SIG FIG: (A) Penalise 4 marks out of 80. (max) – anything other than 3. (units – max 4 in (A))
(B) 2 marks max. (then no more) (units – 2 marks max)

TEE PHYSICS 1989 DRAFT SOLUTIONS AND KEY

Section A: 1-20 All questions worth $\boxed{4 \text{ marks}}$

Part marks indicated (1)

1a. Yes (1)

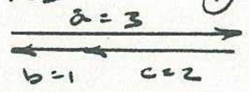
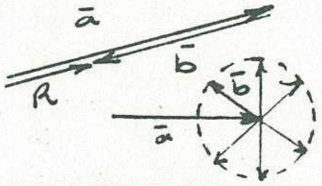


diagram — Reasonable diagram (1)

magnitudes and directions (1)

Resultant $\bar{a} + \bar{b} + \bar{c} = 0$

b. No (1)



Along same line

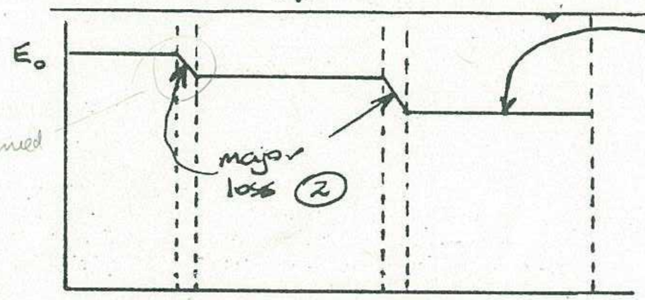
If $\bar{a} \neq \bar{b} \Rightarrow \bar{a} - \bar{b} > 0$ — Reasonable explanation (1)

(1) Range of magnitudes $\bar{a} - \bar{b}$ to $\bar{a} + \bar{b}$

If $\bar{a} > \bar{b}$ $\quad \bar{a} + \bar{b} > 0$

2.

don't need that



zero gradient or at worst gentle slope to show energy loss through air resistance. (2)

STRAIGHT LINE ⇒ FULL MARKS

Heat energy would be absorbed by the ball ⇒ constant energy (straight line)

(Any energy lost to the ground is minimal)

0 MARKS if straight line and rubbish explanation

3. $l = 50.0 \pm 0.5\ \text{mm} = 50.0 \pm 1\%$

$b = 10.0 \pm 0.5\ \text{mm} = 10.0 \pm 5\%$ (1) — Uncertainty

$A = l \times b = 50.0 \times 10.0$ — Add % error.

correct sig. fig gives (2)

$= 5.00 \times 10^2\ \text{mm}^2$

$= 5.00 \times 10^{-4}\ \text{m}^2$ (1) — $\pm 6\%$. (1)

Full marks for — Just the answer – (4)

$500 \pm 30\ \text{mm}^2$

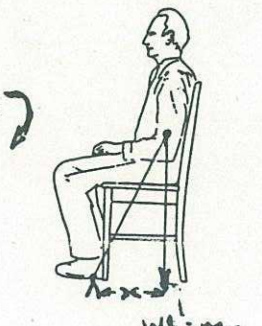
or $(5.00 \pm 0.30) \times 10^2\ \text{mm}^2$ or $(5.00 \pm 0.30) \times 10^{-4}\ \text{m}^2$

or $5.00 \times 10^2\ \text{mm}^2 \pm 6\%$ — (1) for any reasonable expression.

