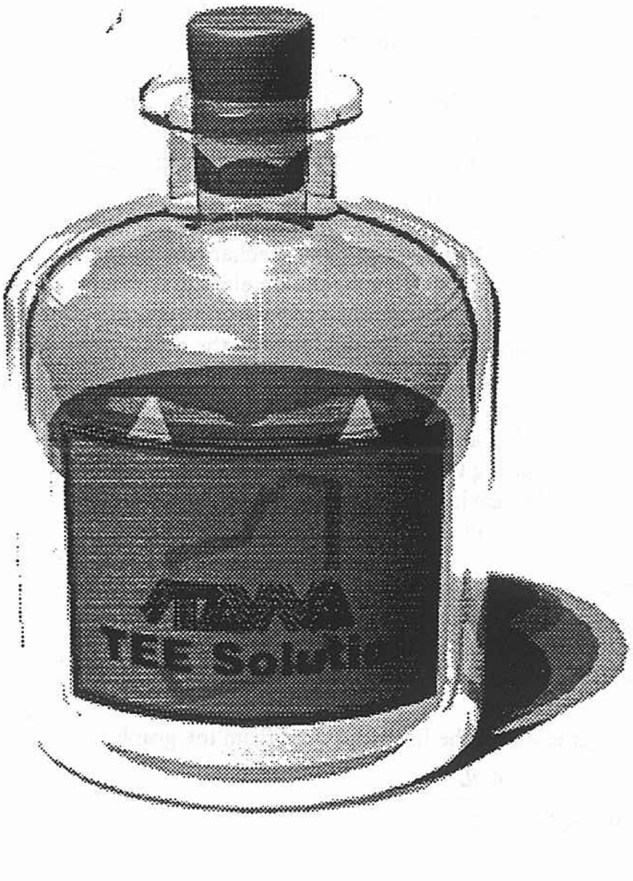
Prepared by the
Science Teachers' Association
of Western Australia (Inc.)

ISSN 0725-6906

Physics

*1997 TEE Solutions**



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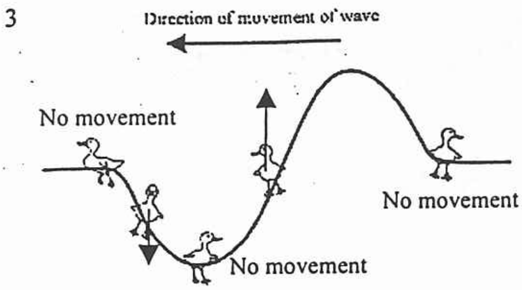
** These solutions are not a marking key. They are a guide to possible answers at a depth that might be expected of Year 12 students. It is unlikely that all possible answers to the questions are covered in these solutions.*

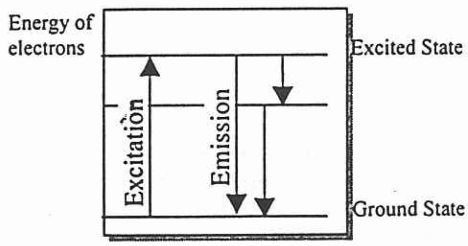
 STAWA appreciates the support of the Curriculum Council, which provided the marker's guides used as a basis for these solutions.

1 The tall cat tips over first.
Because the cat has a high centre of mass in relation to the narrow width of its base, it may be tipped through a smaller angle before the line of its weight force lies outside the area of its base. In that position, the weight no longer produces a restoring torque, but rotates the cat further.

2
$$v = f \times \lambda \qquad E = h \times f$$
$$\lambda = \frac{v}{f} \qquad = 6.63 \times 10^{-34} \times 50\ \mathrm{Jss^{-1}}$$
$$= \frac{3 \times 10^{8}\ \mathrm{ms^{-1}}}{50\mathrm{s}} \qquad = 3.31 \times 10^{-32}\ \mathrm{J}$$
$$= 6 \times 10^{6}\ \mathrm{m\ (to\ 1\ sf)} \qquad = 3 \times 10^{-32}\ \mathrm{J\ (to\ 1\ sf)}$$

3


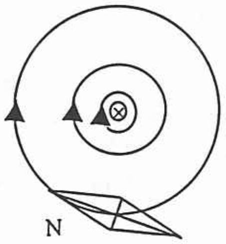
4 Fluorescence is caused when atoms excited by absorbing energy, radiate the energy as light only while the source of excitation is present. The energy is absorbed when electrons in the atoms move to higher energy levels. The energy is then radiated as light when electrons return to their ground state.



