final answer - units must be correct
- lose 1 mark each time right through paper.

TEE PHYSICS 1995
DRAFT SOLUTIONS

SECTION A

1. Amplitude 0.5 m (± 0.05 m) (2 marks)

   Wavelength 3.0 m (± 0.5 m) (2 marks)
   (Half marks if these are shown on the graph)

---

2. Yes formula $F = \frac{GM_1m_2}{r^2}$ - 1 mark only. (1 mark)

   BP : The universal law of gravitation says that all objects attract one another.

   Newton's 3rd law - equal and opposite forces (action / reaction) - quote 2K (3 marks)
   - must be a mutual force of attraction

---

3. Type of emf : AC (alternating, sinusoidal) (1 mark)

   Increasing the rate of rotation increases the output emf (1 mark)

   The source of electrical energy is the work done in turning the coil. (2 marks)
   external energy input.

---

4. The photon energy is $E = hf = hc/\lambda$

   Hence $\lambda = hc/E$ (2 marks)

   $= 6.63 \times 10^{-34} \times 3 \times 10^{8} / (1.1 \times 1.6 \times 10^{-19})$ 1.12

   $= 1.13\ \mu m$ $(1.11\mu m)$ (2 marks)

---

5. The current through the coils generates a magnetic field. (1 mark)

   Electrons passing through this magnetic field are deflected (1 mark)

   Current through the vertical coils causes horizontal deflection (1 mark)

   Shown on diagram (1 mark)

---

6. The force exerted by a mass of 0.25 kg will stretch the band by about 20 mm. If the band is 50 mm long, 3 marks for estimates

3(⅔ mark)

Hence $Y = Fl / \Delta l\, A = 0.25 \times 10 \times 0.05 / \{0.02 \times 2 \times 10^{-6}\}$ ~~(2 marks)~~

$= 6.2 \times 10^4$ N m^{-2} units are 1 mark (1 mark)

---

7. **BP** : Heating causes the ~~molecules~~ atoms to ionize (ionize is the key point. (re-combination occurs)) electron collisions cause the transition of electrons (2 marks)

Pay as well

Question is incorrect.

Electrons drop through energy levels to generate light. (2 marks)

(Give the two marks for the energy levels if an energy level diagram is produced.) excitation is also O.K.

---

8. Goshium would be more suitable. (1 mark)

can accept "S" if explained clearly.

BP : There is only a small region where plastic deformation occurs (best answer) (3 marks)

Answers involving higher plastic deformation stress or being able to withstand greater stresses can receive 2 marks.

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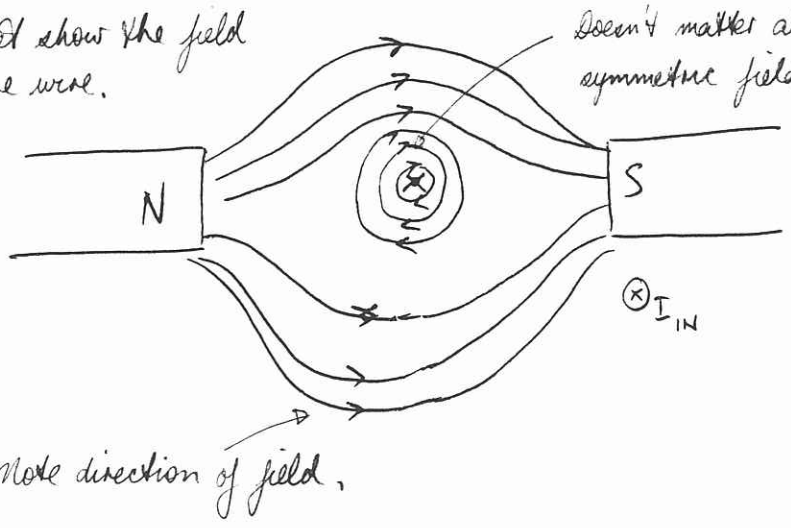
9. **BP** : When running up stairs, you have to do work to increase your potential energy.

(4 marks)

10.



