LES STANNING
309 2948

1992

TEE PHYSICS

MARKING GUIDE

These solutions are only intended to be used as a guide for markers.

A: sig fig - 1 off up to a max of 3.

Stick to 3 figures.

B: 1 mark off to a max. of 2

Units: Same as above.

1992 TEE PHYSICS DRAFT SOLUTIONS

SECTION A

1(a). Magnet A will take slightly longer to hit the bench top than magnet B. (1mark)

current is OK

(b) The difference in time is because as magnet A passes through the coil it induces a magnetic field in the coil (1 mark). The direction of the field induced in the coil opposes that of the magnet (2marks) slowing it down.
(3marks)

must mention field. opposing force O.K. Lenz's law with explanation worth 1 mark. mention of energy loss O.K.

2(a). Power = Energy/time (1mark
$= 5.00 \times 10^3 / 25.0 =$ **2.00×10^2 W** (1marks)

(b) Power $= VI$; $I = P/V$ (1mark)
$= 200 / 12.0 =$ **16.7 A** (1mark)

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3. A charging process such as this (mainly) involves an exchange of electrons between the objects. (This requires energy which comes from the rubbing process : not essential;) (2 marks)

For the ball to become positively charged the ball must **lose** electrons meanwhile the cloth must become negatively charged as it will **gain** the electron from the ball. (2 marks)

$k = 9 \times 10^9$ - 1 mark off.

4. $$F = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}$$ (1mark)

$$F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{r^2} \qquad q = \sqrt{4\pi\varepsilon_0 r^2 F}$$ (1mark)

$$q = \sqrt{4\pi \times 8.85 \times 10^{-12}\left(30.0 \times 10^{-3}\right)^2 0.150}$$ (1mark)

$= \mathbf{1.23 \times 10^{-7}\ C}$ (1mark)

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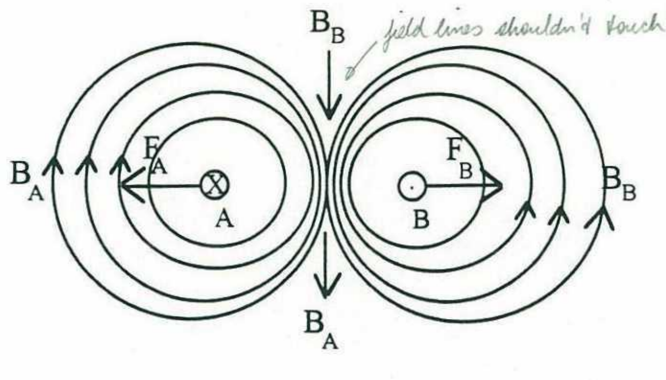
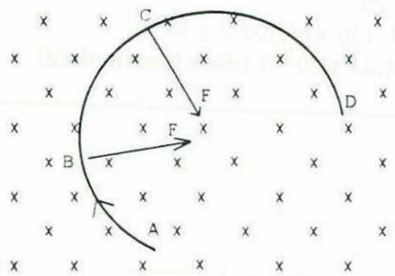
5. (a) attempt at some symmetry in the field (1 mark)
for the correct direction of B_A and B_B (1 mark)
bunching at centre (1 mark)
(b) for the correct direction of F_A and F_B. (1 mark)

field lines shouldn't touch!



6 (a) **NEGATIVELY CHARGED** (1 mark)



(b) see diagram (1 mark)

(c) The radius of curvature of the particles will **decrease**. (1 mark)

(d) **No**. The force does not change the velocity of the particles because it is perpendicular to the velocity. (1 mark)

must give an explanation as well! constant velocity O.K

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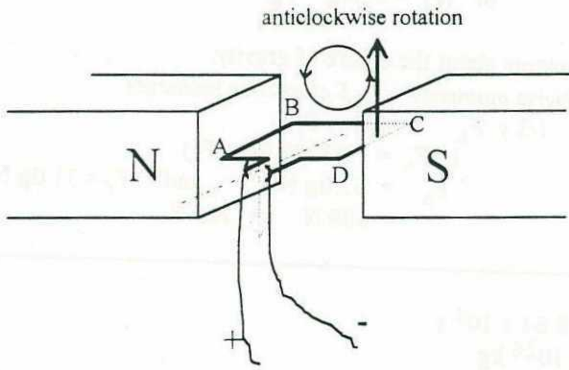
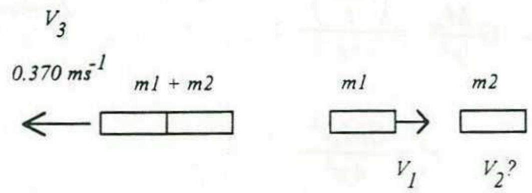
7. a) for correct rotational sense ie **DC UP or AB DOWN** (see diagram) (1 mark)



b) $F = i\,l\,B$ (1 mark)

c)
1. increase the current through the coil
2. increase the number of turns or coils of wire
3. increase the length l. (any 3 for 2 marks)
4. increase the intensity of the magnetic field. (or any 2 for 1 mark)

8.