5 Choose any two differences...

	Sound	Electromagnetic
Medium	Matter particles	space
Energy type	mechanical	electromagnetic
Vibration	longitudinal	transverse intensities

6 By RH rule, thumb into page, fingers curl clockwise. North of needle forced in direction of arrows.



7 Gravitational force of Moon on Earth or Earth on Moon is...
$$F = G\frac{M_E M_M}{r^2}$$
$$= 6.67 \times 10^{-11}\frac{5.98 \times 10^{24} \times 7.35 \times 10^{22}\ \mathrm{Nm^2Kg^{-2}kgkg}}{\left(3.84 \times 10^{8}\right)^2\ \mathrm{m^2}}$$
$$= 2.00 \times 10^{20}\ \mathrm{N\ (to 3sf)}$$

8 Assume:
Air and water temperature 25°C
Sound travels same distance in each medium.
Pool is 25m long
Approximations:
Speed of sound in air is $346\mathrm{ms^{-1}}$
Speed of sound in pool water is $1510\ \mathrm{ms^{-1}}$
Method:
$$v = \frac{s}{t}$$
$$t = \frac{s}{v}$$
$$t_{air} = \frac{25}{346} = 7.2254 \times 10^{-2} \qquad t_{water} = \frac{25}{1510} = 1.6556 \times 10^{-2}\mathrm{s}$$

$$\text{Difference} = 5.57 \times 10^{-2}\ s$$

9 i) Principle(s):
a) An emf is induced in a conductor when the flux cutting it changes over time.
(Flux cutting the plate changes as it swings so the induced emf produces eddy currents in the conducting plate)
b) The induced emf is in a direction so as to oppose the change. (the eddy currents in the plate lie in the field of the magnet and the magnetic force on these currents opposes the movement)
c) Energy is neither created nor destroyed but may change form. (The mechanical energy of the plate is changed into electrical energy in the eddy currents and then to heat as the resistance of the plate acts on the eddy currents.)

ii) a) Increase the magnetic Field intensity by using a stronger magnet – increases the flux cutting the plate.
b) Increasing the size of the plate – increases the flux cutting the plate

10 The graph of m against f^2 should be linear as the equation is of the form y = mx +b

where y=m, $m = \frac{4\mu L^2}{g}$, x=f^2 and b=0.

The gradient of the line estimated from the graph is
$$\frac{2.2}{10 \times 10^4} = \frac{4\mu L^2}{g}$$

$$= \frac{2.2 \times g}{10 \times 10^4 \times 4L^2}$$
$$= \frac{2.2 \times 9.8}{10 \times 10^4 \times 4 \times (0.585)^2}$$
$$= 1.6 \times 10^{-4}\ kgm^{-1}$$

11 Current in the cables produces I^2R heating.
Eddy currents and heating in tranformers.
Current alternating at 50Hz radiates electromagnetic energy.

12 Brigette's 2500W heater produces ...
2500×60 = 0.15 MJ per minute
2500×3600 = 9.0 MJ per hour.

The heater in the advertisement probably produces between 17 and 25 MJ per hour, though the units have been incorrectly stated as mJ or millijoules and without the 'per hour' and the j is lowercase. The advertised heater will probably be warmer than her existing one.

13 The Faunhofer lines form a line absorption spectrum. The atoms of various elements in the Sun's atmosphere absorb particular wavelengths corresponding to the energy needed to raise electrons to excited energy levels in those atoms.