Magnetic field of wire clockwise (1 mark)
Magnetic field from magnets Runs N → S. (1 mark)
Decent shape for total magnetic field squashing at top, spreading out at bottom. (2 marks)

---

11. $F = i l B$ (1 mark)

$= 25 \times 35 \times 10^{-3} \times 33 \times 10^{-3}$ (1 mark)

$= 2.89$ mN (1 mark)

The force is towards you (out of page) for diagram in Q10 (1 mark)

Look carefully at their drawing

---

12. **BP** : Torque depends on both radius and force. (2 marks)

Explanation needs to involve a greater torque on the back wheel exerted by Sally leading to a greater force exerted on the ground. (2 marks)

chain has a greater tension since entire sprocket is smaller

---

13. **BP** : This is solved most easily by estimating a suitable stopping distance and applying the relationship $2as = v^2 - u^2$. Using 50 m for the stopping distance and 60 kph gives a deceleration around ~~3g~~. $\sim \frac{1}{2}g$ range 10-100 m.

(4 marks)

Method is the important thing

Reasonable estimates of quantities - 2 marks (picking the correct quantities is the key point)

Method - 2 marks

---

14. **BP :** The sound waves from the two loudspeakers must be in phase, or there will be destructive interference between the waves from the two speakers.

key to problem.

(is a low frequency problem - not important for answer) (4 marks)

Diagram not important if explanation is good.

Give at least 2 marks for a diagram showing interference between two waves.

---

15. The total sound intensity is calculated from

$$I = I_1 + I_2$$ 2 (½) mark)

$$10^{(dB/10)} = 10^{(dB_1/10)} + 10^{(dB_2/10)}$$

$= 3.14 \times 10^{-3}$ W m^{-2} I_0 has been divided in already. 1 (½) marks)

$dB = 10 \log (3.14 \times 10^{-3}) = 95.0$ dB (1 mark)

< < < < < < < < SECTION B > > > > > > > > >

1.a) **BP** : Sounds of two slightly different frequencies. (electrical pulses OK) (1 mark)
Interference between the two sounds. (2 marks)
Appropriate diagram (2 marks)

b) i) Beat frequency = 1520 cps (2 marks)

ii) It would be audible (1 mark)

c) **BP :** The best answer involves a statement that for beats, there has to be a **small** difference between the two frequencies (i.e., small in relative terms).
(4 marks)

---

2. a) **BP** : The current in the spur line is smaller (1 mark, ✓) (1 mark)
This reduces the power loss along the line according to $P = I^2 R$ (3 marks)

b) The resistance along the wire is $2 \times 70 \times 2.25 \times 10^{-3}$
$= 0.315\ \Omega$ ignore papers with 1 instead of 2 (2 marks)

The total resistance is then $28.8 + 0.315 = 29.115\ \Omega$ (1 mark)

Power delivered = $I^2 R = (240 / 29.115)^2 \times 28.8$ (1 mark)
$= 1957$ W (1978 W if only 1 wire used) (1 mark)

c) **BP** : The total current increases (yes – 1 mark) since total resistance decreases, (Resistors in //) (1 mark)
This increases the line voltage drop using $V = IR$ for each house. 1 (3 marks)

---

3. a) When the satellite is in its orbit, we have

$F = mv^2/r = GMm/r^2$ (2 marks)

Thus $KE = \frac{1}{2} m v^2 = \frac{1}{2} GMm/r$ (1 mark)

$= \frac{1}{2} \times (6.67 \times 10^{-11} \times 9700 \times 5.98 \times 10^{24}) \div (6.37 \times 10^6 + 450 \times 10^3)$ – 1 mark off if this is used

$= 2.84 \times 10^{11}$ J (2 marks)
includes substitution.

b) Mass $= 2.84 \times 10^{11} \div (15.9 \times 10^6)$ J $(\text{J kg}^{-1})^{-1}$

$= 18.9$ Mg 1.89×10^4 kg. (2 marks)

c) **BP** : ~~The fuel is used to supply potential energy.~~ (E_K is less as well) ~~(2 marks)~~
E_p less g decreases with height – 2 marks (1 mark)
worth 2 mark.
Hence **less** than twice the amount of fuel is needed (No) 1 (3 marks)

d) **BP :** At the equator, the surface of the earth is moving fastest, so the satellite already has some of its orbital KE.
(2 marks)

---

4. a) **BP** : ~~The data has to be plotted in the form $y = mx + b$~~ ~~(1 mark)~~
To do this, I would plot l versus $^1/_f$ 2 (½ mark)

b)

l	150	200	250	300	350	400	450	mm
f	513	408	307	263	235	200	157	cps
$1/f$	1.95	2.45	3.26	3.80	4.25	5.00	5.35	$\times 10^{-3}$ cps^{-1}

(2 marks)

4 marks for part (b)
2 marks for slope positivity in (c)
Plotting l vs f – 6 marks only.

