SIG. FIG. - 2-4 is appropriate (4 marks in Section A, 2 in Section B)
UNITS - a must! (4 marks in Section A, 2 in Section B)

TEE PHYSICS 1993
DRAFT SOLUTIONS
SECTION A

1. 22.5 mPa = 2.25 x 10-2 Pa 363 nm = 3.63 x 10-7 m

4.47×10^{-4} A = 447 μA 1.87×10^{7} eV = 18.7 MeV

0·447 mA.

(1 mark each)

2. Number of protons = 92 Number of neutrons = 146

(2 marks each)

3. a) Resonance occurs when the frequency of a driving force applied to a system is equal to the natural frequency of the system. Under these conditions, the system will oscillate with a large amplitude. 1st sentence is enough for 2 marks

(2 marks)

b) Examples

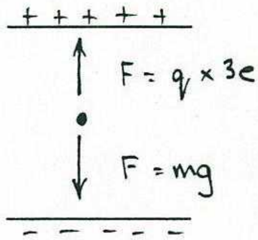
no explanation required.

Pendulum	Organ pipes
Tones in bottles	Wobbling car wheels
Singing glasses	Masses on springs.
Whistling wires.	Children on swings.

2 marks for three examples.
(1 mark for two examples)

4. The particle can be suspended since the force due to gravity is counteracted by the force due to the electric field. Hence there is no net force on the particle.

(2 marks)



$$qE = mg$$

$$m = qE/g = 3 \times 1.6 \times 10^{-19} \times 50 \times 10^{3} / 9.8$$

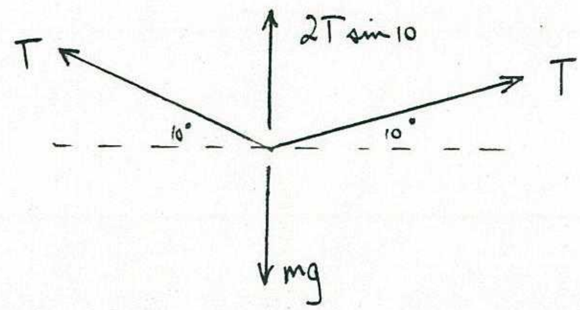
$$= 2.45 \times 10^{-15} \text{ kg}$$

(2 marks)

5. From the diagram, the vertical force exerted on the jeans is 2 T sin 10°, where T is the tension in the line. Hence

$$2\,T \sin 10^\circ = m\,g$$

(2 marks)



$$T = 1.95 \times 9.8 / (2 \sin 10^\circ)$$

$$= 55.0 \text{ N}$$

(2 marks)

can be blank

magnitude of arrow not important.

6. <——— A <——— B 0 C <——— D

(1 mark each position)

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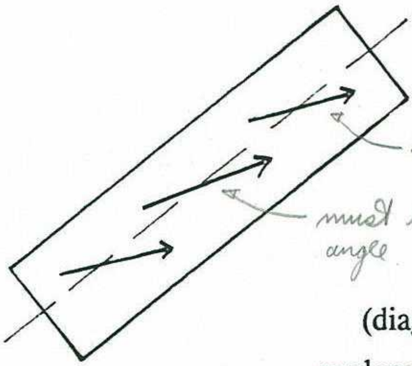
7. The magnets will exert a force on each other, so that they will tend to line up with each other. The central magnet will be more affected than the other two since it has a magnet at both ends.

3 marks: if the student understands the compass' affect each other.

1 mark: middle compass must be deviated from the others.



must be < 20°

must be at some other angle

(diagram 2 marks
explanation 2 marks)

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8. $[\mu_0] = \left[\dfrac{F\ d}{\ell\ I_1\ I_2}\right] = \dfrac{M\ L\ T^{-2}\ L}{L\ Q^2\ T^{-2}}$ (1 mark) (2 marks)

unit analysis is O.K.

$= M\ L\ Q^{-2}$ (1 mark). $MLT^{-2}A^{-2}$ is O.K.