14

$$\text{EMF} = lv \times B$$
$$B = \frac{\text{EMF}}{lv}$$
$$= \frac{5000}{20.7 \times 10^3 \times 7.92 \times 10^3} \frac{V}{ms^{-1}m}$$
$$= 3.05 \times 10^{-5}\ T$$

15 Assume:
100 close turns of the wire.
Estimate:
Radius of cardboard tube 2.0cm
Method:

$$\text{EMF} = -n\frac{(BA)}{t}$$
$$t = -n\frac{(B)\ \times A}{\text{EMF}}$$
$$= -100 \times \frac{(0-0.12) \times \quad (0.02)}{1}$$
$$= 1.5 \times 10^{-2}\ s$$

SECTION B

1. a) Musical sounds have a periodic pattern of vibration.
Noise has random pattern of vibration.

b) The intensities are additive not the intensity levels so.

The intensity levels are...

For the CD...

$$96dB = 10\log\left(\frac{I_1}{10^{-12}}\right)$$
$$\frac{I_1}{10^{-12}} = \log^{-1}(9.6)$$
$$I_1 = 10^{-12} \times 3.9811 \times 10^9$$
$$= 3.9811 \times 10^3\ Wm^{-2}$$

For the hairdrier

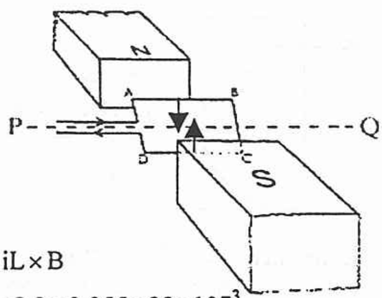
$$99dB = 10\log\left(\frac{I_2}{10^{-12}}\right)$$
$$\frac{I_2}{10^{-12}} = \log^{-1}(9.9)$$
$$I_2 = 10^{-12} \times 7.9433 \times 10^9$$
$$= 7.943 \times 10^3\ Wm^{-2}$$

Now find the intensity level of the sum of the intensities...

$$L = 10\log\left(\frac{I_1 + I_2}{10^{-12}}\right)$$
$$= 10 \times \log((3.9811 + 7.9433) \times 10^9)$$
$$= 100.8\ dB$$

c) The ornament vibrates due to **resonance**. When the frequency of the sounds given out by the CD matches the **natural frequency** of vibration of the ornament, then the ornament will absorb energy from the sound of the CD and begin to vibrate.

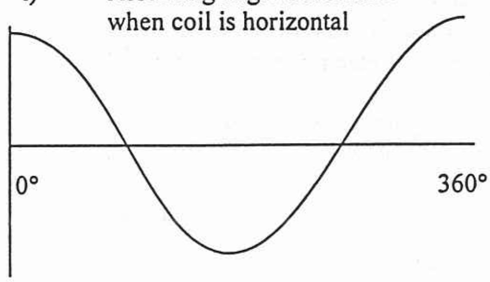
2. a)



b)

$$F = n \times iL \times B$$
$$= 25 \times 2.2 \times 0.055 \times 98 \times 10^{-3}$$
$$= 2.964 \times 10^{-1}$$
$$= 3.0 \times 10^{-1}\ N \text{ (to 2 sf)}$$

c) i) Assuming angle of rotation is zero when coil is horizontal



ii) Maximum torque is when radius to the line of the force is a maximum. Because the force is vertical, this occurs when the coil is horizontal. Minimum torque is when the radius to the vertical force is zero, which happens when the coil is vertical.

iii) You have to provide a commutator to maintain the current in the same direction with respect to the magnet despite the coil being reversed every half turn. This ensures the torque is always positive.

d) Increase:- the current, the strength of the magnets, the number of turns in the coil, the area of the coil (length of the coil and/or the radius of turning), shape the magnets to maintain the field perpendicular to the circumference.