Statement of principle for 1 mark i.e. $P_i = P_f$ (1 mark)

Using left as positive)

$m_1 = m_2 = 0.255$kg Using $m_1v_1 + m_2v_2 = (m_1+m_2)v_3$ (1 mark)

$v_1 = -0.370\ ms^{-1}$

$v_3 = 0.370\ ms^{-1}$

Find v_2

$$v_2 = [(m_1+m_2)v_3 - m_1v_1]/ m_2$$

$= [\ (0.255 + 0.255)(0.370) - (0.255)(-0.370)]\ /\ 0\ 255$

= 1.11 ms^{-1} to the right (1 mark)

opposite to the direction of v_1 (1 mark)

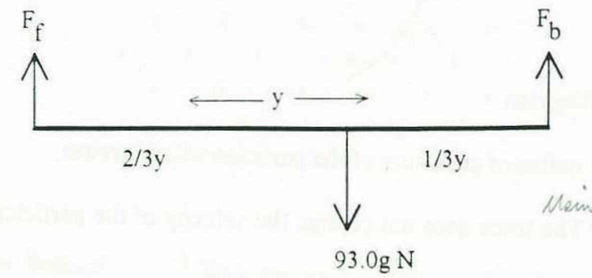
0·370 ms^{-1} – 2 marks off (for not using a -ve)

9. $\Delta t = 55.0$ ms $\quad F = m\dfrac{\Delta v}{\Delta t}$ (1 mark)

$\Delta v = 60.0$ ms^{-1} $\quad = 0.150 \times 60/(55.0 \times 10^{-3})$ (1 mark)

$m = 0.150$ kg $\quad$ **= 1.64 x 10^{2} N (direction implied)** (2 marks)

10.



forces wrong way around - 2 off.

Using ⅓, ⅔ ratio gets full marks!

Bike is not moving up or down, therefore;

Σ forces up = Σ forces down

$F_f + F_b = 93.0g$ or $(F_f = 93.0g - F_b)$ (1 mark)

Now; Taking moments about the centre of gravity.

Σ anticlockwise moments = Σ clockwise moments (1 mark)

$1/3\ y\ F_b = 2/3\ y\ F_f$

$1/3 F_b = 2/3\ (93.0g - F_b)$ (1 mark)

$F_b = 62.0g$ N and $F_f = 31.0g$ N

= 608 N = 304 N (1 mark)

11 $T_{satellite} = 1$ day $= 8.64 \times 10^{4}$ s

$M_{earth} = 5.98 \times 10^{24}$ kg

$G = 6.67 \times 10^{-11}$

A stable orbit is achieved when $F_G = G\dfrac{M_m m_s}{r^2} = F_C = \dfrac{mv^2}{r}$ where $v = \dfrac{2\pi r}{t}$ These 3 are worth 1 mark in isolation.

$$G\frac{M_m m_s}{r^2} = \frac{m_s\left(\frac{2\pi r}{t}\right)^2}{r} \quad G\frac{M_m}{r^2} = \frac{\left(\frac{2\pi r}{t}\right)^2}{r} \ :$$

Working worth 3 marks.

(3 marks)

$$GM_m = \frac{4\pi^2 r^3}{t^2} \ : \quad r^3 = \frac{GM_m t^2}{4\pi^2}$$

$$r = \sqrt[3]{\frac{6.67\times10^{-11}\ 6.37\times10^{22}\left(8.64\times10^{4}\right)^2}{4\pi^2}}$$

= 9.75 x 10^{6} m (1 mark)

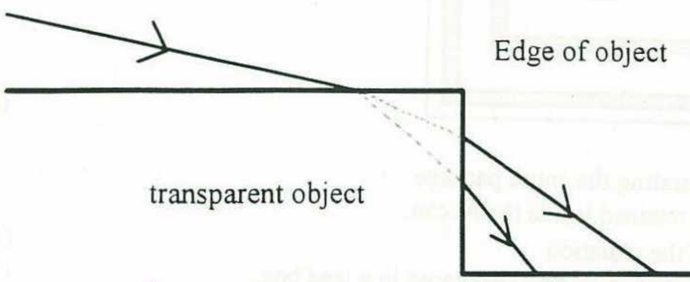
12 **RESONANCE** (1mark)

At the slow speed, the frequency of the vibrations from the motor moving parts matches the natural vibrational frequency of the other mechanical components of the machine. (1mark)

These vibrations will increase in amplitude (or combine constructively) rapidly making the whole machine vibrate. (1 mark)

At higher speeds the higher vibrational frequencies of the motor do not match the natural or resonant frequency of the structure and hence they do not add constructively, leaving the machine running smoothly. Full marks for explaining either situation (2 marks only) (1mark)

13.



Accept anything with reasonable Physics in it! (3 marks)

chromatic aberration - mark up to 3 marks based on explanation.

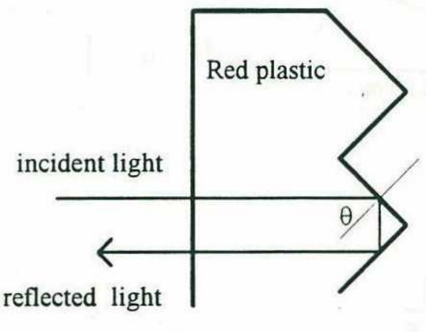
Full marks if the diagram shows this! (3 marks)

The coloured fringes are caused by **dispersion** of light incident on the edges of the transparent object.

(1 mark only if they use the word dispersion without the diagram) (1 mark)

14.

(a)



(2 marks)

(1 mark for correct path, 1 mark for correct angle)

(b) For this to occur the light must be totally internally reflected

Angle of contact is $\theta_1 = 45^o$.