(4 marks)

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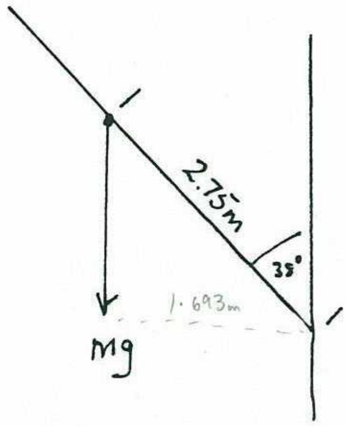
9. Torque = $r\ F \sin\theta$ (1 mark)

$= r\ m\ g \sin\theta$

$= 2.75 \times 125 \times 9.8 \times \sin 38$

$= 2.07$ kNm (3 marks)

2.07×10^3 Nm



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10. The centripetal force exerted on an electron moving in a circular path is

$m\,v^2/_r = q\,v\,B$ $v = 5.927 \times 10^6\ ms^{-1}$. (1 mark)

Now KE = $\frac{1}{2} m v^2$ so $v = \sqrt{\{^{2\ KE}/_m\}}$

Thus $r = {}^{m}v/_{q\,B} = m \times \sqrt{\{2\ KE / m\}}/_{q\,B}$

1 mark off for any mistake

$= 9.11 \times 10^{-31} \times \sqrt{\{2 \times 1.6 \times 10^{-17} / 9.11 \times 10^{-31}\}} / 1.6 \times 10^{-19} \times 5 \times 10^{-5}$

$=$ 675 mm (3 marks)

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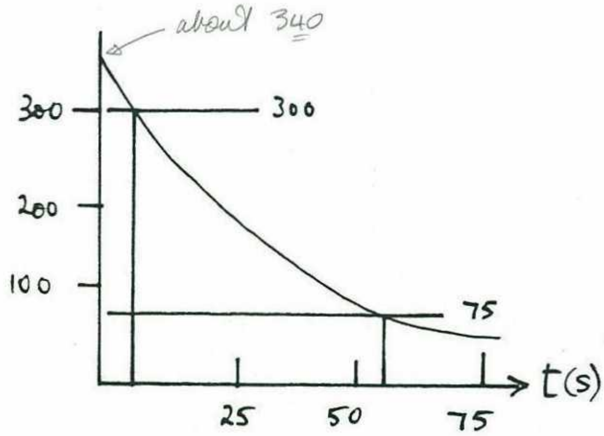
11. The time taken for the activity to fall from 300 to 75 s^{-1} is

$$54 - 4 = 50 \text{ s.}$$

(2 marks)

Hence the half life of the material is 25 s.

Accept $\pm \underline{3}$ in the answer. (2 marks)



12. The change in momentum of the speck of dust is

$m\, v_2 - m\, v_1$ implies a direction (1 mark)

Take 2 marks off for missing "-"

$= \{ 4.5 - (-1.5) \} \times 50 \times 10^{-6}$ only needed if the answer only given.

$= 3.00 \times 10^{-4}$ kgms^{-1} in the direction of the cyclist. (3 marks)

13. The evidence is not consistent with the police findings.

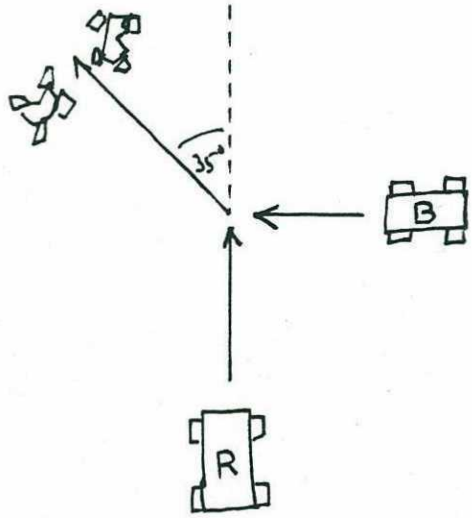
(1 mark)

Calculation of the angle is O.K.

Since the cars were of similar mass, the blue car, having the greater speed, also had the greater momentum. In this case, the two cars would have moved off at an angle **greater** than 45° from the north after impact in order to conserve momentum.

must mention momentum?

(3 marks)



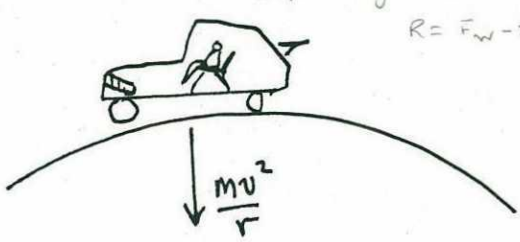
14. As the car moves over the crest of the hill, the car seat accelerates towards the centre of curvature of the crest. As a result, the passenger feels less force exerted by the seat, which is interpreted as a loss in weight.

