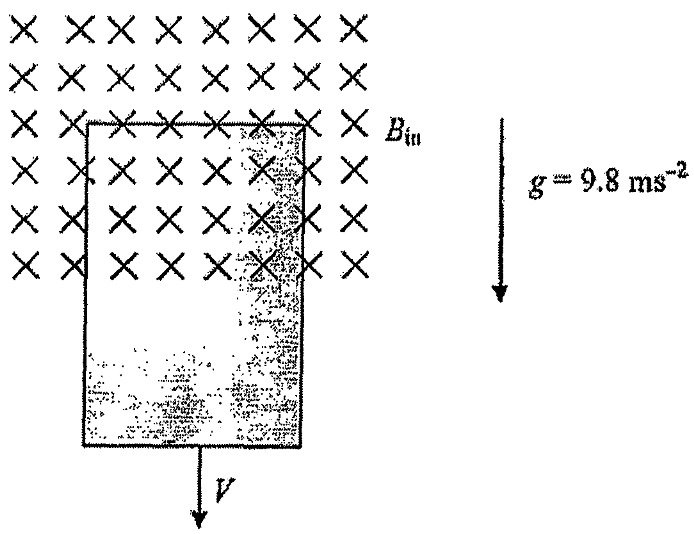
Question 24 (5 marks)

The following diagram shows an aluminium sheet dropping, under the influence of gravity, between the poles of a strong permanent magnet. At the position shown, the sheet has an instantaneous velocity, *V*, and is dropping out of the field. Only the top half of the sheet remains between the poles of the magnet.



(a) On the diagram above, draw in the eddy current that is generated in the sheet, showing both the position and the direction of the current. **2**

(b) Explain, in terms of the physical principles involved, the production of eddy currents in the sheet and their effect on the subsequent motion of the sheet. **3**

Question 25 (3 marks)

Heinrich Hertz performed an experiment where he measured the speed of radio waves using the principle of interference of waves produced by a reflection from a metal plate. Outline the significance of the result of this experiment. **3**

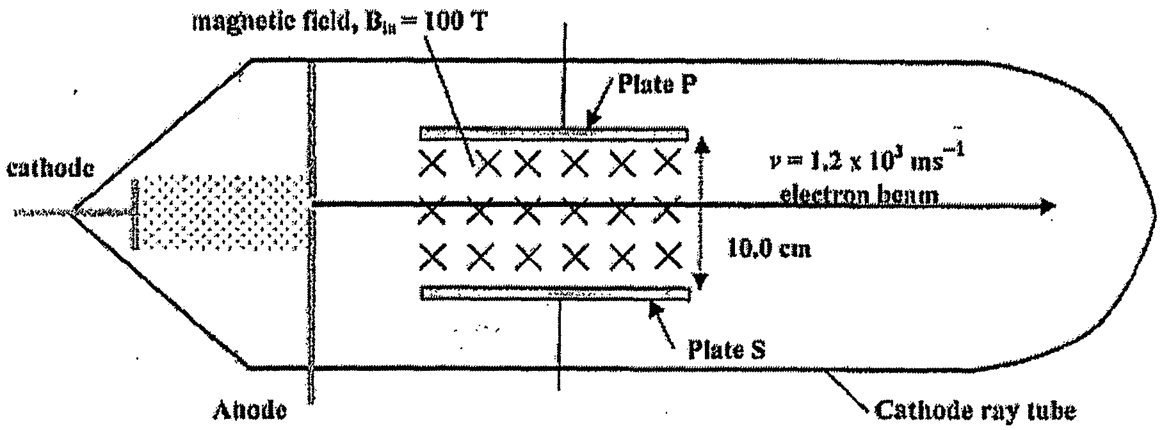
Question 26 (4 marks)

In the early nineteenth century, it was experimentally shown that light had wave properties such as interference and diffraction. However, this classical wave model of light could not be used to explain the observations made in experiments on the photoelectric effect. Use Einstein's reconceptualisation of the model of light to explain why the photoelectric effect will not occur if incident light is below the threshold frequency. **4**

Question 27 (6 marks)

The diagram below shows a thin beam of electrons in a cathode ray tube. The electrons are moving at a velocity, v = 1.2×10^3 ms-1 into a region of magnetic field between two electrically charged deflector plates (P and S). Due to the combined effect of the electric and magnetic fields between plates P and S, the electrons pass undeflected between the plates.

The magnetic field has a magnitude of 100 T.



(a) Determine the magnitude and direction of the force on a single electron due to the magnetic field only. **2**

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(b) Determine the magnitude and direction of the electric field. Show working . **2**

(c) Derive an equation for the velocity of an electron between the deflector plates when the magnetic and electric forces are in balance. **1**

(d) Calculate the potential difference between plates P and S. State which plate is positive. **1**

Question 28 (6 marks) **6**

Explain how energy savings are currently made during the transmission of electricity through power grids and assess the possible use of superconductors in these applications.