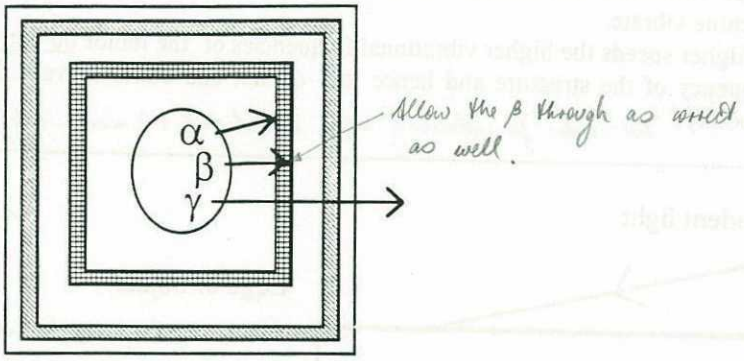
$n_{plastic} \sin \theta_1 = n_{air} \sin \theta_2$ (1 mark)

For total internal reflection: $\theta_2 = 90^o$; $n_{air} = 1.00$; $n_{plastic}/n_{air} = 1/\sin \theta_1$

$n_{plastic} = 1/(\sin 45) = \mathbf{1.41}$ (1 mark)

15. (a)

Sample is low level radioactivity so thin layers of the correct materials will act as affective absorbers.
Virtually all of the **a** radiation will effectively be absorbed on the **surface of the Aluminium can**..
Most of the **β** radiation will be absorbed **some way into the aluminium can**.
Most of the **γ** will penetrate **all** of the packaging materials.



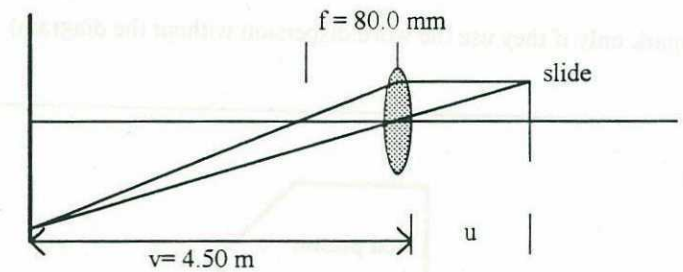
(2 marks)

One mark showing the γ penetrating the entire package
one mark for α **and** β being retained inside the Al can.

(b) Al will absorb the most of the radiation (1 mark)

(c) the package should be wrapped in lead foil or placed in a lead box. (1 mark)

16.



$$\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$$ (1 mark)

$$\frac{1}{0.080}=\frac{1}{u}+\frac{1}{4.5}$$

u = 81.5mm 81·4mm ✓ (1 mark)

(b) The image is **real** (1 mark)
because the image is visible as being projected on a screen. (1 mark)
u > f
image + object on opposite sides of lens } both OK

17 (a) After one half life the rock will have half the material left etc
One eighth of the material remaining is equal to 3 half lives (2 marks)

3 half lives = 3 x 1.28 x 10^9 years = **3.84 x 10^9 years** (1 mark)

(b) Because the element has such a long half life (or low activity) a sample containing this element will not show any appreciable change in activity over a human life time. (1 mark)

18 Using E = hv or $E = \frac{hc}{\lambda}$ (1 mark)

$= (6.63 \times 10^{-34} . 3.00 \times 10^{8})/(555 \times 10^{-9})$ (1 mark)

$= 3.58 \times 10^{-19}$ J per photon (1 mark)

1350 W m^{-2} = 1350 $Js^{-1}m^{-2}$ or 1350 / (3.58 x 10-19) = **3.77 x 10^{21}** photons $s^{-1}m^{-2}$ (1 mark)

19. Using the following dimensions

n : length : L^{-3} m : mass : M e : charge : C T : time : T

$\sigma = \frac{e^2 nT}{2m}$ *or dimensions of* $\frac{C^2 L^{-3} T}{M}$ (1) (1 mark)

Conductivity: $(\Omega m)^{-1}$ is equivalent to $\left(\frac{Vm}{I}\right)^{-1}$ or $\left(\frac{I}{Vm}\right)$ (2) (1 mark)

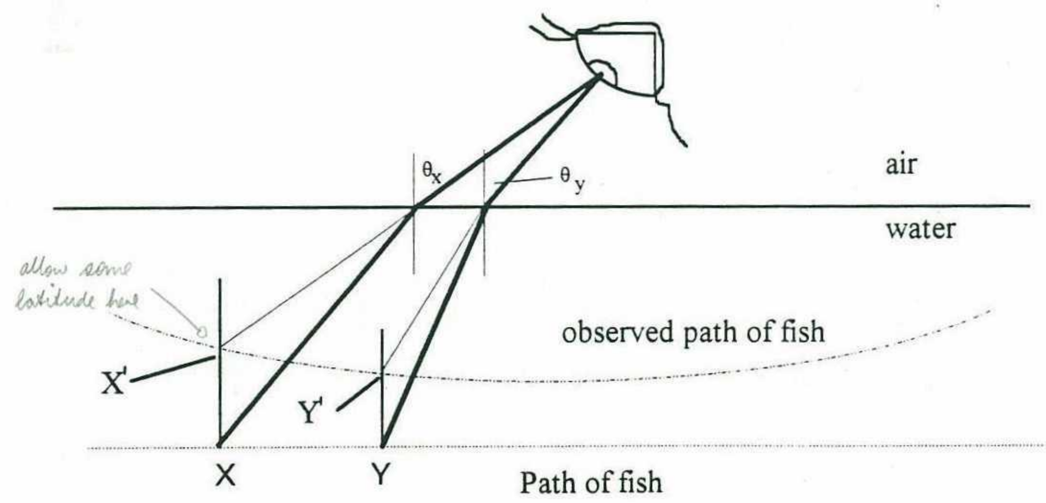
Using $I = q/t$; the dimensions are C/T (3) (1 mark)

Can use dimensions or units.

and, using $V = E\,d = \frac{F}{q}d$; the dimensions are $\frac{ML^2T^{-2}}{C}$ (4)

Combining (3) and (4) into (2) gives $\frac{\left(\frac{C}{T}\right)}{\left(\frac{ML^2T^{-2}}{C}\right)L} = \left(\frac{C^2L^{-3}T}{M}\right)$ = answer (1 mark)

20.