4. The torque or turning effect of the weight force acts to return the sitting position (2) unless that person's centre of gravity is over or forward of the pivot point at the foot (2)

(Use judgement interpreting diagram / Torque = mg x

Body rotates



5. $Ft = mv - mu$ ①

$F = \frac{m}{t}(v-u)$

$= \frac{m}{t}(-v-v)$ ①

But $s = \frac{m}{t}$ — ①

$\therefore F = -2sv$ ①

Thus magnitude of the force $= \underline{2sv}$

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6 $F = ?$

$m = 1.05 \times 10^3$ kg

$v = \frac{1000}{3600} \times 90.0 \text{ m s}^{-1}$

$= 25.0 \text{ m s}^{-1}$ ①

$r = 80.0$ m

$F_c = \frac{mv^2}{r}$ ①

$= \frac{1.05 \times 10^3 \times 25.0^2}{80.0}$

$= 8.20 \times 10^3$ N ①

$Wt = mg = 1.05 \times 10^3 \times 9.80$ N

$= 10.29 \times 10^3$ N

$\therefore$ Reaction force $= Wt - F_c = 10.29 \times 10^3 - 8.20 \times 10^3$

$= \underline{2.09 \times 10^3 \text{ N}}$ up ① No penalty for omitting up.

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7. The movement of a non-conducting substance over another (petrol over rubber) can produce a buildup of static electricity or charge. ②

Mention how the charge is built up — ①

The conducting wire allows continuous discharge and hence reduces/avoids the possibility of sparking (arcing) which could result in an explosion (fire) ① ①

Conducts static electricity to earth without sparking - full marks. (no mention of sparks/explosion ③

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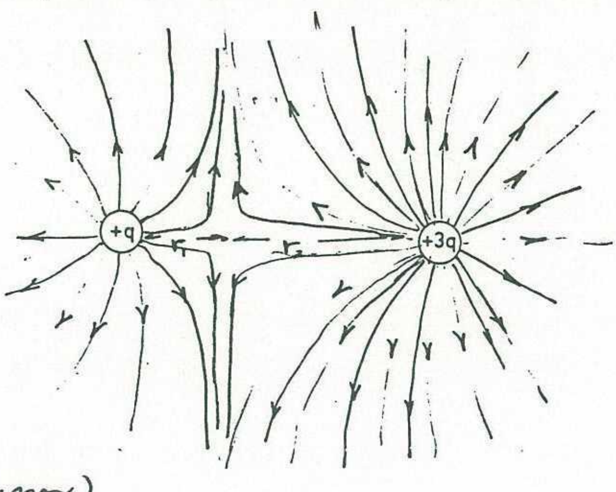
8. • Lines symmetrical
• Field direction away from positive.
• Zero field position closer to +q than +3q ($r_2 = \sqrt{3}\, r_1$)
• Field lines more dense around +3q
• Field lines leave perpendicularly to surfaces (approx)

④ for all 5 - ① off for each missing.



$W = Vq \Rightarrow$ no marks.

9. $V = 1.30 \times 10^{6}\ V$

$q = 1.60 \times 10^{-19} \times 1.00 \times 10^{6} = 1.60 \times 10^{-13}\ C$ ①

$P = \frac{W}{t} = \frac{qV}{t}$ ① $= \frac{1.60 \times 10^{-19} \times 1.00 \times 10^{6} \times 1.30 \times 10^{6}}{1}$

$= \underline{2.08 \times 10^{-7}\ W} = 0.208 \times 10^{-6}\ W = 0.208\ \mu W$

numerical value ① correct units ①

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10. $I = q/t$ ① $= \frac{15.0}{3.00} = 5.00\ A$ ①

$R = V/I$ ① $= \frac{4.50}{5.00} = \underline{0.900\ \Omega}$ ①

11a. The movement of the magnet into the coil ① induces a current in the coil. The current induced is in a direction such that it produces a magnetic field in the coil which opposes the movement of the magnet.① Work must be done to overcome this repulsive force ①

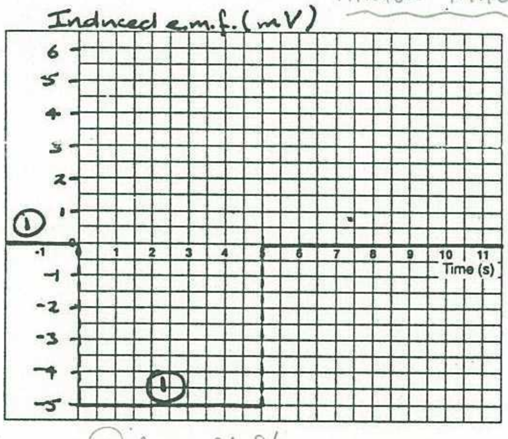
Work done to heat the resistor

-3

b. Mechanical (kinetic) energy
→ Electrical energy (induced e.m.f.)
→ Heat energy (or ohmic losses in coil/resistor). ①

12

MIRROR IMAGE OK



① before + after – zero.