(4 marks)

sufficient to mention "less reaction force from the seat ∴ feel loss in weight"

$\Sigma F = \frac{mv^2}{r} = mg - R.$

$R = F_w - \Sigma F$



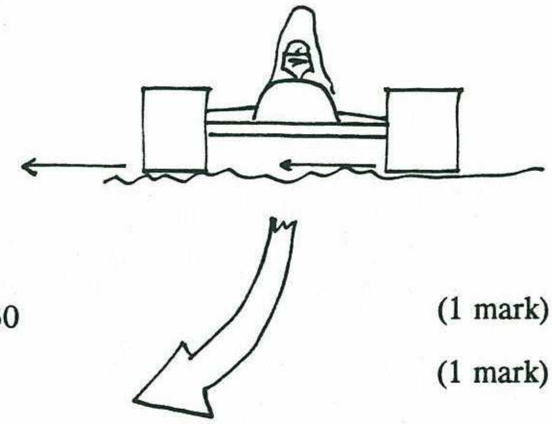
"Friction" only = 1 mark

need some explanation

Friction between the tyres + road.

15. a) The force exerted on the tyres by the road supplies the centripetal force.

(2 marks)



b) $v = 120 \times 10^3/3600$

$= {}^{100}/_{3}\ \mathrm{ms^{-1}}$

$F = m\,v^2/r = 8 \times \{{}^{100}/_{3}\}^2 / 30$ (1 mark)

$= 296$ N (1 mark)

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16. The force exerted by gravity on the astronaut is

$$F = m\,g = {}^{G\,M\,m}/_{d^2}$$ (1 mark)

Comparing the forces exerted on the astronaut on the two planets

$$\frac{F_2}{F_1} = \frac{M_2\,d_1^2}{M_1\,d_2^2}$$

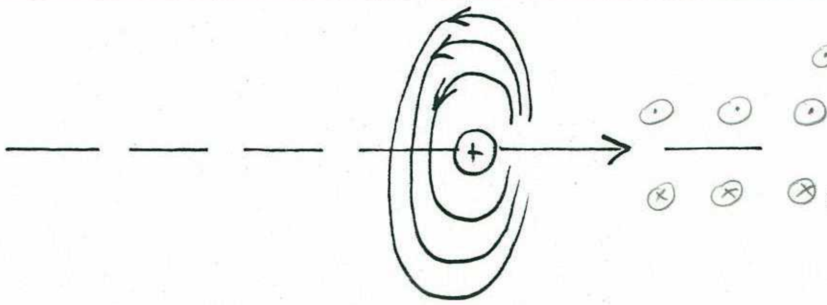
$$F_2 = \{{}^{95.2 \times 65}/_{(9.5)^2}\} \times 65\,g$$

$$= 68.6\,g$$

Since the bathroom scales measure force, we see that the weight registered on the scales will be 68.6 kg 68.8 kg (if all numbers are put in)

(3 marks)

17.



B_{OUT}

one line is O.K.

circular lines (2 marks)

direction (2 marks)

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18. The centripetal force exerted on a satellite is

Show a relationship between r and T

$$F = {}^{G\,M\,m}/_{r^2} = m\,v^2/r = \{m/r\} \times \{4\,\pi^2\,r^2/T^2\}$$

Hence

$$r^3/T^2 = {}^{G\,M}/_{4\,\pi^2} = \text{constant}$$

Some good analysis needed for marks.

Since a geostationary satellite must have exactly the same period of rotation as the earth, this shows that there is only one possible orbital radius the satellite can have if it is to have the required period of rotation.

(4 marks)

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mention the sun's light passing through atoms that absorb light.

19. The light from the sun has to pass through the sun's atmosphere, in which there are atoms which can absorb the light coming from the sun. The atoms absorb just those wavelengths which can move the electrons in the atoms between definite energy levels, which creates the lines in the spectrum.

(2 marks)

The light from the globe also has to pass through atmosphere. However, the amount it passes through is so little, you would never notice the absorption lines.