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SECTION II

25 Marks

Attempt Question 34 only from Questions 31-35

Allow about 45 minutes for this section.

Answer the question in a writing booklet. Extra writing booklets are available.
Show all relevant working in questions involving calculations.

Question 31	**Elective 1**
Question 32	**Elective 2**
Question 33	**Elective 3**
Question 34	**From Quanta to Quarks**
Question 35	**Elective 5**

Question 34 – From Quanta to Quarks (25 Marks)

(Use the lined paper over leaf for you answers)

(a) Rutherford analysed an experiment where alpha particles where fired at gold foil. From this experiment Rutherford concluded that the atom :

* was mostly free space and
* had a dense positively charged nucleus.

With reference to experimental observations made by Geiger and Marsden, justify Rutherfords conclusions shown above. **(2 marks)**

(b) Bohr described an atomic model where electrons occupied energy levels. Compare the Bohr model to that proposed by Rutherford. **(3 marks)**

(c) State 4 shortcomings(difficulties) of the Bohr model of the atom. **(4 marks)**

(d) Assess the role of the Pauli exclusion principle in explaining one aspect or shortcoming of the Bohr model. **(2 marks)**

(e) Bohr postulated that an atom's angular momentum was quantised and occurred in multiples of $h/2\pi$. Using the de Broglie relation $\lambda = h/mv$, derive an expression to show that angular momentum is quantised. **(2 marks)**

(f) The flowchart represents one model of scientific method used to show the relationship between theory and the evidence supporting it.

Observation
↓
Problem raised
↓
New Hypothesis ← ← ← ←
↓
Experiment to test hypothesis ↑
↓
Collection of data ↑
↓
Analysis of results ↑
↓
Support for hypothesis → → → Lack of support
↓
New theory or law

Discuss de Broglie's "matter wave" model and the evidence supporting it, in terms of the model of Scientific Method shown above. **(2 marks)**

(g) Write the transmutation equations for the following processes; **(4 marks)**

(i) Alpha decay of Uranium 238

(ii) Beta decay of Thorium 234

(h) Calculate the magnitude of the gravitational and electrostatic forces between 2 protons separated by 1.2×10^{-15}. ($F = kq.q/ d^2$, $k = 9 \times 10^9$) **(2 marks)**

(i) Account for the need for the strong nuclear force. **(2 marks)**

Answer sheet for Quanta option **Student number** ....

(a)

(b)

(c)

(d)

---

e)

(f)

(g)

(h) ---

(i) ---

END OF PAPER

Physics

Data Sheet

Charge on the electron, q_e	-1.602×10^{-19} C
Mass of electron, m_e	9.109×10^{-31} kg
Mass of neutron, m_n	1.675×10^{-27} kg
mass of proton, m_p	1.673×10^{-27} kg
Speed of sound in air	340 m s^{-1}
Earth's gravitational acceleration, g	9.8 m s^{-2}
Radius of Earth, R_E	6.4×10^6m
Speed of light, c	3.00×10^8m s^{-1}
Magnetic force constant, $\left[k \equiv \frac{\mu}{2\pi}\right]$	2.0×10^{-7} N A^{-2}
Universal gravitational constant, G	6.7×10^{-11} N m^2 kg^{-2}
Mass of earth	6.0×10^{24} kg
Planck's constant, *h*	6.626×10^{-34} J s
Rydberg's constant, *R* (hydrogen)	1.097 x 107 m^{-1}
Atomic mass unit, *u*	1.661 x $10-^{27}$ kg 931.5 MeV/c^2
1 eV	1.602×10^{-19} J
Density of water, ρ	1.00×10^3 kg m-3
Specific heat capacity of water	4.18×10^3 J kg^{-1} K^{-1}

FORMULAE SHEET

$$v = f\lambda$$

$$I \propto \frac{1}{d^2}$$

$$\frac{v_1}{v_2} = \frac{\sin i}{\sin r}$$

$$E = \frac{F}{q}$$

$$R = \frac{V}{I}$$

$$P = VI$$

$$Energy = VIt$$

$$v_{av} = \frac{\Delta r}{\Delta t}$$

$$a_{av} = \frac{\Delta v}{\Delta t} = \frac{v-u}{t}$$

$$\sum F = ma$$

$$F = \frac{mv^2}{r}$$

$$E_k = \frac{1}{2}mv^2$$

$$W = Fs$$

$$p = mv$$

$$Impulse = Ft$$

$$E_p = -\frac{Gm_1m_2}{r}$$

$$F = mg$$

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2}a_y t^2$$

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

$$F = \frac{Gm_1m_2}{d^2}$$

$$E = mc^2$$

$$l_v = l_0\sqrt{1-\frac{v^2}{c^2}}$$

$$t_v = \frac{t_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$m_v = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