Axes and scales (2 marks)
Points plotted correctly (2 marks)
Line of best fit (2 marks)

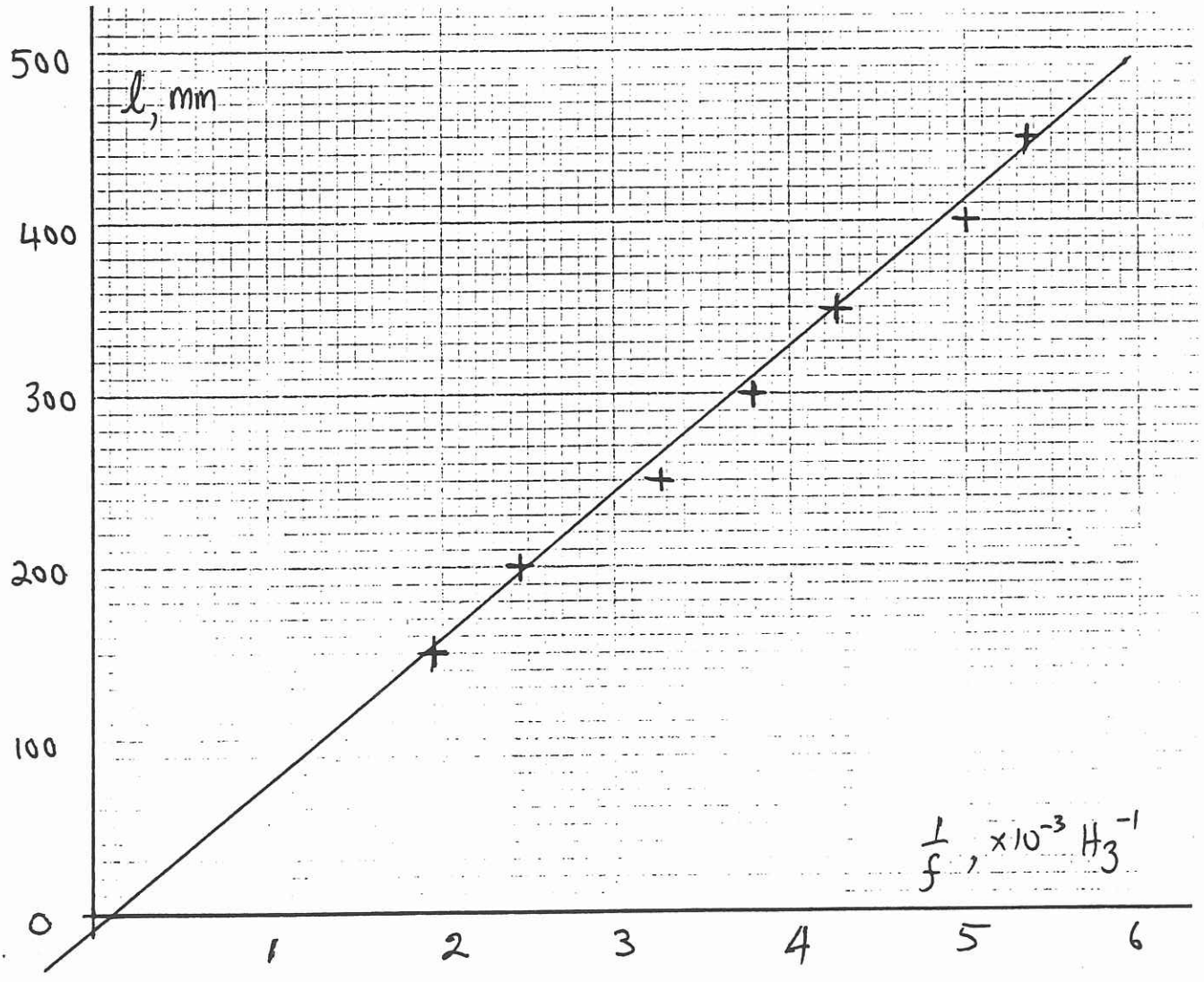
c) i) Slope = $\{ (413 - 0) \times 10^{-3} \} \div \{ (5 - 0.12) \times 10^{-3}) \}$ = ¼ v (2 marks)

v = 338 m s^{-1} Must have graph drawn to get these 3 marks. (1 mark)