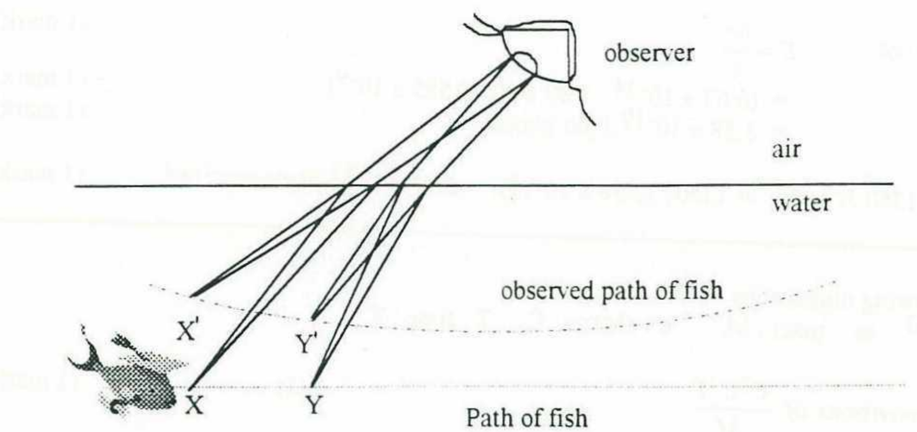


(a) 2 marks for correct lines from fish to eye (single dark lines only required) (2 marks)

(b) 2 marks for any reasonable answer acknowledging that the further away the fish is from the observer, the shallower the grazing angle or the greater the incident angle (θ). Thus, the larger incident angle (θ_x) is refracted more than (θ_y) placing the apparent position of the fish closer to the surface at positions X' and Y'. (Intersection of thin vertical with thin straight line direct from eye). (2 marks)

Technically the students should show both the effect of refraction on the two angles and show the final positions of the observed fish X' and Y' **directly above X and Y** as shown on the next page.

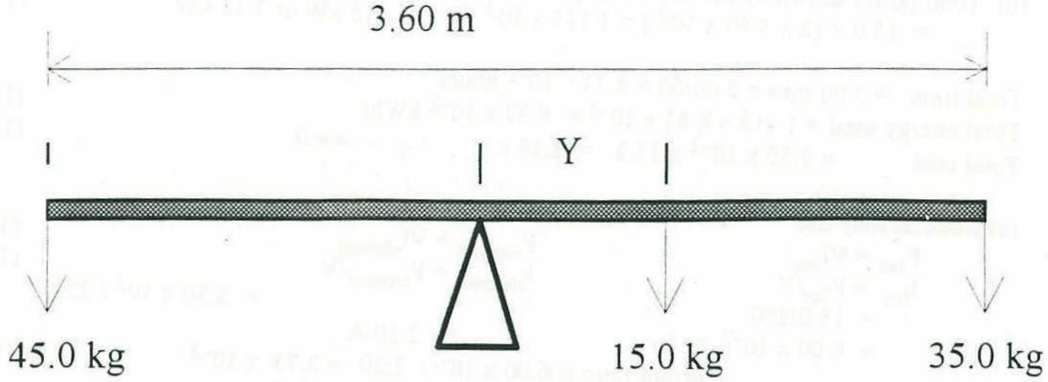
EG



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

SECTION B.

1 (a) Up to 1 mark for a suitable diagram (1 ~~mark~~)



Taking moments about centre point;

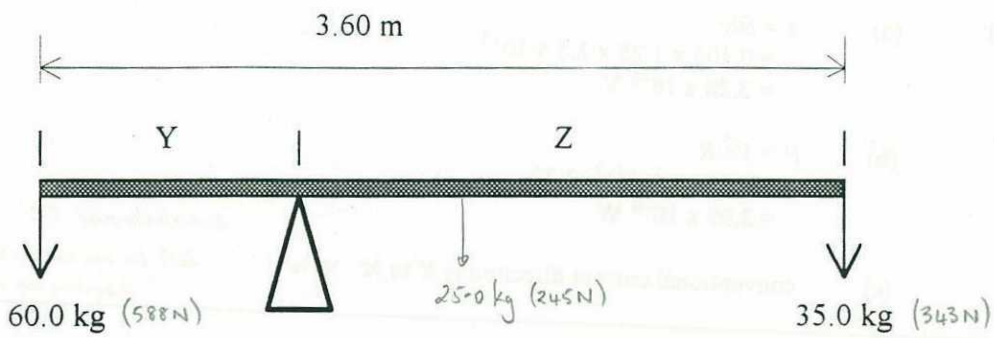
Σ anticlockwise moments = Σ clockwise moments (1 mark)

45.0 x 1.8 = (15.0 x Y) + (35 x 1.8) (~~1~~ mark)

or Y = [(45.0 x 1.8) - (35 x 1.8)]/15.0 = **1.20 m** (1 mark)

(b) Diagram useful but not required

Not using mass of plank - 1 off
Not having small child on the correct end - 1 off.