$$\frac{F}{l} = k\frac{I_1 I_2}{d}$$

$$F = BIl\sin\theta$$

$$\tau = Fd$$

$$\tau = nBIA\cos\theta$$

$$\frac{V_p}{V_s} = \frac{n_p}{n_s}$$

$$F = qvB\sin\theta$$

$$E = \frac{V}{d}$$

$$E = hf$$

$$c = f\lambda$$

$$Z = \rho v$$

$$\frac{I_r}{I_0} = \frac{[Z_2 - Z_1]^2}{[Z_2 + Z_1]^2}$$

$$d = \frac{1}{P}$$

$$M = m - 5\log\left(\frac{d}{10}\right)$$

$$\frac{I_A}{I_B} = 100^{\frac{(m_B - m_A)}{5}}$$

$$m_1 + m_2 = \frac{4\pi^2 r^3}{GT^2}$$

$$\frac{1}{\lambda} = R_H\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$$

$$\lambda = \frac{h}{mv}$$

$$A_0 = \frac{V_{out}}{V_{in}}$$

$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R_i}$$

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79	
	Au	Symbol of element
Atomic Weight	197.0	
	Gold	Name of element

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.39 Zinc	31 Ga 69.72 Gallium	32 Ge 72.61 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.62 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.94 Molybdenum	43 Tc [98.91] Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanides	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.8 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po [210.0] Polonium	85 At [210.0] Astatine	86 Rn [222.0] Radon
87 Fr [223.0] Francium	88 Ra [226.0] Radium	89–103 Actinides	104 Rf [261.1] Rutherfordium	105 Db [262.1] Dubnium	106 Sg [263.1] Seaborgium	107 Bh [264.1] Bohrium	108 Hs [265.1] Hassium	109 Mt [268] Meitnerium	110 Uun — Ununnilium	111 Uuu — Unununium	112 Uub — Ununbium	113	114 Uuq — Ununquadium	115	116 Uuh — Ununhexium	117	118 Uuo — Ununoctium

Lanthanides

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm [146.9] Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.0 Ytterbium	71 Lu 175.0 Lutetium

Actinides

89 Ac [227.0] Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	93 Np [237.0] Neptunium	94 Pu [239.1] Plutonium	95 Am [241.1] Americium	96 Cm [244.1] Curium	97 Bk [249.1] Berkelium	98 Cf [252.1] Californium	99 Es [252.1] Einsteinium	100 Fm [257.1] Fermium	101 Md [258.1] Mendelevium	102 No [259.1] Nobelium	103 Lr [262.1] Lawrencium

Where the atomic weight is not known, the relative atomic mass of the most common radioactive isotope is shown in brackets.
The atomic weights of Np and Tc are given for the isotopes ^{237}Np and ^{99}Tc.

ANSWERS

Part B

Total Marks – 60

Attempt Questions 16-28

Allow about 1 hour and 45 minutes for Part B

Answer the questions in the spaces provided

Show all relevant working in questions involving calculations.

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

Question 16 (2 Marks) **Marks**

The modern definition of the metre is "the distance travelled by light in a vacuum during 1/299,792,458 of a second." 2

Explain why the modern metre is defined in this way.

2 MARKS
- Identifies that "c" is constant for all observers regardless of relative position or motion

OR

- Identifies that light travels the same distance in a given time for all observers (in any inertial frame) ∴ it is a standard that can be reproduced anywhere