(Must be done from the graph! (Not calculator))

ii) intercept = ~~-0.8 mm~~

e = ~~0.8 mm~~, 8.0 mm (check intercept) (1 mark)



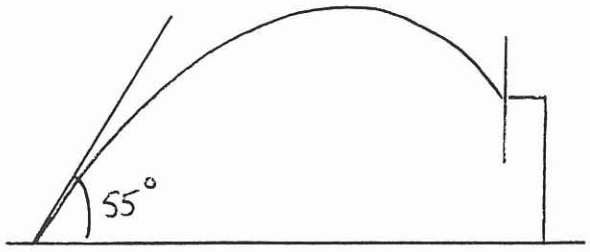
5. a) Initial horizontal velocity

$$v_H = v_0 \cos 55$$

Initial vertical velocity

$$v_V = v_0 \sin 55$$

(2 marks)



The final height of the ball is given by

$$s_V = v_V t + \tfrac{1}{2} a t^2$$

In this expression, the time t is the time taken to travel the horizontal distance. This is given by

$$t = s_H / v_H$$ (2 marks)

Hence the distance travelled in the vertical direction is

$$4.5 = \{ v_0 \sin 55 \times s \div (v_0 \cos 55) \} + \{ \tfrac{1}{2} g s_H^2 \div (v_0 \cos 55)^2 \}$$

(2 marks)

$$4.5 - s_H \tan 55 = \{ g s_H^2 \div (2 v_0^2 \cos^2 55) \}$$

$$v_0^2 = \{ g s_H^2 \} \div \{ 2 \cos^2 55 (4.5 - s_H \tan 55) \}$$

$$v_0 = 33.6 \text{ m s}^{-1}$$

(2 marks)

(Note that in the frame of reference used here, up is positive so that g is negative).

b) If Damien hit the ball too high, it would go under the target.

(1 mark)

No proof by calculation needed.

BP : The ball has a smaller component of horizontal velocity

(1 mark)

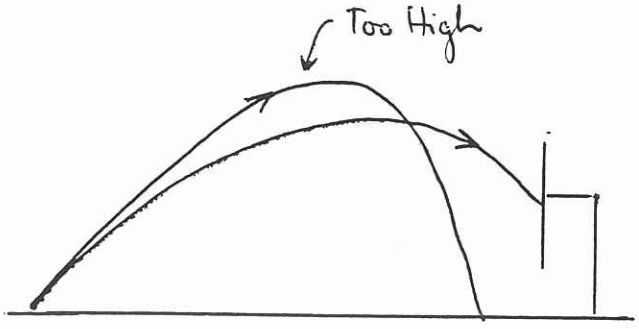


Diagram (2 marks)

6. a) **BP** : An emf is generated in a coil when there is a change in the magnetic flux within the coil. (3 marks)

Faraday's law of induction – 2 marks only.
Electromagnetic induction – 1 mark only.

b) The magnetic field generated by the maximum current in coil J is

$$B = 2.51 \times 10^{-3} \, I$$

Hence the maximum magnetic flux in coil J is $\Phi = B A$ (1 mark)

The magnetic flux in coil K will be the same since the same flux passes through both coils. From Faraday's law of induction,

$$\text{emf} = N (\Phi_2 - \Phi_1) / t = N 2.51 \times 10^{-3} \, I \, A / t$$ (1 mark)

Thus the current is

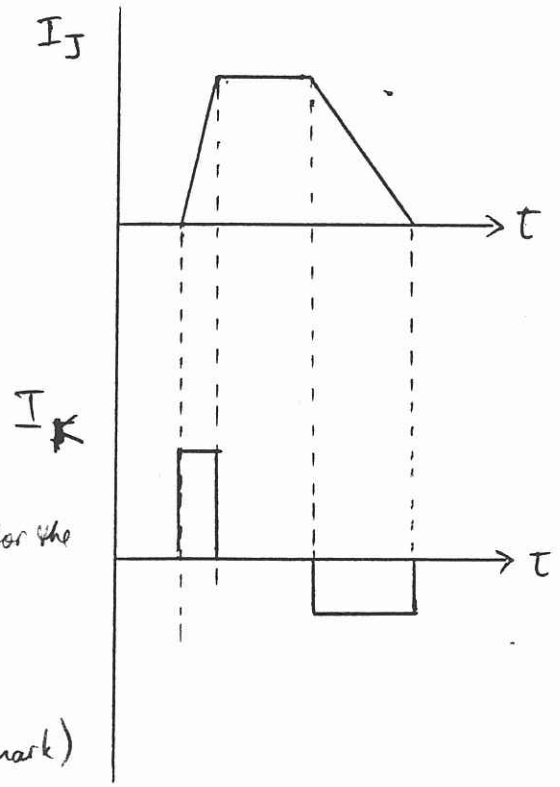
$$I = V/R = 2.51 \times 10^{-3} \times 1.8 \times 2.4 \times 10^{-4} / (0.1 \times 2.25)$$