Sum of the forces down = 95g N, therefore pivot exerts a force of 95g N up (1 mark)

Taking moments about 60 kg point;
Σ anticlockwise moments = Σ clockwise moments (1 mark)

(1 mark) - for substitution

(Y x 95) = 3.60 x 36 or Y = (3.60 x 35)/95 = **1.33 m** X (1 mark)

(or 2.27 m from other end or move 0.47 m closer to end with the 2 children

1.43 m from 1 end
2.18 m from the other.

2. (a) switch S1 is effectively a master switch which prevents either of the heating elements from working if power is not supplied to the fan . This prevents the heating elements from overheating (and perhaps burning out). (1 mark)

(b) Total power drawn by the fan motor plus 2 heating elements
$= 15.0 + (2 \times 5.50 \times 10^2) = 1.115 \times 10^3$ W = 1.115 kW or 1.12 kW (1 mark)

Total time $= 5.00$ min $= 5.00/60 = 8.33 \times 10^{-2}$ hours
Total energy used $= 1.115 \times 8.33 \times 10^{-2} = 9.29 \times 10^{-2}$ kWhr (1 mark)
Total cost $= 9.29 \times 10^{-2} \times 12.3$ = **1.14 c** 1 ¢ is correct. (1 mark)

(c) students may use P = VI

$P_{fan} = VI_{fan}$	:	$P_{element} = VI_{element}$	(1 mark)
$I_{fan} = P_{fan}/V$	:	$I_{element} = P_{element}/V$	(1 mark)
$= 15.0/250$	:	$= 5.50 \times 10^2 / 250$	
$= 6.00 \times 10^{-2}$ A	:	$= 2.20$ A	

Current ratio is $6.00 \times 10^{-2} / 2.20$ = $\mathbf{2.73 \times 10^{-2}}$ (1 mark)
3 : 110 , 1 : 36.7 , 0.06 : 2.2 are O.K.

OR (c) Current drawn by each of the components is proportional to the power dissipated by each component. (1 mark)
For both elements;
Current ratio = $\text{Current}_{fan}/\text{Current}_{element}$ = $\text{Power}_{fan}/\text{Power}_{element}$ (1 mark)
$= 15.0/5.50 \times 10^2 = \mathbf{2.73 \times 10^{-2}}$ (1 marks)

3. (a) $\varepsilon = Blv$ (1 mark)
$= 0.105 \times 1.25 \times 2.5 \times 10^{-3}$ (1 mark)
$= \mathbf{3.28 \times 10^{-4}}$ **V** (1 marks)

(b) $P = V^2/R$
$= (3.28 \times 10^{-4})^2 / 2.70$ (1 mark)
$= \mathbf{3.99 \times 10^{-8}}$ **W** (1 marks)

(c) conventional current direction is ***Y* to *X*** X to Y Anticlockwise OK. (look for an arrow on the diagram as well) (1 mark)

4. (a) $^{238}_{94}\text{Pu} \Rightarrow {}^{4}_{2}\text{He} + {}^{234}_{92}\text{U}$ (1 mark)

(b)

Masses			
	Pu :	-238.0495 u	
	U :	+234.0409 u	
	He :	+ 4.0026 u	
Mass difference:	:	0.0060 u	(1 mark)

Each disintegration is equivalent ot a mass loss of $0.0060 \times 1.661 \times 10^{-27} = 9.97 \times 10^{-30}$ kg (1 mark)

Using $E = mc^2 = 9.97 \times 10^{-30} \times (3.00 \times 10^8)^2 = 8.97 \times 10^{-13}$ J (1mark)

Total energy = energy per disintegration x disintegration rate:
$8.97 \times 10^{-13} \times 1.9 \times 10^{15}$ = $\mathbf{1.7 \times 10^3}$ **W** (or $\mathbf{1.70 \times 10^3}$ **W**) (1 mark)
Using 4.0026u to get 1.14×10^6 J - 2 marks only!

OR student may remember 1u is equivalent to 931 MeV and use it appropriately.

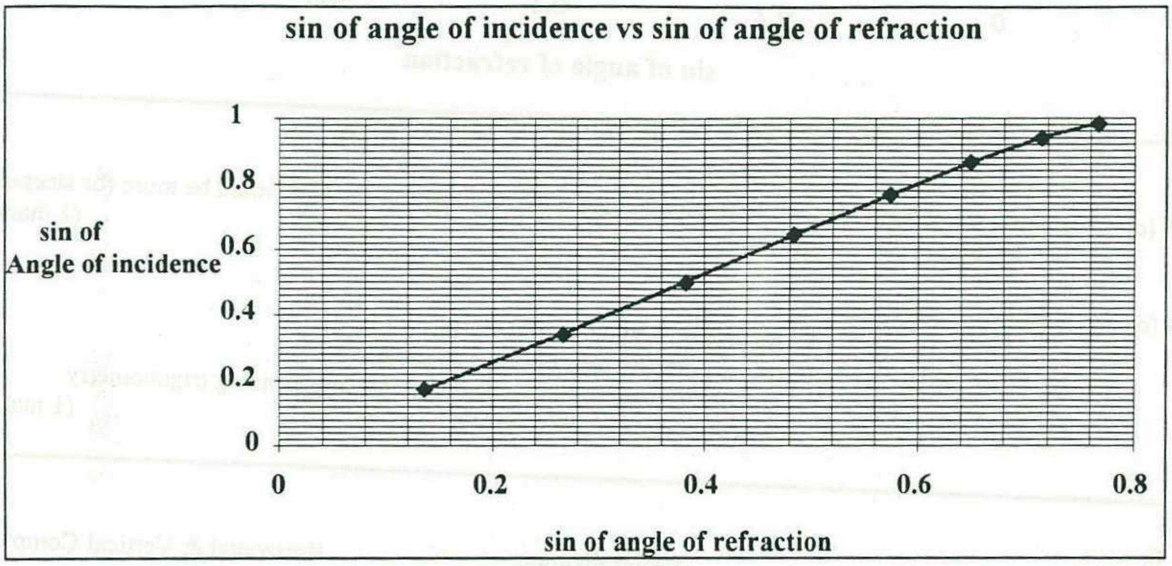
(c) the distance minimises the chance of radiation being generated in the thermionic source from damaging the electronics in the payload. Heat causing problems is OK (1 mark)