(2 marks)

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20. The angle at which the light refracts from the surface of the pool is found from

$$n_1 \sin i = n_2 \sin r$$ (1 mark)

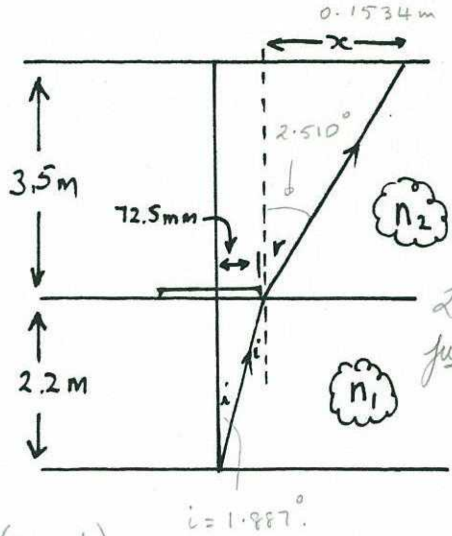
$$1.33 \times {}^{72.5}/_{2200} = 1 \times \sin r$$

In the diagram, the distance x on the ceiling is

$$x = 3500 \tan r = 153.5 \text{ mm}$$ (1 mark)

Hence the diameter of the shadow on the ceiling is

$$d = 2 \times (72.5 + 153.5) = 452 \text{ mm}$$ (1 mark)



(1 mark)

2 marks if fully labelled.

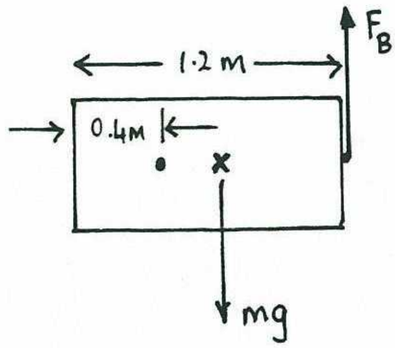
(4 marks)

MULTIPLE CHOICE

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

SECTION B

B1. a) i) When the bin is held by the base, equating torques about Q



$$m\,g \times 0.2 = F_B \times 0.8$$

$$F_B = 36.5 \times 9.8 \times 0.2 / 0.8$$

$$= 89.4 \text{ N}$$

(1 mark)

ii) When the bin is held by the top, the procedure is the same as part a) and the figures are the same except the moment arm at the top is half the length. Thus the force required is twice that found above; i.e., $F_T = 179$ N

(1 mark)

b) The bin is not hinged at the middle since when it is nearly filled with rubbish, a small push at the top could easily push it over and allow the rubbish to fall out.

(1 mark) 2 marks for either answer.

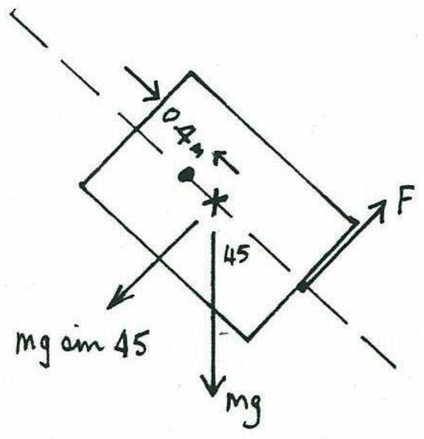
The bin is not hinged at the top since then a larger force would be needed to turn it over and tip the rubbish out. This is done because people these days are not supposed to exert themselves.

(1 marks)

c) The minimum necessary force is exerted when the force is at right angles to the axis of the bin.

(1 mark)

From the diagram, we see by equating torques about S that



$$0.8 \times F = 0.2 \times m\,g \,\sin 45$$

$$F = \tfrac{1}{4} \times 36.5 \times 9.8 \times \sin 45$$

$$= 63.2 \text{ N}$$

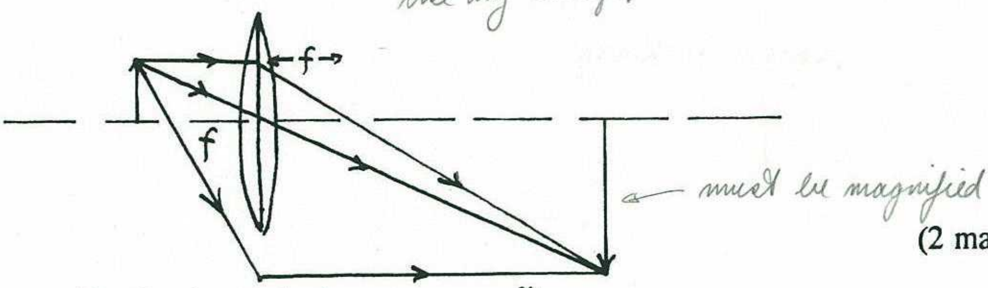
(2 marks)

B2. a) You would use a convex lens (1 mark)

This is because a real image is required, and only a convex lens can produce a real image.