$$= 4.82 \, \mu A \quad 241 \, \mu A$$ (1 mark)

so

The time taken for the current to fall is twice as great as to rise, so here the current is ~~241 μA~~ 120 μA

Graph (2 marks)



c) **BP** :
The current depends on the time. It takes for the current to change in the primary (1 mark)
which determines the change in flux
The direction of the current depends on the direction of flux change (1 mark)
Magnitude of one current is ½ the other (1 mark)

– Any two will do

d) **BP** : The emf generated is proportional to the number of turns. Hence the current will be greater. (2 marks)

7. a) i) PQ has to be designed to take the greatest force. (1 mark)

BP : The components of the forces exerted at Q are such that SQ has only horizontal components whereas PQ has to provide vertical components as well.
(Give full credit for a clear diagram.)  Vector diagram quickest way. (3 marks)

ii) The centre of mass of the bar is 1.25 m from the end R. The torque exerted by this mass about R is

$$28.8\,g \times 1.25 \;=\; 36\,g \text{ Nm}$$

(2 marks)

The torque exerted about the point R by a person hanging on the end is

$$75\,g \times 0.5 \;=\; 37.5\,g \text{ Nm}$$

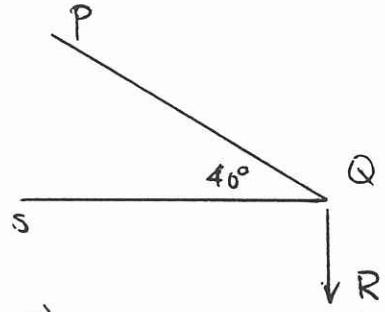
(1 mark)

Therefore the bar does not meet the criterion. (1 mark)

iii) The total downward force exerted at R is

$(75 + 14.4)\,g$

(1 mark)



Hence the vertical component of the force exerted in PQ is

$89.4\,g \;=\; PQ \sin 50 \cos 50^\circ \; (\sin 40^\circ)$ (2 marks)

Hence $PQ = 1363$ N (1 mark)

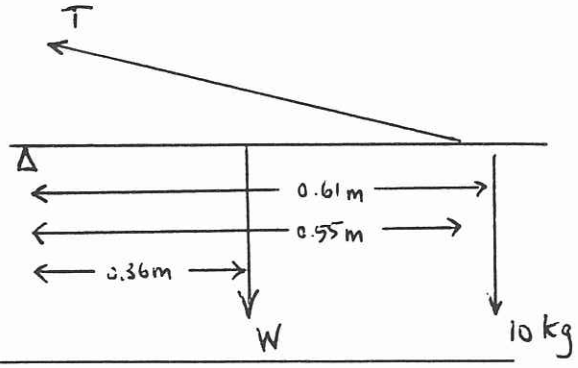
---

7. b) i) **BP** : The tension T is determined by the angle between its line of action and the spine.. Compression in spine is large. T is very large. (2 marks) 4 (½ mark)
There is no component of the force W exerted by the mass which is carried by the spine. Angle/distance from line of action is small (2 marks) (3 marks)
(T is much greater than W – 4 marks)

ii) Taking moments about the pivot,

$(0.55)\; T \sin 12 \;=\; 35\,g \times 0.38 \;+\; 10\,g \times 0.61$ (3 marks)

$T = 1660$ N
(1 mark)



(Diagram 4 marks)