5. (a)

angle of incidence (^{o})	angle of refraction (^{o})	sin of angle of incidence	sin of angle of refraction
10.0	7.8	.1736	.1357
20.0	15.5	.342	.2672
30.0	22.5	.5	.3827
40.0	29.0	.6428	.485
50.0	35.0	.766	.5736
60.0	40.5	.866	.6494
70.0	45.5	.9397	.7133
80.0	50.0	.985	.766

(1 mark) for reproducing

Graph of rubbish is worth 0!



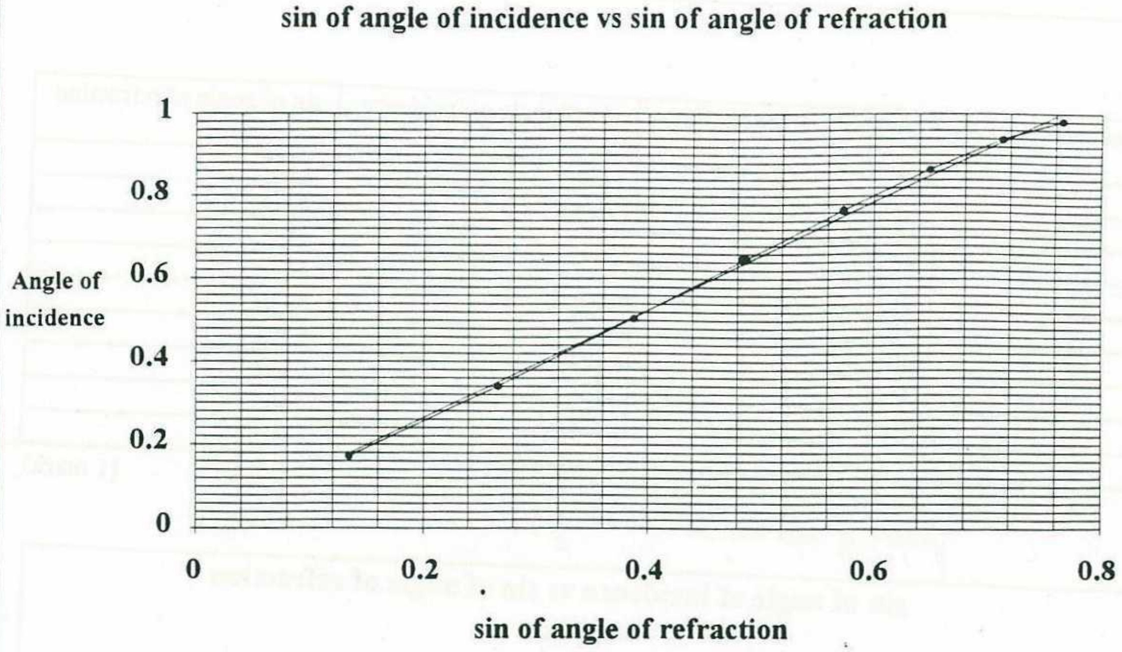
(a) Graph, axes (1 mark) , data plotted (1mark) (2 marks)

(b) refractive index of water. From slope of graph $n = \Delta y/\Delta x$ must use slope (1 mark)

I get $(1.00 - 0.16) / (0.78 - .14) = 0.84/0.64 = \mathbf{1.31}$ ($\pm$ 0.02) (1 mark)

Student must use slope of the line of best fit from the graph rather than substituting data direct from the table of results to find n.

REFERENCE ONLY



5 (c) Because the refractive index is greater that for water, the slope of the line would be more (or steeper) than for that shown on the graph. (1 mark)

(d) Any reasonable answer EG

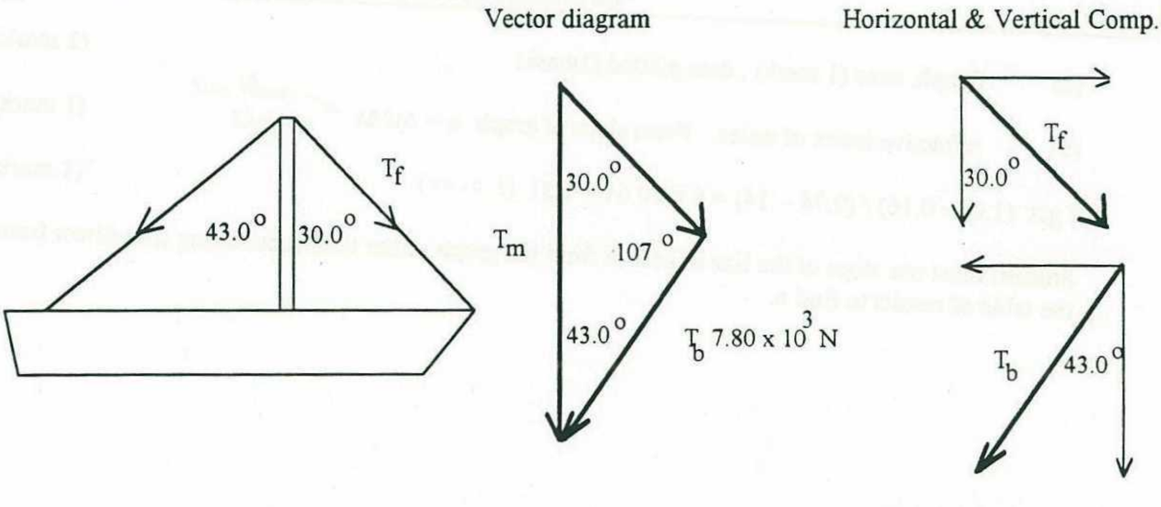
i) watch for parallax error.