(1 mark)

b)



(2 marks)

c) If the magnification is x4.5, then $m = v/u$

so that $v = 4.5\,u$

But $v + u = 250$ mm

$4.5\,u + u = 250$ (1)

$u = 250/5.5$ and $v = 4.5 \times 250 / 5.5$

Then $1/f = 1/u + 1/v = 5.5/250 + 5.5/4.5 \times 250$

$f = 37.2$ mm (2 marks)

B3. a) Regardless of the shape of the wire, the emf induced when a wire moves in a magnetic field is

$V = B \ell v$ (1 mark)

Thus $V = 20 \times 10^{-6} \times 5.0 \times 80$

$= 8.00$ mV (1 mark)

8.00×10^{-3} V.

b) The force exerted on one arm of the loop is

$F = i \ell B = 5 \times 0.141 \times 1 \times 10^{-3}$ N 7.05×10^{-4} N (1 mark)

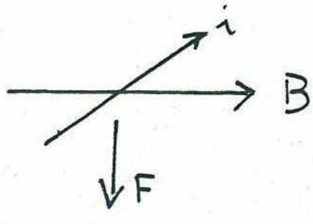
The torque is equal to r F since the wire is perpendicular to the magnetic field. Thus

torque $= 2 \times ½\,{}^{0.141}_{\wedge}5 \times 0.141 \times 1 \times 10^{-3}$

$= 705\ \mu\text{Nm}^{-1}$ $99.4\ \mu$Nm 9.94×10^{-5} Nm (2 marks)

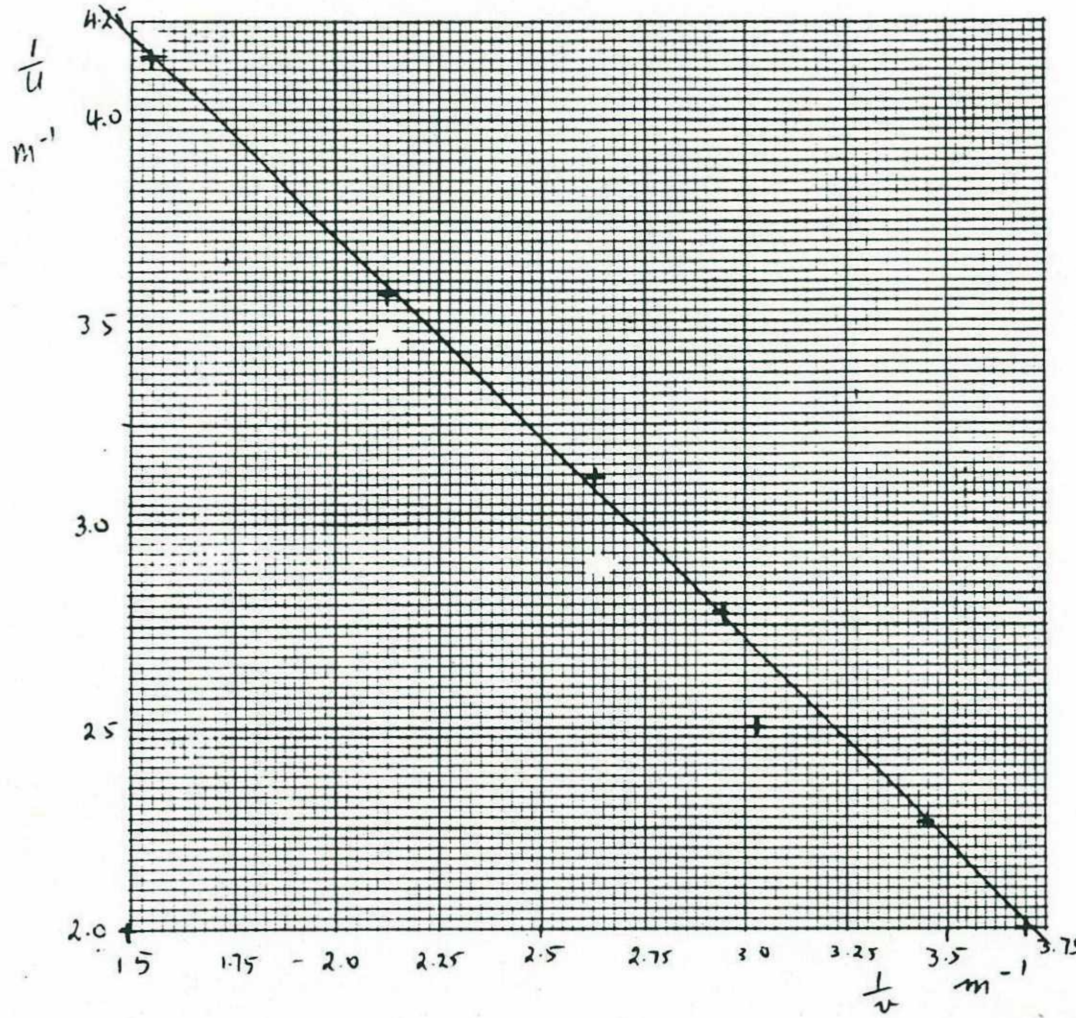
c) The loop rotates in a clockwise direction as seen when looking into the page.