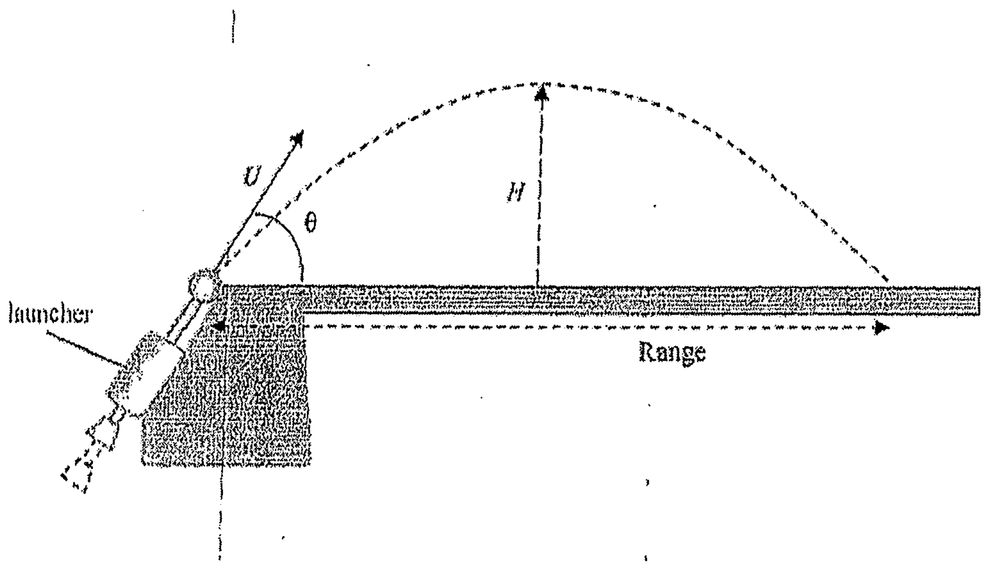
1 MARK
- Some attempt

AND/OR

- highly accurate
- ease of access
- indestructable
- invariant
- c is a constant value
- can be measured anywhere.

Question 17 (6 marks) **Marks**

A boy performs an experiment with the simple projectile launcher shown below, which launches steel balls on a flat surface.



By pulling the spring in the launcher to a fixed distance, the boy gives the ball an initial velocity.

In one test run of the launcher, the boy makes a number of observations about the trajectory of the ball. These are shown in the table below as Test Run A.

Result Table Test Run A

Angle of Launch, θ	30°
Maximum Height, H	0.26 m
Range of Ball	1.80 m

(a) For Test Run A, calculate the magnitude of the initial vertical velocity of the ball. 2

$u_y = u\sin\theta = u\sin 30 = \frac{u}{2}$

$v_\uparrow^2 = u_\uparrow^2 + 2a_\uparrow s_\uparrow$ $v_\uparrow = 0$ at max ht.

$u_\uparrow = \sqrt{2as}$

1 MARK OR 1 MARK $\rightarrow = \sqrt{2 \times 9.8 \times 0.26\ m}$

$u_\uparrow = 2.26$ m/s

~~$u = 2u_y = 2 \times 2.26 = 4.52$ m/s~~

OR 2 MARKS

(b) For Test Run A, calculate the total time the ball is in the air. **2**

$v = u + at$

$t_{max\,ht} = \frac{v_{\uparrow} - u_{\uparrow}}{a}$

$= \frac{0 - 2.26}{-9.8}$

$= 0.231$ s

$t_{TOT} = 2t_{max\,ht}$

$= 0.46$ s

(c) For Test Run A, calculate the magnitude of the initial horizontal velocity of the ball. **2**

$u_x = u \cos 30$

$= 3.9$ m/s

Question 18 (6 marks)

The following information was included in a NASA press release of 13 June 2005:

> **Astronomers Announce the Most Earth-Like Planet Yet Found Outside the Solar System.**
>
> Taking a major step forward in the search for Earth-like planets beyond our own solar system, a team of astronomers has announced the discovery of the smallest extra-solar planet yet detected. "We keep pushing the limits of what we can detect and we're getting closer and closer to finding Earths," said team member Steven Vogt, a Professor of astronomy and astrophysics at the University of California, Santa Cruz.
>
> The newly discovered "Super Earth" orbits the star Gliese 876, located just 15 light years away in the direction of the constellation Aquarius. The team measured the mass of the planet to be 5.9 Earth masses, and its radius to be 2.2 times that of the Earth. It orbits Gliese 876 with a period of 1.94 days at a distance of 3.15×10^9 m.

Use the information contained in the passage above to answer the following questions:

(a) Calculate the acceleration due to gravity at the surface of the planet. 2

$g = \frac{GM}{r^2}$

$= \frac{6.67\times10^{-11} \times 5.9 \times 6\times10^{24}}{(2.2\times 6300 \times10^3)^2}$

$= \frac{2.36\times10^{15}}{(1.386\times10^7)^2}$

$= 12.29$ m/s²

(11.96)

(b) Compare the escape velocity of the planet to that of the ~~Earth.~~ 2

$V_{E\ \text{planet}} = \sqrt{\frac{GM\times2}{r}}$

$= \sqrt{\frac{6.67\times10^{-11}\times5.9\times6\times10^{24}\times2}{13\,860\times10^3}}$

$= \sqrt{\frac{4.72236\times10^{15}}{13\,860\times10^3}}$

$= 18,460$ m/s

* some calc. +/or compare in words. (1)

(c) Calculate the mass of the star, Gliese 876. 2

$\frac{GM}{4\pi^2} = \frac{r^3}{T^2}$

$M = \frac{r^3\times4\pi^2}{G\times T^2}$

$= \frac{(3.15\times10^9)^3\times4\pi^2}{6.67\times10^{-11} \times (1.94\times24\times60\times60)^2}$ ~~× 1.94 × 86400~~

$= \frac{1.23393\times10^{30}}{\text{~~1.179987×10^{-5}~~}\ 1.88}$

~~= 1.104 × 10^35~~ kg

$= 6.56\times10^{29}$ kg

Question 19 (6 marks) 6

Describe the procedure used and evaluate the reliability of the result.