① for constant.

$\phi_1 = BA = .300 \times 1.00 \times 10^{-4}$

$= 3.00 \times 10^{-5}\ Wb$

$\phi_2 = 8.00 \times 10^{-5}\ Wb$

$\mathcal{E} = -N \frac{\Delta\phi}{\Delta t}$

$= \frac{-\cancel{500}\ 100\ (8.00 - 3.00) \times 10^{-5}}{\cancel{500}}$

$= -5.00 \times 10^{-3}\ V$ ① for value

① Axes (reasonable labelling)

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13 Atoms of an element that have different numbers of neutrons are called isotopes of that element ②

or Two or more nuclides having an identical atomic number (nuclear charge / number protons) but differing in atomic mass

Carbon always has 6 protons but has 6 neutrons in ${}^{12}_{6}C$ or 8 neutrons in ${}^{14}_{6}C$. ②

14 • Curved paths of α and β with γ (if shown) straight

no γ O.K.

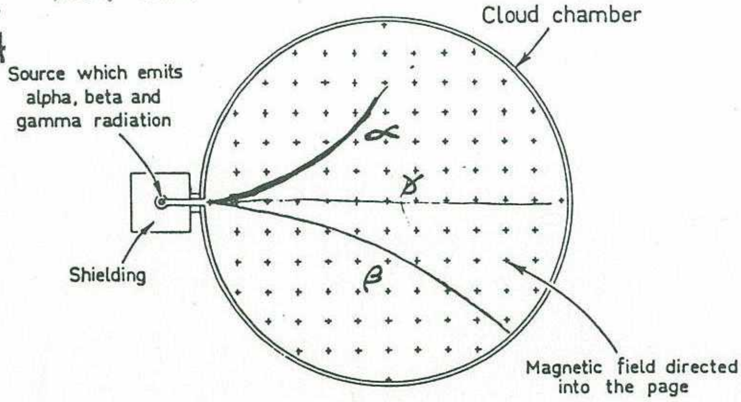
• α heavy, β medium, γ little or none

• α upwards

• β downwards

④ for all points

① off for each wrong



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15. $E_2 - E_1 = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_2}$ ① $= hc\left(\frac{1}{\lambda_1} - \frac{1}{\lambda_2}\right)$ ①

$= 6.63 \times 10^{-34} \times 3.00 \times 10^{8}\left(\frac{1}{589.0\times10^{-9}} - \frac{1}{589.6\times10^{-9}}\right)$

$= 1.989 \times 10^{-25} (1697792.9 - 1696065.1)$

$= 1.989 \times 10^{-25} \times 1727.7$

$= 3.44 \times 10^{-22}$ J ①

$= 2.15 \times 10^{-3}$ eV − ①

16a. $n = \frac{1}{\sin\theta_c}$ ① $= \frac{1}{\sin 27.0^\circ} = \frac{1}{0.45399}$

$\therefore n = \underline{2.20}$ ①

b. Total internal reflection occurs for 27° → 90° unlike glass 41° → 90° ∴ A greater probability for internal reflection with diamond

Also greater dispersion of the visible wavelengths

More light "trapped" and range of colours ②

For anything that is reasonable (difficult to verbalise).