(1 mark)



B4. a)

u =	240	280	320	360	400	440	500	mm
$1/u$ =	4.17	3.57	3.12	2.78	2.5	2.27	2.0	m^{-1}
v =	650	470	380	340	330	290	270	mm
$1/v$ =	1.54	2.13	2.63	2.94	3.03	3.45	3.70	m^{-1}



must be a straight line graph.

(3 marks)

b) Taking the point on the line of best fit, where $1/u$ = 3.0 m^{-1}, the corresponding value of $1/u$ is 2.74 m^{-1}. Then

$$1/f = 1/u + 1/v = 3.0 + 2.74 = 5.74 \text{ m}^{-1}$$

Hence f = 174 mm More interested in method – answer can be "ball park" figure. (2 marks)

c) One point was read from the graph along the line of best fit. A point near the middle of the graph was used, sincethis will minimize uncertainty. This point was then substituted into the lens equation to determine the focal length.

can use $\frac{1}{u}$ and $\frac{1}{v}$ intercepts. (2 marks)

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can plot uv vs $u+v$ – most accurate method

B5. a) The total power produced by the power station is $4 \times 250 = 1000$ MW.
Since $P = V I$, the current produced is

$$I = {}^{P}/_{V} = 1000 \times 10^6 / 16 \times 10^3 = 62.5 \text{ kA}$$ $6{\cdot}25 \times 10^4$ A

(2 marks)

b) The energy generated by the power station in five minutes is

$$E = P t = 1 \times 10^6 \times {}^5/_{60} \text{ kW-hr}$$ (1 mark)

The value of this energy is

$$5 \times 10^6/60 \times 0.179 = \$14917.67$$ sufficient for 1 mark. (2 marks)

c) When the voltage is stepped up, less current is required to transmit the same amount of power along the line. Since the energy lost in heat is proportional to the square of the current, this reduces considerably the amount of energy used just to heat the wire and the feet of any birds that happen to be sitting on the wire.

(1 mark)

B6. a) $_{62}Sm^{146} \longrightarrow {}_{60}Nd^{142} + {}_2He^4$ or alpha particle. (1 mark)

b) From $KE = \frac{1}{2} m v^2$, we see that the velocity of the alpha particle is

$$v = \sqrt{\{{}^{2\,KE}/_m\}}$$

Because momentum is conserved when the nucleus disintegrates, we can write

$$m_{Nd}\, v_{Nd} = m_{He}\, v_{He}$$ (1 mark)

Thus

$$v_{Nd} = \frac{4.0026}{\cancel{147.9}\ 141{\cdot}9077} \sqrt{\frac{2 \times 2.55 \times 10^6 \times 1.6 \times 10^{-19}}{4.0026 \times 1.661 \times 10^{-27}}}$$

2·51 MeV

$$= 3.12 \times 10^5 \text{ ms}^{-1}$$ (1 mark)

For those that use "mass defect" method, and then say the conclusion "it is impossible", then full marks

The neodymium atom is moving in the opposite direction to the alpha particle.