The Michelson-Morley experiment attempted to measure the velocity of the Earth through the aether. ~~Evaluate the significance of this experiment to the aether model of light.~~

NB - 3 Marks for the description AND 3 Marks for evaluation of reliability

3 Marks

* Gives an outline of the experiment and the interferometer
* States outcome as a NULL RESULT & explains OR, that no change in interference pattern was observed

3 Marks

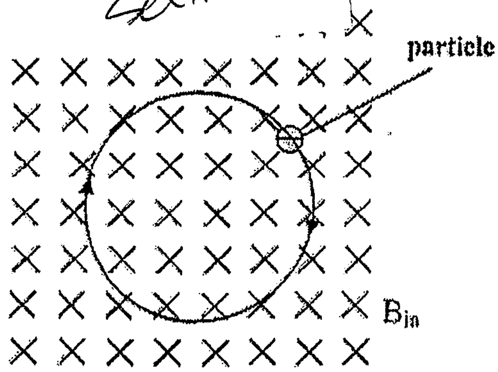
* Describes aspects of procedure related to reliability i.e. repeating experiment many times over several months
* Makes a judgement that reliability was good due to sound methodology.

↳ Many repititions giving consistent results

Question 20 (4 marks)

BW'S ANSWER SCHEME

The diagram below illustra[…] arged particle moving in a magnetic field. The magnetic field i[…]



(a) Explain why the path of the particle is circular. **2**

2 MARKS – CLEARLY EXPLAINS THAT THE PARTICLE EXPERIENCES A CENTRIPETAL FORCE BECAUSE THE MAGNETIC FIELD EXERTS A FORCE PERPENDICULAR TO THE MOTION OF THE CHARGED PARTICLE. i.e. $qvB = \frac{mv^2}{r}$

1 MARK – SOME PART OF ABOVE

(b) Explain what would happen to the radius of the path if a negatively charged particle of the same mass and speed, but twice the charge is travelling in the same magnetic field. **2**

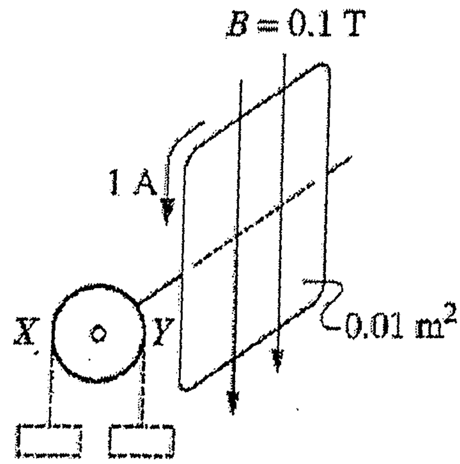
2 MARKS EXPLAINS THAT BECAUSE $r = \frac{mv}{qB}$ $r \propto \frac{1}{q}$

THEREFORE RADIUS DECREASES TO ½ OF PREVIOUS

1 MARK QUALITATIVE STATEMENT THAT RADIUS DECREASES ONLY

Question 21 (4 marks) **Marks**

A simple motor consists of a flat rectangular coil with *n* turns in a magnetic field *B* as shown. 4



The coil has an area of 0.01 m^2 and carries a current of 1 A. The motor drives a pulley of diameter 20cm and weights can be hung from either side of the pulley at point X or point Y.

(a) In order to prevent rotation, should a weight be hung at point X or at point Y? Justify your answer. 1

1 MARK CORRECT ANSWER AND JUSTIFICATION

EG. — X, BECAUSE THE COIL MOVES CLOCKWISE DUE TO THE MOTOR EFFECT.

(b) What is the magnitude of the torque provided by a mass of 0.2kg suspended from either point X or point Y? 2

$\tau = Fd$

$= mgd$

$= 0.2 \times 9.8 \times 0.1$

$= 0.196$ Nm

2 MARKS CORRECT SUBSTITUTION ANSWERS AND UNITS

1 MARK AS ABOVE BUT INCORRECT UNITS

(c) If the motor is just stopped by a mass of 0.2kg how many turns does the coil have? 1

$\tau = nBIA$ $\therefore n = \frac{0.196}{0.1 \times 1 \times 0.01}$

$n = \tau / BIA$ $= 196$ Turns

1 MARK - CORRECT ANSWER

Question 22 (3 marks)

An electricity transmission line consists of two wires separated by 4.0 metres and the towers supporting the wires are 200 metres apart. Each wire is carrying a current of 1.78 x 10^2 A. The currents are flowing in opposite directions.