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17. $W = qV$ or $V = W/q$ ⇒ $1\,V = 1\,JC^{-1}$

$\therefore Vm^{-1} = JC^{-1}m^{-1}$ or use dimensional analysis with M, L, T, Q.

but $1\,J = 1\,Nm$

$\therefore Vm^{-1} = N\cancel{m}C^{-1}\cancel{m^{-1}}$

$= NC^{-1}$

Use judgement ④

No marks for the formulae or statements!

Be liberal!

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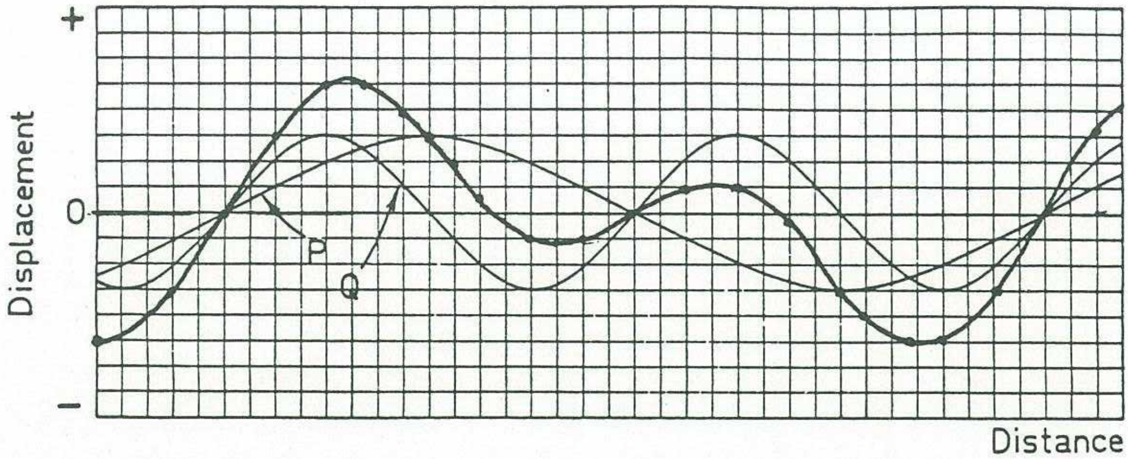
18. 1 Coil contracts: ① Coil consists of parallel wires carrying current in the same direction. Magnetic field produced causes wires to attract ①

2 Coil base ① swings to north or south: Magnetic field induced in the coil has north or south pole at its lower end. This swings in the Earth's magnetic field.... ①

Any reasonable effect and explanation. (Twisting is due to contraction of coil)

Induced current in the stand causing attraction − ①

19.



"Perfect" 4 Obviously knows principle but "sloppy" 3
Only odd point correct 1 Otherwise 0

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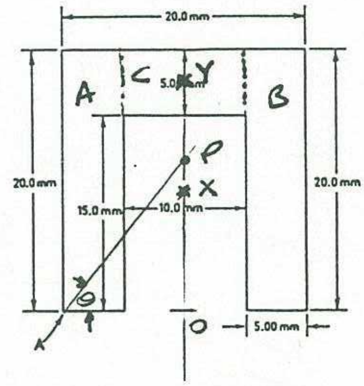
20. c of m A and B together is X
mass of A and B together = 200 units.
c of m of C is Y
mass of C = 50 units



$$P = \frac{200 \times 10 + 50 \times 17.5}{200 + 50}$$

$$= \frac{2000 + 875}{250}$$

$$= \underline{11.5 \text{ mm}}$$

Coordinates with reference to A

$(x, y) = (10.0 \text{ mm}, 11.5 \text{ mm})$

or Relative to A $= \sqrt{10^2 + 11.5^2}$

$= \sqrt{232.25}$

$= 15.2 \text{ mm at } 49.8° \text{ to AO}$

or 10.0 mm along and 11.5 mm up.