ii) use as narrow a beam of light as possible.

iii) use long (beam) distances and calculate angles using trigonometry

iv) repeat measurements (1 mark)

6.



suitable diagram(s) (1 mark)

Using vector components shown in figure above:

(i) $T_{b\,(\text{horizontal})} = T_b \sin 43^o = 7.80 \times 10^3 \sin 43^o = 5.32 \times 10^3$ N

$T_{f\,(\text{horizontal})}$ = but opposite to $T_{b\,(\text{horizontal})}$

or $T_f = T_{f(\text{horizontal})} / \sin 30^o = (5.32 \times 10^3) / \sin 30^o = \mathbf{1.06 \times 10^4\ N}$ (1 mark)

(ii) Force on mast $= \Sigma$ vertical components:

$T_{h\,(vert)} = T_b \cos 43^o = 7.80 \times 10^3 \,.\, \cos 43^o = 5.70 \times 10^3$ N

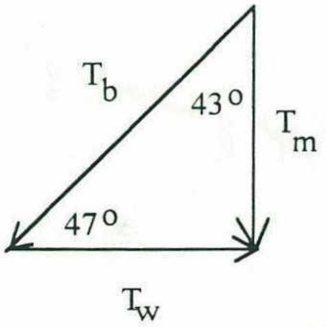
$T_{f\,(vert)} = T_f \cos 30^o = \mathbf{1.06 \times 10^4} \cdot \cos 30^o = 9.18 \times 10^3$ N

Σ vertical components $= T_{f\,(vert)} + T_{h\,(vert)}$

$= \mathbf{1.49 \times 10^4\ N}$ **towards the deck** (1 mark)

(b) When $T_f = 0$ and T_b doubles to 1.56×10^4 N.

Suitable diagram (1 mark)



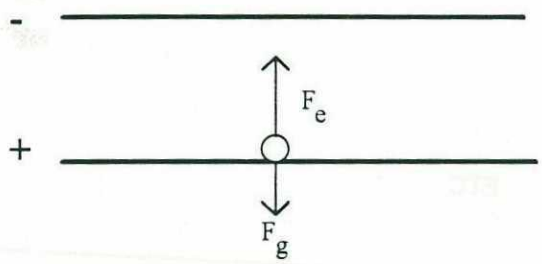
$T_w/T_b = \sin 43^o$ (1 mark)

$T_w = T_b \sin 43^o$

$= 1.56 \times 10^4 \sin 43^o$

$= \mathbf{1.06 \times 10^4\ N}$ (1 mark)

7.



(a) Using $E = V/d$ and $F_e = E\,q$ $F_e = (V/d)\,q$ (1 mark)
mark)

$= (1.50 \times 10^3 / 0.025) \times 45.0 \times 10^{-12} = \mathbf{2.70 \times 10^{-6}\ N\ up}$

(1 mark)

5.51

(b) $F_g = mg = 9.8 \times 5.0 \times 10^{-8} = 4.90 \times 10^{-7}$ N down
$F_e = 5.5$ times $> F_g$ must state something about
The weight of the object cannot be ignored in this system relative magnitude (1 mark)

(c) The net force on the particle is $2.70 \times 10^{-6} - 4.90 \times 10^{-7} = 2.21 \times 10^{-6}$ **N**
Using: $v^2 = u^2 + 2aS$ and $F = ma$ $v^2 = u^2 + 2(F/m)\,S$ ← must get down to here (1 mark)

$= 0^2 + 2\,[(2.21 \times 10^{-6})/(5.00 \times 10^{-8})] \times 0.025$

$\frac{1}{2}mv^2 = Vq$ – 1 mark only.

$\mathbf{v = 1.49\ ms^{-1}}$ (1 mark)

(d) **As the (positively charged) particles moves to lower electrical potential it loses electrical potential energy and gains kinetic energy and gravitational potential energy.**

Work done on particle by field = gain in KE + gain in PE (1 mark)

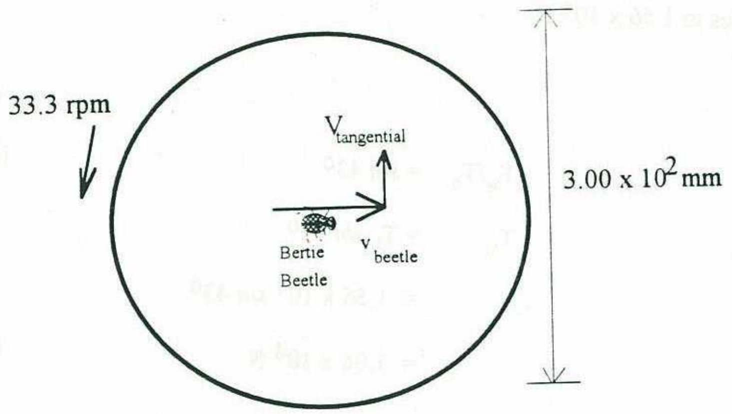
$$qV = 1/2\, m v^2 + mgh$$

$$45.0 \times 10^{-12} \times 1.50 \times 10^{3} = 1/2 \times 5.00 \times 10^{-8} \times (1.49)^2 + 5.00 \times 10^{-8} \times 9.8 \times 0.0250$$

6.75×10^{-8} J : 6.77×10^{-8} J (is close enough) (1 mark)

Full marks if the working is O.K. (allowing for the error due to rounding)

8.