Determine the magnitude and direction of the force per metre exerted by each current on the other. **3**

$$\frac{F}{l} = \frac{k I_1 I_2}{d}$$

$$= \frac{2 \times 10^{-7} \times (1.78 \times 10^2)^2}{4}$$

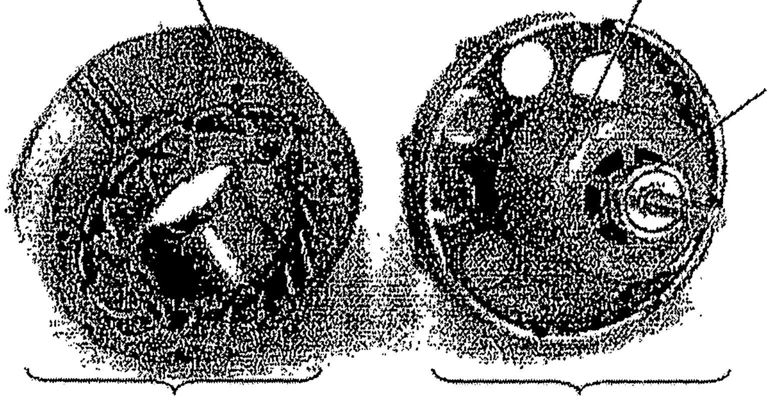
$$= 1.6 \times 10^{-3} \text{ Nm}^{-1} \text{ repulsion}$$

MAGNITUDE UNITS DIRECTION

1 MARK EACH

Question 23 (5 marks) **Marks**

The photograph below shows the parts of an AC electric motor.



(a) Outline the function of the stator coils in this motor. 2

2 MARKS - CORRECTLY INICATES MAIN FEATURES E.G. THE STATOR PROVIDES AN EXTERNAL MAGNETIC FIELD FOR THE ROTOR. THIS MAGNETIC FIELD ROTATES/MOVES TO PRODUCE A TORQUE. 1 MARK - PART OF ABOVE

(b) Describe the principle of operation of the type of motor illustrated above. 3

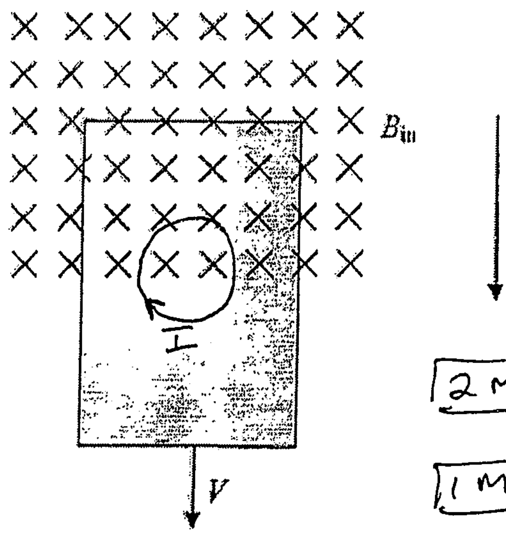
3 MARKS - CLEARLY PROVIDES CHARACTERISTICS AND FEATURES OF THE PRINCIPLE OF OPERATION. E.G. THE AC CURRENT GENERATES A ROTATING MAGNETIC FIELD. THIS INDUCES CURRENT IN THE ROTOR DUE TO FARADAY'S LAW. THE CURRENT IN THE ROTOR PRODUCES A MAGNETIC FIELD THAT INTERACTS WITH THE STATOR'S MAGNETIC FIELD ACCORDING TO LENZ'S LAW. AS THE FIELD'S OPPOSE EACH OTHER THERE IS A TORQUE FORCE ON THE ROTOR. ~~AS THE~~

2 MARKS - MOSTLY CORRECT

1 MARK - PARTLY CORRECT

Question 24 (5 marks)

The following diagram shows an aluminium sheet dropping, under the influence of gravity, between the poles of a strong permanent magnet. At the position shown, the sheet has an instantaneous velocity, V, and is dropping out of the field. Only the top half of the sheet remains between the poles of the magnet.