1 Some attempt to show P
(on centre line and above X)

On centre line 1
1.5 mm from X between X and Y 2
(i.e. correct location of c of m).
Correct reference to A 1

Section A: 21-30 All questions recorded $\boxed{\text{1 or 0 marks}}$

21	22	23	24	25	26	27	28	29	30
D	A	C	E	B	C	B	C	D	C

Section B

[2] 1 a. System is in equilibrium

Moments about B

$\Sigma M = 0$ or CWM = ACWM

$(0.500)(98.0) = (0.250)(F_A)$ Nm

$F_A = \underline{196 \text{ N}}$ ①

Force of peg A on plank = $\underline{1.96 \times 10^2 \text{ N downwards}}$ ①

① for downwards

[2] b. Either $\Sigma F_{upwards} = \Sigma F_{downwards}$

$F_B = 196 + 98 = \underline{2.94 \times 10^2 \text{ N upwards}}$

or Moments about A

CWM = ACWM

$(0.750)(98) = (0.250)(F_B)$ Nm.

$F_B = \dfrac{98 \times 0.750}{0.250}$

① for upwards

$= \underline{2.94 \times 10^2 \text{ N upwards}}$ ① ①

[1] c Apply Newton's Third Law

Force of plank on peg A = 1.96×10^2 N upwards ①

[1] d. Force of plank on peg B = 2.94×10^2 N downwards ①

Any direction not specified (½) off.

Each time or only once? Round off to nearest whole number.

$\boxed{\text{6 TOTAL}}$

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[3] 2 a $F_{AB} = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1 q_2}{r^2}$ ①

$= \dfrac{1}{4\pi \times 8.85\times10^{-12}} \; \dfrac{3.00\times10^{-6} \times 3.00\times10^{-6}}{0.0500^2} = 32.37 \text{ N}$

$F_{AC} = 32.37$ N ①

See diagram over

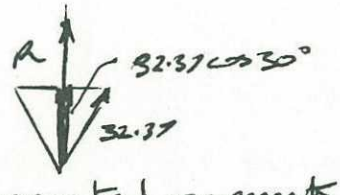
$R^2 = 32.37^2 + 32.37^2 - 2(32.37)(32.37)(\cos 120°)$

$= 2095.7 + 1047.8$

$= 3143.5$

$\therefore R = \underline{56.1 \text{ N upwards as shown}}$ ①

OR



As horizontal components cancel

$R = 2 \times 32.37 \cos 30°$

$= 56.1$ N upwards.

[2] b. $E = \dfrac{F}{q}$ ①

$= \dfrac{56.1}{3.00\times10^{-6}} = 1.87\times10^7 \text{ NC}^{-1}$ upwards

$= \underline{18.7 \times 10^6 \text{ NC}^{-1} \text{ upwards}}$. ①

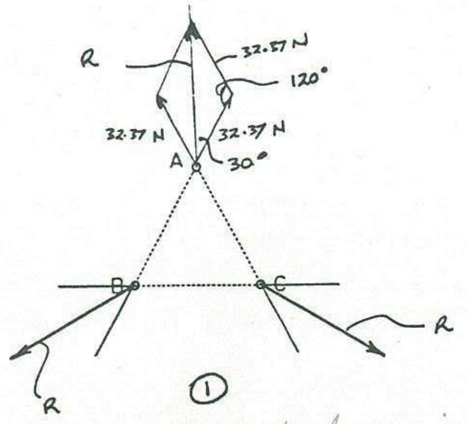
or (over)

Use

$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}$

etc.

[1] c.



(1)

Needs to be precise

6 TOTAL

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2 [1] 3.a. $E = h\nu = \frac{hc}{\lambda}$ I + no reason – (1)

$\Rightarrow$ Highest energy has shortest wavelength

$\therefore$ I is most likely to eject electrons (2) (1)

Mention of highest energy O.K. (disregard)

[3] b. Energy in = ϕ + Energy photoelectron

$h\nu = \phi + E_k$ (1)

$\phi = h\nu - E_k$

$= 6.63\times10^{-34} \times 7.14 \times 10^{14} - 0.480 \times 10^{-19}$ (1)

$= 4.734 \times 10^{-19} - 0.480 \times 10^{-19}$

$= 4.25 \times 10^{-19}$ J (1)