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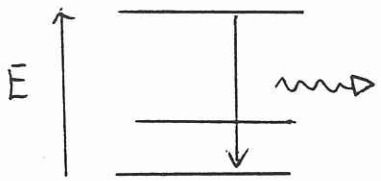
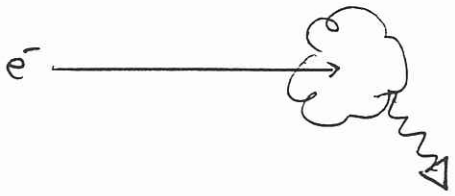
8. a)

i) A suitable example would be line spectra emitted by stars.
(1 mark)



BP : Light is generated when electrons fall between energy levels, which have very definite values.
(2 marks)
(diagram 1 mark)

ii) **BP** : X-rays are generated when electrons are decelerated.
(1 mark)
(diagram 1 mark)



BP : There are free electrons with high energies which can be decelerated.
(2 marks)

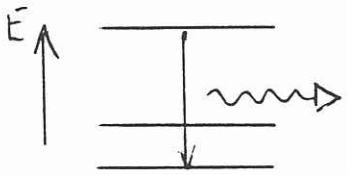
(Alternative answers could involve electrons curving in magnetic fields or changing energy levels deep within the atom).

iii) **BP** : The ozone layer absorbs ultraviolet light. (2 marks)

BP : The increase in ultraviolet light will increase the occurrence of skin cancer.
(2 marks)

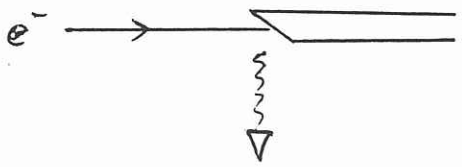
8.b)

i) A suitable example would be the gas discharge tube.
(1 mark)



BP : Light is generated when electrons fall between energy levels, which have very definite values.
(2 marks)
(diagram 1 mark)

ii) **BP** : X-rays are generated when electrons are decelerated.
(1 mark)
(diagram 1 mark)



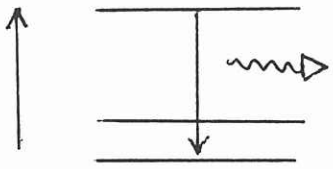
BP : Electrons are thrown at a target where they are decelerated.
(2 marks)

iii) **BP** : X-rays have a large energy and can ionize atoms. (1 mark)

BP : This ionization can affect molecules and hence human tissue. (3 marks)

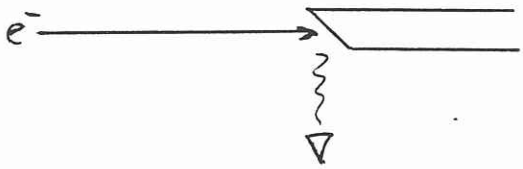
8.c)

i) A suitable example would be a neon sign.
(1 mark)



BP : Light is generated when electrons fall between energy levels, which have very definite values.
(2 marks)
(diagram 1 mark)

ii) **BP** : X-rays are generated when electrons are decelerated.
(1 mark)
(diagram 1 mark)



BP : Electrons are thrown at a target where they are decelerated.
(2 marks)

iii) **BP** : Sunburn is caused by ultraviolet light. (2 marks)

BP : Welders emit ultraviolet light but incandescent globes very little.
(2 marks)

<<<<<<<<<<<< SECTION C >>>>>>>>>>>

1. a) The recycling mirror reflects heat back to the filament.

(1 mark)

This means that the infrared radiation helps to heat the filament.

(2 marks)

Because of this, less current is required to maintain the filament temperature and the globe is more efficient.

(2 marks)

b) i) The transmission in the visible region allows visible light to escape the bulb.

(3 marks)

The high reflectance in the infrared region ensures that the infrared radiation, which is of no value in making anything visible, is reflected back to the filament, helping to maintain its temperature.

(3 marks)

ii) The graph shows that not much energy is radiated in the ultraviolet region

(1 mark)

Therefore the high reflectance in this region is of (some) little value.

no u'v wanted to escape!

(1 mark)

c) 200 kg of coal would be saved by a reduction in ~~energy~~ power consumption of 125 W.

(1 mark)

Therefore, an energy efficient 375 W bulb would consume 3 times this amount, a total of 600 kg.

(2 marks)

2. a) The pressure on the rocks at the bottom of the mountain is so great that the rocks deform.

2(½ mark)

In fact, if the mountain were any higher, the pressure would cause the rock to flow and the mountain would squash sideways.