Graph of rubbish is 0!

$v_{beetle} = 0.0150\ ms^{-1} = s/t$ or $s = v_{beetle} \cdot t$

where s = radial distance beetle has travelled from the centre of the disc.

(1 mark)

Also: $v_{tangential} = 2\pi \cdot s \cdot (\text{rpm}/60) = 2\pi \cdot v_{beetle} \cdot t \cdot \text{rpm} / 60$

time (s)	$v_{tangential}$ (ms^{-1})
0	0
1	5.23×10^{-2}
2	1.04×10^{-1}
5	2.62×10^{-1}
10	5.23×10^{-1}

ETC (1 mark)

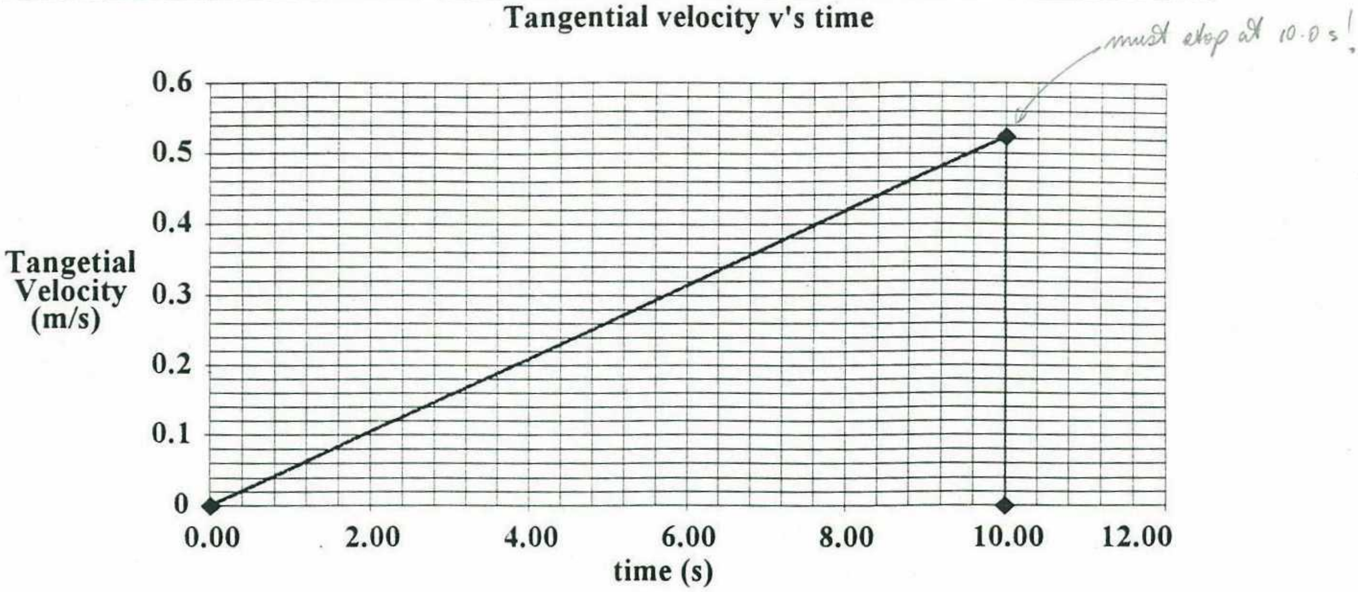
OR $v_{tangential} \propto t$

So a straight line with a slope of $(2\pi \cdot v_{beetle} \cdot \text{rpm})/60 = (2\pi \cdot 0.0150 \cdot 33.3)/60 =$ **0.0523**

The beetle crawls from the centre (s = 0) where $v_{tangential} = 0$

Maximum $v_{tangential}$ is 2π . radius of disc . rpm . 60 = $(2\pi \cdot 1.50 \times 10^{-1} \cdot \text{rpm}) / 60 = 0.523\ ms^{-1}$

This happens at time : $t = s/v_{beetle} = 1.50 \times 10^{-1} / 0.015 = 10.0$ seconds



Do not deduct marks if the student shows a velocity beyond 10s.
If student messes it up but demonstrates a linear relationship allow at least 1 mark.

(b) Beetle will slip off the disc when $F_{friction} < F_{centrifugal}$ (1 mark)

$$F_{friction} < \frac{mv^2}{r} \quad \text{where} \quad v = (2\pi . r\ .\ \text{rpm})/60 = 3.49r$$ (1 mark)

$$F_{friction} < \frac{m(3.487r)^2}{r}$$

$$r < \frac{F_{friction}}{m(3.487)^2} \ or\ \frac{6.00 \times 10^{-4}}{0.45 \times 10^{-3}(3.487)^2}$$ (1 mark)

$$= \mathbf{1.10 \times 10^{-1}\ m}$$ (1 mark)