1 (~~2~~ marks)

c) If the emitted particle had a smaller mass, it would have a smaller momentum. This is because the particle energy depends on the square of the velocity. Hence, the conservation of momentum will result in the neodymium having a smaller momentum, and hence a smaller velocity. (This can also be seen from $p = \sqrt{2mE}$).

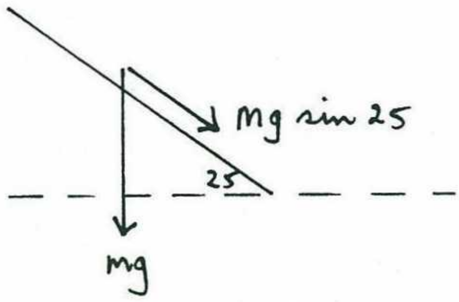
(1 mark)

d) Three means of detecting the alpha particle are

geiger counter	spark chamber
cloud chamber	scintillation screens
photographic film	ionization chamber

2 mark for 3 means
(1 mark for 2 means)

B7. a) Since the child moves at constant speed down the second section of the slide, the force due to friction is equal to the component of the force due to gravity acting parallel to the surface of the slide.



$$F_{friction} = m\,g\,\sin 25$$
$$= 30 \times 9.8 \times \sin 25$$
$$= 124 \text{ N}$$

(2 marks)

b) The force accelerating the child down the first part of the slide is the force due to gravity less the force due to friction. From $v = u + at$, the time required to get down the slope is

t = 1.99s F = 40.4 N (first part of slide)

$$t = {}^{v}/_{a} = {}^{v\,m}/_{F}$$

Thus the average rate of change of kinetic energy is $\Delta E_K = 107.7$ J

$$KE/_{t} = \tfrac{1}{2} m v^2 \times {}^{F}/_{v\,m} = \tfrac{1}{2} F v$$
$$= \tfrac{1}{2} \{ m\,g \sin 34 - m\,g \sin 25 \} \times 2.68$$
$$= 0.183 \text{ Js}^{-1}$$

53.8 Js^{-1}

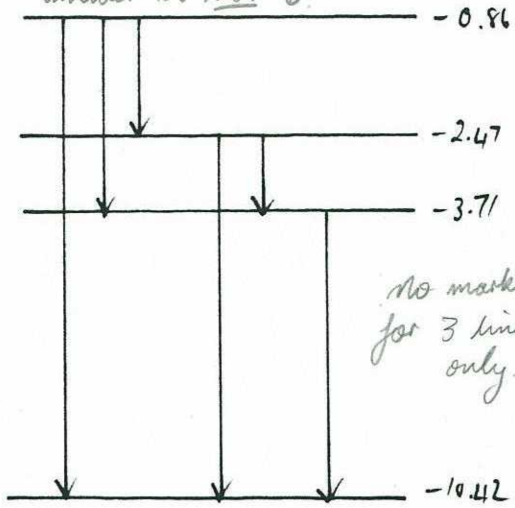
(3 marks)

c) As the child moves down the first section of the slide, potential energy is converted into kinetic energy plus heat energy lost to friction.
Down the second part of the slide, all the potential energy lost is converted into heat due to friction.

1 mark each.

(2 marks)

1 mark for diagram if the answer is not 6.



No marks for 3 lines only.

6 is OK

B8. a) From the diagram, it can be seen that the maximum number of lines which could appear in the line emission spectrum of mercury from the energy levels given is six.

(2 marks)

b) The longest wavelength photon will come from the electron which moves between the two levels closest in energy. This gives the photon an energy of

$$(-2.47 - (-3.71)) = 1.24 \text{ eV}.$$

Hence from

$$hc/\lambda = E$$

$$\lambda = hc/E = 6.63 \times 10^{-34} \times 3 \times 10^{8} / (1.24 \times 1.6 \times 10^{-19})$$

$$= 1002 \text{ nm}$$ 1.00×10^{-6} m

(1 mark)

c) An atom must be excited in order to induce it to emit its line emission spectrum. This can be achieved by various methods, such as heating and electron bombardment. The change that takes place in the atom is that an electron is moved from a low energy level to a higher level.

(2 marks)

d) The major limitation of the Bohr model of the atom is that it applies only to one-electron atoms.

(1 mark)