$(= 2.65 \text{ eV})$

[2] c. $E_{III} = h\nu$

$= 6.63\times 10^{-34} \times 5.28 \times 10^{14}$

$= 3.50 \times 10^{-19}$ J (1)

This is less than the work function

$\Rightarrow$ will not have sufficient energy to eject electrons. (1)

6 TOTAL

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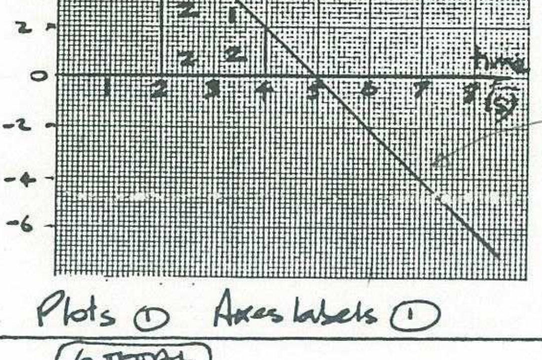
[2] 4.a.

t	0	5	6	8
I	10	0	-2	-6



TAKE (1) OFF

[2] b. $q = It$ = area under graph (1)

$= (\frac{1}{2}\times4\times2)+(2\times2) = 4+4$

$= 8.00$ C (1)

[2] c Power = VI (1)

At t = 5.00 s I = 0.00

$\therefore$ Zero power generated when t = 5.00 s (1)

Plots (1) Axes labels (1)

ZERO – (2)

6 TOTAL

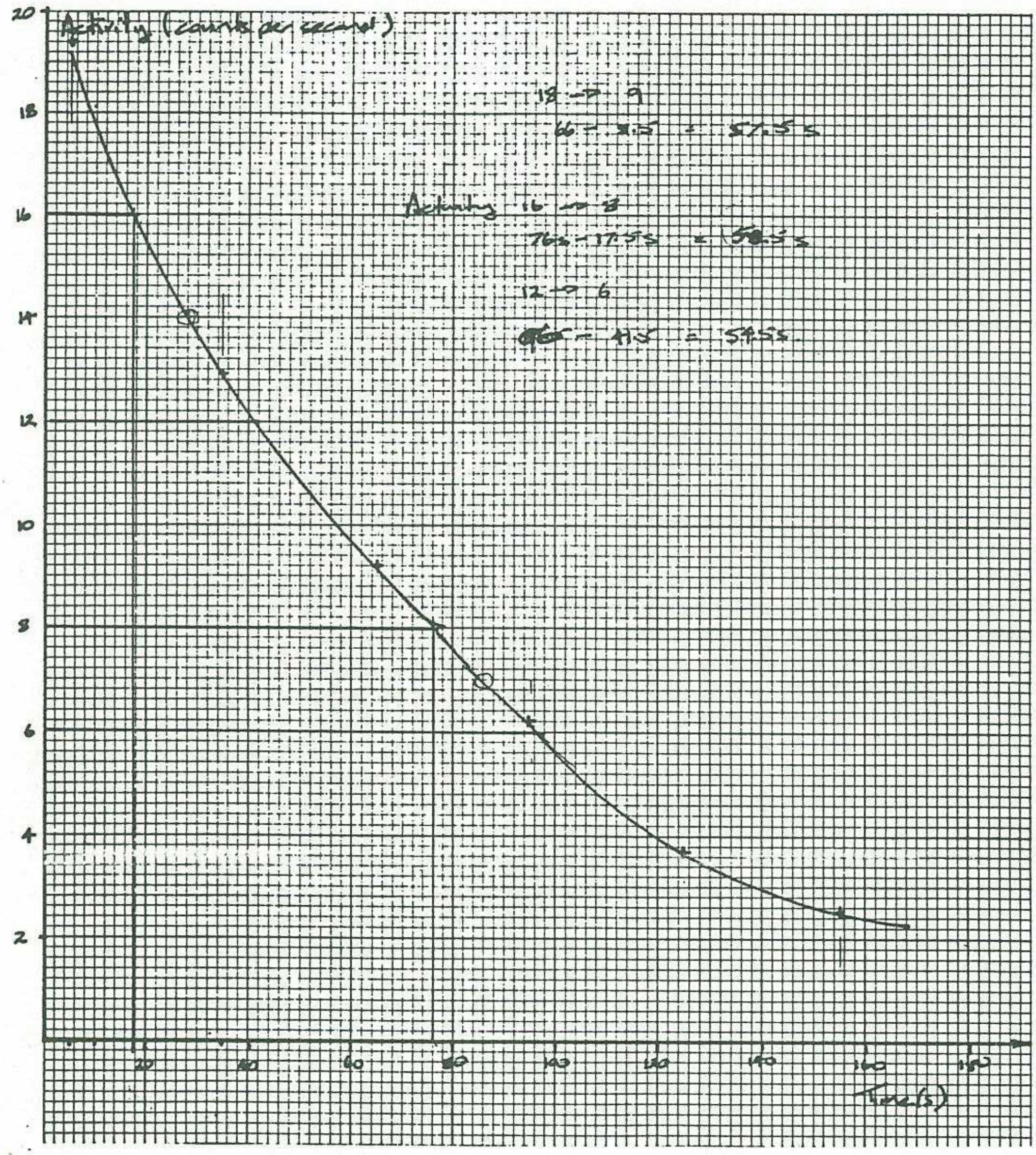
15 5a. 96 counts per minute => 16 counts per 10 s. ~~1~~