2 MARKS CORRECT LOCATION AND DIRECTION

1 MARK AS ABOVE BUT DIRECTION INCORRECT

(a) On the diagram above, draw in the eddy current that is generated in the sheet, showing both the position and the direction of the current. 2

(b) Explain, in terms of the physical principles involved, the production of eddy currents in the sheet and their effect on the subsequent motion of the sheet. 3

3 MARKS
- RELATES PRODUCTION OF CURRENTS TO CHANGE IN MAGNETIC FIELD (FARADAY'S LAW)
- RELATES LENZ'S LAW TO EDDY CURRENT PRODUCING MAGNETIC FIELD THAT OPPOSES MOTION ~~BY OPPOSING~~
- DESCRIBES SUBSEQUENT MOTION AS DOWNWARD ACCELERATION $< 9.8\ ms^{-2}$

2 MARKS 2 OF ABOVE

1 MARK 1 OF ABOVE

Question 25 (3 marks)

Heinrich Hertz performed an experiment ~~to~~ where he measure(d) the speed of radio waves using the principle of interference of waves produced by a reflection from a metal plate. ~~Discuss~~ Outline the significance of the result of this experiment. 3

3 MARKS
- Interference effect supported wave model
- The experiment proved Maxwell's predictions to be true : ie E/M waves could exist at many freq. and that all E/M wave propagate at same speed
- That Hertz's radio waves were E/M waves just like light

2 Marks - 2 of above

Question 26 (4 marks)

In the early nineteenth century, it was experimentally shown that light had wave properties such as interference and diffraction. However, this classical wave model of light could not be used to explain the observations made in experiments on the photoelectric effect. Use Einstein's reconceptualisation of the model of light to explain why the photoelectric effect will not occur if incident light is below the threshold frequency. 4

4 Marks
1. Describes Einsteins model of light as applied to the photo electric effect -
   - light photons.
   - $E = hf$
   - all energy given to electron
   - $E_{kmax} = hf - \phi$
2. Specifically applies Einsteins model to explain why no photo current occurs when incident f < threshold freq -

3 MARKS As above but poor use of language or student's explanation or description lacks clarity -

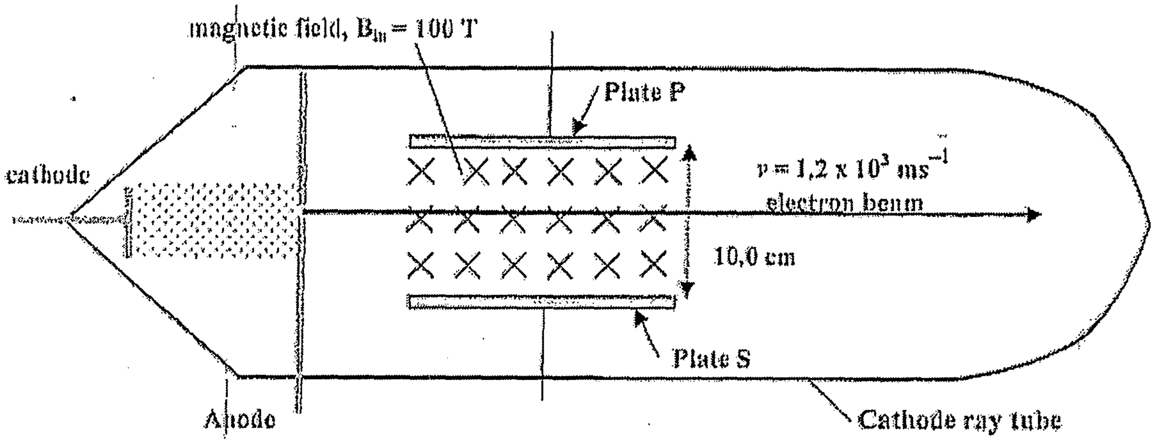
2 MARKS Answer misses one of points given in 4 point answer or answer ~~lacks depth~~

1 MARK - Some attempt.

Question 27 (6 marks)

The diagram below shows a thin beam of electrons in a cathode ray tube. The electrons are moving at a velocity, v = 1.2 x 10^3 ms-1 into a region of magnetic field between two electrically charged deflector plates (P and S). Due to the combined effect of the electric and magnetic fields between plates P and S, the electrons pass undeflected between the plates.

The magnetic field has a magnitude of 100 T.



(a) Determine the magnitude and direction of the force on a single electron due to the magnetic field only. **2**

$F = qvB$

$= 1.6 \times 10^{-19} \times 1.2 \times 10^3 \times 10^2$

$= 1.92 \times 10^{-14}$ N down page

↑ 1 mark ↑ 1 mark

(b) Determine the magnitude and direction of the ~~force on each electron due to the electric field~~ electric field. Show working ~~or explain your answer~~. 2

$F = qE = qvB = 1.92 \times 10^{-14}$

$= 1.6 \times 10^{-19} \times E = 1.92 \times 10^{-14}$

$\therefore E = \frac{1.92 \times 10^{-14}}{1.6 \times 10^{-19}}$

1 Mark → $= 1.2 \times 10^{5}$ V/m

down page – or from P to S — 1 Mark

(c) Derive an equation ~~for the velocity~~ of an electron between the deflector plates when the magnetic and electric forces are in balance. 1

$qE = qvB$

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

(d) Calculate the potential difference between plates P and S. State which plate is positive. 1

$E = \frac{V}{d}$

$V = Ed$

$= 3.2 \times 10^{5} \times 0.1$

$= 1.2 \times 10^{4}$ volts and Plate P is positive

Question 28 (6 marks) 6

Explain how energy savings are currently made during the ~~generation and~~ transmission of electricity through the power grid and assess the possible use of superconductors in these applications.