3. a) Using RH rule for + charge then reversing because electrons are negative (or using LH rule for negative charges), a force into the page gives a force to the centre of the circle for the clockwise direction . Choose B

b) i) The electrons experience a magnetic force which is also centripetal so

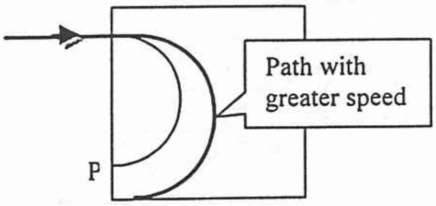
$$F = vq \times B = \frac{mv^2}{r}$$

$$r = \frac{mv^2}{vq \times B}$$

$$= \frac{m}{q \times B} \times v$$

Because electrons have a constant mass and charge and the magnetic field intensity B is constant, then the radius of the electron path depends only on the speed of the electrons v.

ii) Greater v means greater r...



c) Because the energies of the electrons are up to 100keV, x-ray production is possible when the electrons decelerate on collision with metal atoms in the walls.

d) *Assume*:
The examiner means "magnitude of the magnetic field intensity" when "magnitude of the magnetic field" is asked for.
Mass of the electron m= 9.11×10^{-31}kg
Charge of the electron q = -1.60×10^{-19}C
Estimate:
Radius of path r ~ 10cm = 0.1m
Energy of electrons = 50keV (10 to 100keV)
Method:
Calculate estimated speed of electrons...

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

$$v = \sqrt{\frac{2E_k}{m}}$$

$$= \sqrt{\frac{2\times50\times10^3\times1.6\times10^{-19}}{9\times10^{-31}}}$$

$$= 1.33\times10^8\ ms^{-1}$$

$$r = \frac{m}{q \times B} \times v$$

$$B = \frac{m}{q \times r} \times v$$

$$= \frac{9\times10^{-31}}{1.6\times10^{-19}\times0.1}\times1.33\times10^8$$

$$= 7.5\times10^{-3}T$$

e) Protons have opposite charge so you would need to **reverse the magnetic field** ie have it coming out of the page.
Protons have the same size charge so no changes needed there.
Protons have a greater mass than the electrons so you would need a bigger centripetal force for the same velocity and radius. Hence you would need **a bigger magnetic field intensity**

$$B = \frac{m}{q\times r}\times v$$

$$= \frac{1.67\times10^{-27}}{1.6\times10^{-19}\times0.1}\times1.33\times10^8$$

$$= 13.9T$$

4. a) The time of flight to maximum vertical height is best done using the vertical component of the initial velocity.
s = ? t= ? $u_y = 27.5\sin\theta$ $v_y = 0$ $a_y = -9.8ms^{-2}$

$$v_y = u_y + a_y t$$

$$0 = 27.5\sin50 + (-9.8t)$$

$$t = \frac{27.5\sin50}{9.8}$$

$$= 2.15s$$

b) $v_y^2 = u_y^2 + 2a_y s$

$$0 = (27.5\sin50)^2 + 2(-9.8s)$$

$$s = \frac{(27.5\sin50)^2}{2\times9.8}$$

$$= 22.6\text{ m}$$

Add height of start

$$h = 22.6 + 2.10$$

$$= 24.7m$$

c) The time of flight to the ground is again done with the vertical component of the intital velocity.
$s_y = -2.10m$ $u_y = +27.5\sin\theta$ $v_y = ?$ $a_y = -9.8ms^{-2}$

$$s_y = u_y t + \tfrac{1}{2}a_y t^2$$

$$-2.10 = +27.5\sin50t + \tfrac{1}{2}(-9.8)t^2$$

$$4.9t^2 - 21.1t - 2.10 = 0$$

(using binomial theorem or grpahics calc solver)

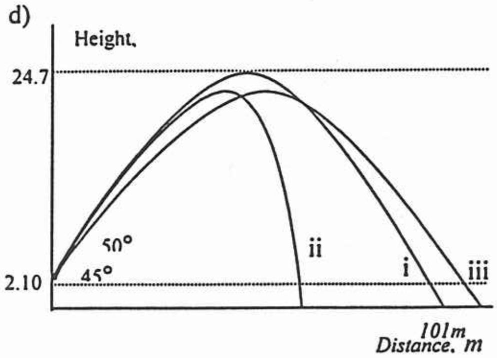
$t = +4.403s$

(or $t = -0.097s$ – discard as before $t = 0$)