(2 marks)

(Diagram 2 marks)

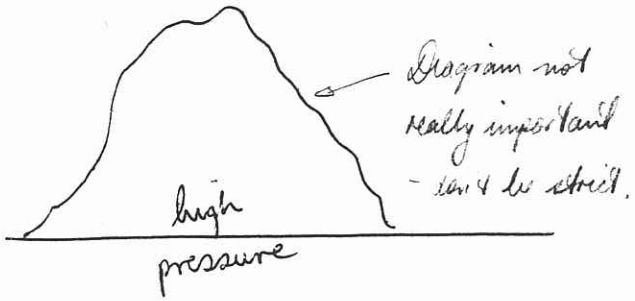


Diagram not really important - can't be strict.

~~Also~~, the rock under the mountain is molten, so to some extent, the mountain "sinks" into the molten rock.

(½ mark)

b) If the material has a different density, then the pressure on the rocks at the bottom would be different since the total mass of the mountain would be different.

(2 marks)

Thus the rocks would reach their plastic flow point for a different height of the mountain. and/or different bond strengths

2 marks

(2 marks)

c) The plumb bob near the mountain will have the gravitational force of the earth exerted on it.

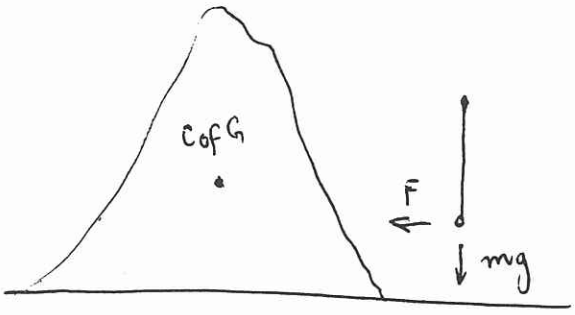
2(½ mark)

However, the mass of the mountain exerts a sideways gravitational force on the plumb bob.

(2 marks)

The vector sum of these two forces means the plumb bob does not point directly to the centre of the earth.

2(½ mark)



d) **BP** : There is an acceleration due to the mass of the earth

(3 marks)

The mass of the mountain adds an extra amount to the acceleration due to gravity.

(5 marks)

The acceleration due to the mass of the earth M is found from

$$F = Mg = G\,M\,m / r^2$$

(1 mark)

Thus the gravitational acceleration due to the earth is

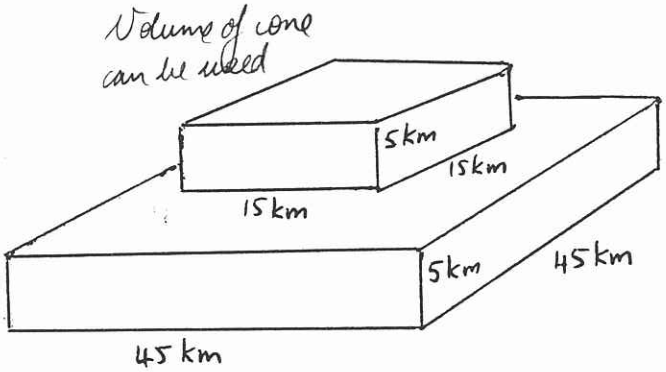
$$g_e = 6.67 \times 10^{-11} \times 5.98 \times 10^{24} \div (6.37 \times 10^6 + 10^4)^2$$

(1 mark)

$$g_e = 9.7991 \text{ m s}^{-2}$$

(1 mark)

To estimate the acceleration due to the mass of the mountain, we need to have a model. A possible model could be two rectangular blocks placed on top of one another.



The acceleration due to the top block is

$$g_t = G\,M / r^2$$

must state

The mass of a block is ρ V, where ρ is the density and V the volume. Assuming the density of the earth is 3000 kg m^{-3}, the acceleration due to the top block is

$$g_t = 6.67 \times 10^{-11} \times 15000^2 \times 5000 \times 3000 \div 2500^2$$

$$= 0.03602 \text{ m s}^{-2}$$

Similarly, for the second block,

$$g_b = 6.67 \times 10^{-11} \times 45000^2 \times 5000 \times 3000 \div 7500^2$$

$$= 0.03602 \text{ m s}^{-2}$$

Hence the total acceleration due to gravity is

$$g = 9.7991 + 0.03602 + 0.03602 = 9.87 \text{ m s}^{-2}$$

Marks :		
	Suitable model	2 marks
	Calculations	2 marks
	Final answer	1 mark