Time intervals (s)	0–10	30–40	60–70	90–100	120–130	150–160
Total counts in each 10·0 s interval	210	145	108	78	53	41
Corrected counts in 10.0 s	194	129	92	62	37	25
Activity per sec.	19.4	12.9	9.2	6.2	3.7	2.5

} MISS THIS - load 2

Analysis of data

2



Plots

1 for mid-point

+ 1

Axes labels

1

12 b. Half life 2

From graph or other

Range ~~52~~ 45 s − 60 s.

1 for method if incorrect

7 TOTAL.

$\boxed{3}$ 6a. Energy of emitted alpha particle

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

$4.60 = \frac{1}{2} \times 4.00u \times v^2$

$\therefore v^2 = \dfrac{2 \times 4.60 \times 1.602 \times 10^{-19} \times 10^6}{4.00 \times 1.660 \times 10^{-27}}$ (1)

$v^2 = 2.2183 \times 10^{14}\ m^2 s^{-2}$

$v = 1.49 \times 10^7\ m s^{-1}$ (1)

$\boxed{2}$ b. Momentum is conserved

$P_{before} = P_{after}$

$0 = m_\alpha V_\alpha + m_{Th} V_{Th}$ (1)

$0 = (4 \times \cancel{u} \times 1.49 \times 10^7) + (231 \times \cancel{u} \times V_{Th})$

$V_{Th} = \dfrac{-4 \times 1.49 \times 10^7}{231}$

$= 2.58 \times 10^5\ m s^{-1}$

Recoil speed is $\underline{2.58 \times 10^5\ m s^{-1}}$ (1)

$\boxed{2}$ c. $E_{kTh} = \frac{1}{2}mv^2$

$= \frac{1}{2} \times 231 \times 1.660 \times 10^{-27} \times (2.58 \times 10^5)^2$

$= 1.28 \times 10^{-14}\ J$ (1)

$= \dfrac{1.28 \times 10^{-14}}{1.602 \times 10^{-19}} = 7.97 \times 10^4\ eV$

$= \underline{0.0797\ MeV}$ (1)