Use time of flight in horizontal direction.
s_x = ?, t =4.403s, $u_x = v_x = 27.5\cos50$, $a_x = 0$

$$s_x = u_x \times t$$
$$= 27.5\cos 50 \times 4.403$$
$$= 77.8\text{m (to 3 sf)}$$

d)

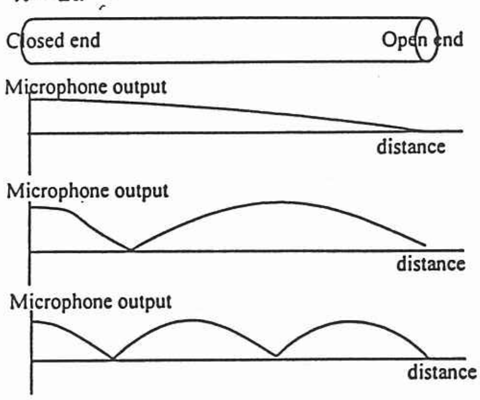


5. a) You can use the loudspeaker connected to the sinewave generator to produce resonance in the closed pipe.

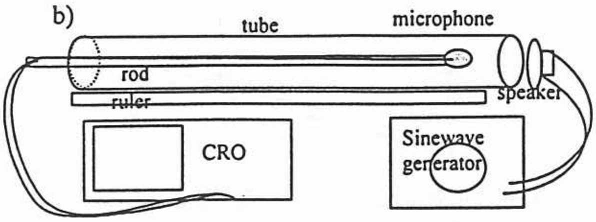
The resonant frequencies of the pipe occur when the following conditions are satisfied...

1st harmonic $\lambda = 4L$
2nd harmonic $\lambda = 4/3L$
3rd harmonic $\lambda = 4/5L$

You find the position of the nodes in a particular resonant frequency, by moving the microphone along the tube with the thin rod. A pressure node occurs when the microphone picks up minimum sound. The distance between any two nodes is half a wavelength of that resonant frequency or
$\lambda = 2d$



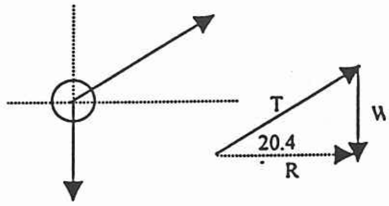
b)



c)

Frequency	Node position	Node position	Internodal distance d	λ= 2d

6. a) There are only two forces on the hammer the resultant of which has to be centripetal.

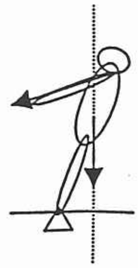


For zero vertical acceleration...
$T\sin\Delta = W$

$$T = \frac{W}{\sin\Delta}$$
$$= \frac{mg}{\sin\Delta}$$
$$= \frac{7.26 \times 9.8}{\sin 20.4}$$
$$= 204\text{N (to 3 sf)}$$

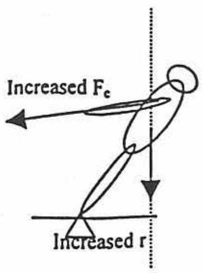
b) Simon has to maintain equilibrium under the action of three forces on him.
Force of hammer (fixed by centripetal force needed at that speed)
Weight (fixed by his mass and the Earth)
Support force by ground.

The only control Simon has for balancing the torques that the hammer and the weight produce around the axis of his feet, is to move the line of the weight force further from the axis by leaning back



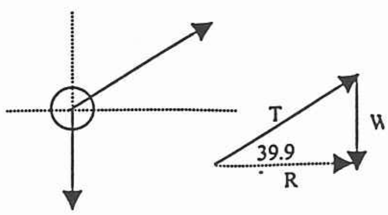
c) If Simon increases the rate of rotation , then the hammer needs a greater centripetal resultant force applied.

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



This increases the force the handle applies to Simon. In order to maintain equilibrium, as explained in part b, Simon will have to increase the balancing torque of his fixed weight by leaning back further and increasing the radius to the line of the force.

6. a) There are only two forces on James, the resultant of which has to be centripetal.



For zero vertical acceleration...