Divide answer into - current energy savings - 3 MARKS

- assessment of superconduct. applications - 3 Marks

ANSWER SHOULD ADDRESS

For the 1st 3 MARKS - Current E savings in transmission of electricity - Heat loss reduction by use of AC power, transformers and transmission using high V and low I.
- Transformer efficiency is improved using laminated cores to reduce eddy currents reducing E loss through heat radiation. Step up transformers have low I outputs which also reduces heat loss

For 2nd 3 Marks

- Describe how superconductors could be applied - e.g. no heat loss would occur and fewer transformers could be used. Transmission of DC would also be possible.

The answer must make a judgement

e.g. The zero resistance of superconductors reduce energy losses and increase energy savings

ANSWERS

(g) Write the transmutation equations for the following processes; **(4 marks)**

(i) Alpha decay of Uranium 238

(ii) Beta decay of Thorium 234

(h) Calculate the magnitude of the gravitational and electrostatic forces between 2 protons separated by 1.2×10^{-15}. ($F = kq.q/d^2$, $k = 9 \times 10^9$) **(2 marks)**

(i) Account for the need for the strong nuclear force. **(2 marks)**

Answer sheet for Quanta option **Student number ....**

(a) 1 Mark for justifying each part (2 MARKS)

e.g. "Mostly free space" because α particles passed thru Au foil undeflected.

"dense +ve nucleus" because α particles (1 in 10 000 ish) rebounded elastically.

(Accept any reasonable justification)

(b)

3 MARKS – 2 similarities & 1 difference OR VICE VERSA – 1 mk for each part if correct

2 MARKS – 1 correct similarity and 1 correct difference

e.g. Both Bohr and Rutherford had electrons orbitting the nucleus with electrostatic force providing the necessary centripetal force. Bohr's model differed because his model had many possible radii (or E levels) to occupy. Rutherford simply stated that electrons orbit at a large distance from nuclei.

(c)

1 MARK for each correct shortcoming

e.g.s * only works for single e^- atoms

* couldn't explain – intensity variation of emission spectrum

* " " – zeeman effect

* " " – hyperfine splitting

* Uses a combination of classical and quantum ideas.

(d)

for [2 MARKS] – Makes a clear assessment of P.E.P
– Justifies the assessment

e.g. The P.E.P. made a significant and positive contribution as it provided reasons why a limited number of electrons can occupy each E level OR / gave reasons for hyperfine splitting

[1 MARK] – Gives only 1 correct part of the answer above

e) [OPTIONAL]

$n\lambda = 2\pi r$

$n\frac{h}{mv} = 2\pi r$

$\therefore mvr = \frac{nh}{2\pi}$

$\therefore mvr$ (angular momentum) occurs in "n" multiples of the quantity $\frac{h}{2\pi}$

[2 MARKS]

[1 MARK] – Some attempt.

(f)

[2 MARKS] – Answer presents a for and an against argument.

e.g. deBroglie didn't experiment to test his hypothesis so didn't follow the model however later on, Davisson and Germer showed high energy e's form a diffraction pattern when fired at metallic crystals – ie experimental evidence

[1 MARK] If either a for or against argument

(g)

For each part; SUBTRACT 1 MARK (max 2 mks/part) for each error.

(i) $^{239}_{92}U \rightarrow {}^{4}_{2}\alpha + {}^{234}_{90}Th$

(ii) $^{234}_{90}Th \rightarrow {}^{0}_{-1}\beta + {}^{234}_{91}Pa + \bar{\nu}$

(h)

$F_{grav} = \frac{Gm_1m_2}{r^2}$

$= \frac{6.7\times10^{-11} \times (1.67\times10^{-27})^2}{(1.2\times10^{-15})^2}$

$= \frac{1.8685 \times 10^{-64}}{1.44\times10^{-30}}$

$= 1.3\times10^{-34}$ N ATTRACTIVE

$F_{Elect} = \frac{kq_1q_2}{r^2}$

$= \frac{9\times10^{9} \times (1.6\times10^{-19})^2}{1.44\times10^{-30}}$

$= 160$ N REPULSIVE

1 MARK

1 MARK

(Unit Required in One case.)

(i)

2 MARKS

1. Identifies gravitational force much weaker than electrostatic attraction

2. States that another stronger attractive force must be present i.e. strong Nuclear Force.

1 Mark — Correct statement but incomplete or poorly worded.

END OF PAPER