0.0799 MeV possible?

$\boxed{7\ \text{TOTAL}}$

$\boxed{3}$ 7a

$B = 0.200\ T$

$V = 20.0 \times 10^3\ V$

$q = 1.602 \times 10^{-19}\ C$

$m_e = 9.11 \times 10^{-31}\ kg$

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

$\therefore v^2 = \dfrac{2qV}{m_e}$

$= \dfrac{2 \times 1.602 \times 10^{-19} \times 20.0 \times 10^3}{9.11 \times 10^{-31}}$ (1)

$= 7.034 \times 10^{15}$

$v = 8.39 \times 10^7\ m s^{-1}$ (1)

direction not required

$F = qvB$

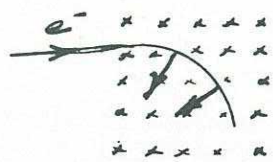
$= 1.602 \times 10^{-19} \times 8.39 \times 10^7 \times 0.200$

$= 2.6872 \times 10^{-12}\ N$

$a = \dfrac{F}{m} = \dfrac{2.6872 \times 10^{-12}}{9.11 \times 10^{-31}}$

$= \underline{2.95 \times 10^{18}\ m s^{-2}}$ no direction needed (1) this is the important point.

[1] b. The force is always perpendicular to the direction of motion (velocity) and constant because magnitude of v and B do not alter (1)



[3] c.

$$F_{cent} = F_{mag}$$

$$\frac{mv^2}{r} = qvB \quad (1)$$

$$r = \frac{mv}{qB}$$

But $T = \frac{dist}{vel} = \frac{2\pi r}{v} = \frac{2\pi m \cancel{v}}{\cancel{v} qB} = \frac{2\pi m}{qB}$ (1)

$$= \frac{2\pi \times 9.11 \times 10^{-31}}{1.602 \times 10^{-19} \times 0.200}$$

$$= \underline{1.79 \times 10^{-10} \text{ s}} \quad (1)$$

7 TOTAL

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[1] 8a. The globe (filament) is placed at the principal focus of the thick lens. (1)

[3] b. $u + v = 2.40$ m $\qquad \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ (1)

$v = 2.40 - u \qquad \frac{1000}{35} = \frac{1}{u} + \frac{1}{2.4-u}$

$f = 0.035$ m

$$\frac{1000}{35} = \frac{2.4 - u + u}{u(2.4-u)} = \frac{2.4}{u(2.4-u)}$$

$u = \frac{-b \pm \sqrt{b^2-4ac}}{2a} \qquad \therefore 2400u - 1000u^2 = 84$ (1)

$$1000u^2 - 2400u + 84 = 0$$

$$u = \frac{2400 \pm \sqrt{5760000 - 336000}}{2000}$$

Using $\frac{1}{2.40}$ instead of $\frac{1}{2.40-u}$ to get answer − (1)

$$= \frac{2400 \pm 2328.9}{2000}$$

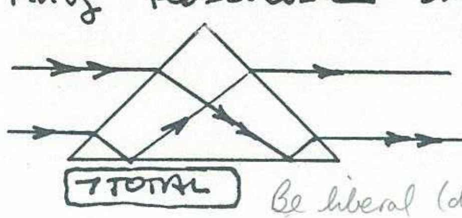
$$= 0.0355 \text{ m}$$

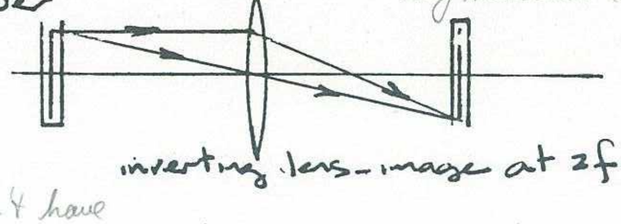
$$= \underline{35.5 \text{ mm}} \quad (1)$$

[2] c Chromatic aberration (1) caused by dispersion into colours because different wavelengths are refracted by different amounts (bubbles act as prisms) (1)

[1] d. Any reasonable answer

Any reasonable answer.





inverting lens - image at 2f

− (1)

7 TOTAL

Be liberal (doesn't have to be 45° angle)

Suitable mirror arrangement will do also