$T\sin\Delta = W$

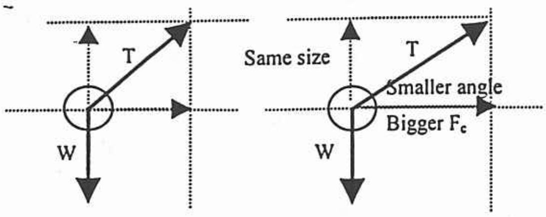
$$T = \frac{W}{\sin\Delta} = \frac{mg}{\sin\Delta} = \frac{50\times9.8}{\sin39.9} = 764 \text{ (to 3 sf)}$$

b) James does nor fall out of his seat because both James and the seat are accelerating at the same rate. The resultant of his weight and the force from the seat is centripetal. The resultant of its weight, James pressing on the seat and the pull of the chains is centripetal.

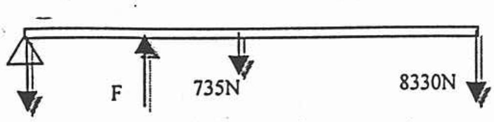
c) Increasing the speed of rotation means that James needs a greater centripetal force.

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

James's weight is fixed so the tension has to supply the same vertical component but a greater horizontal component. To do this, the tension rises and the angle to the horizontal decreases.



7. a) 75kg = 75×9.8=735N 850kg=850×9.8=8330N



Take moments around the attachment to the LH end. (assuming the point of attachment is at the end of the board)

Σ“ $= (F\times1.5)-(735\times2.25)-(8330\times5.5)$

$F\times1.5 = 1654+45815$

$$F = \frac{47469}{1.5} = 3.16\times10^4\text{ N}$$

b)

$$\text{Stress} = \frac{F}{A}$$

$$A = \frac{F}{\text{Stress}} = \frac{3.16\times10^4\text{ N}}{3.0\times10^8\text{ Nm}^{-2}} = 1.1\times10^{-4}\text{ m}^2$$

c)

$$Y = \frac{F/A}{\Delta L/L}$$

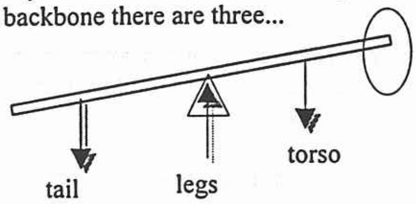
$$\Delta L = \frac{1}{Y}\times\frac{F}{A}\times L = \frac{3.0\times10^8\times0.3}{1.93\times10^{11}} = 4.7\times10^{-4}\,m$$

d) You need a large downwards force at the left end of the board to balance the other three forces. E.g.

$\Sigma F = C-31600+735+8330 = 0$

$C = 2.3\times10^4\,N$

7. a) If you consider the forces acting on Albert's backbone there are three...



To maintain equilibrium, the torques around the pivot formed by the legs have to be equal and opposite. The head and torso produce a clockwise moment and the tail therefore has to produce an anticlockwise moment to balance it.

Σ“ $= (W_{tail}\times r_{tail})-(W_{torso}\times r_{torso}) = 0$

b)

$$\text{Stress} = \frac{F}{A}$$

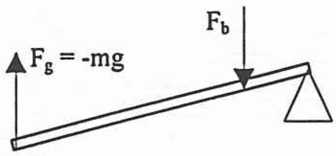
$$A = \frac{F}{\text{Stress}} = \frac{1500\times9.8\text{N}}{1.8\times10^8\text{ Nm}^{-2}} = 8.2\times10^{-5}\text{ m}^2$$

c)

$$Y = \frac{F/A}{\Delta L/L}$$

$$\Delta L = \frac{1}{Y}\times\frac{F}{A}\times L = \frac{1.8\times10^8\times0.5}{0.17\times10^{11}} = 5.3\times10^{-3}\,m$$

d)



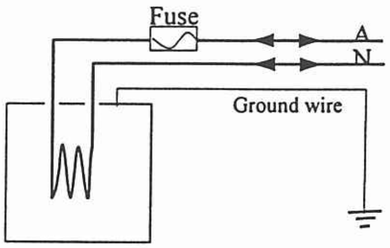
Take moments around the RH end.

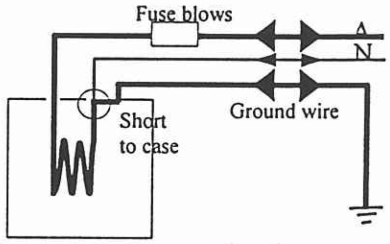
Σ“ $= (F_b\times0.11)-(F_g\times0.65) = 0$

$$F_b = \frac{1500\times9.8\times0.65}{0.11} = 8.7\times10^4\text{N}$$

SECTION C

1. a) According to this article a ground is "a short circuit to the ground, capable of handling all the current in the circuit". **Unfortunately paragraph 2 does not explain how a ground can protect you against electrocution. Neither does any of the other paragraphs!**
The earth wire in a household wiring system connects the exposed metal case of any appliance to the ground as in paragraph 3, however its primary function is to draw a high current and blow the fuse if the active wire ever shorts to the case. This safety feature is designed to work as soon as a faulty appliance is turned on. A person sould never be exposed to the live metal case as a consequence.





b) The ground wire should make good contact with the soil so as to reduce the resistance. This ensure a current high enough to blow the fuse when a fault occurs.

c) 1 electrocution 2 heating causing fire

d) A nail is capable of withstanding the high current caused by a short circuit, or by too many appliances, withour blowing. The case can become live without the fuse blowing or excess current may produce heating and fire in the wiring.

e) Assuming the worse case resistance of the skin as 1000R with damp hands and one hand on active and one hand on neutral or earth...

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

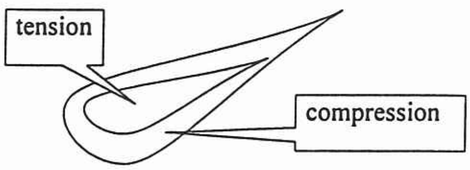
$$I_{Australia} = \frac{240}{1000} \qquad I_{USA} = \frac{120}{1000}$$

$$= 0.240 \qquad = 0.120$$

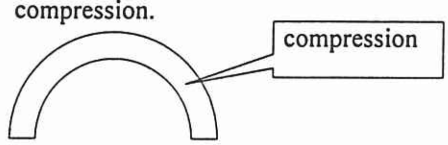
$$= 240mA \qquad = 120mA$$

Both of these current are above the 100-300mA needed to cause ventricular fibrillation and death. The American voltage produces half the current for the same resistance which may reduce the damage. However American appliances would have to draw greater current for the same power increasing the risk of excessive heating in the wiring and greater danger of fire.

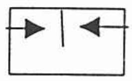
1. a)



b) Hooke said that the outer part of the glass drop is under compression just like an arch is under compression . If you take out a segment of an arch, you lose the compression and the structure crumbles. The glass drop also crumbles if you scratch the compressed surface, losing the compression.

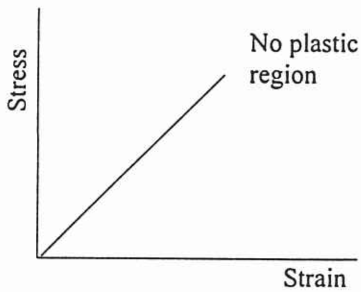


c) The microcracks ar normally in the compressed surface region of the drop so the cracks are held together and can't split any further.



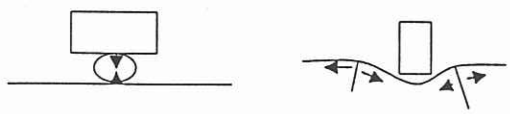
Bending the tail puts the surface under tension which allows the cracks to split wider

d)



As the stress increases, the sample of glass changes size in proportion. The glass fractures suddenly at its elastic limit rather than undergoing rapid change of size with stress which happens with ductile materials.

e) A hammer blow would increase the pressure in the surface of the drop. This would tend to keep the microcracks even more strongly closed and prevent them extending and shattering the drop. Being much smaller than the hammer head, it is unlikely that the hammer surface could bend the glass drop surface inwards to produce tension as it would if it hit a piece of glass wider than the hammer head.



Compression Tension.