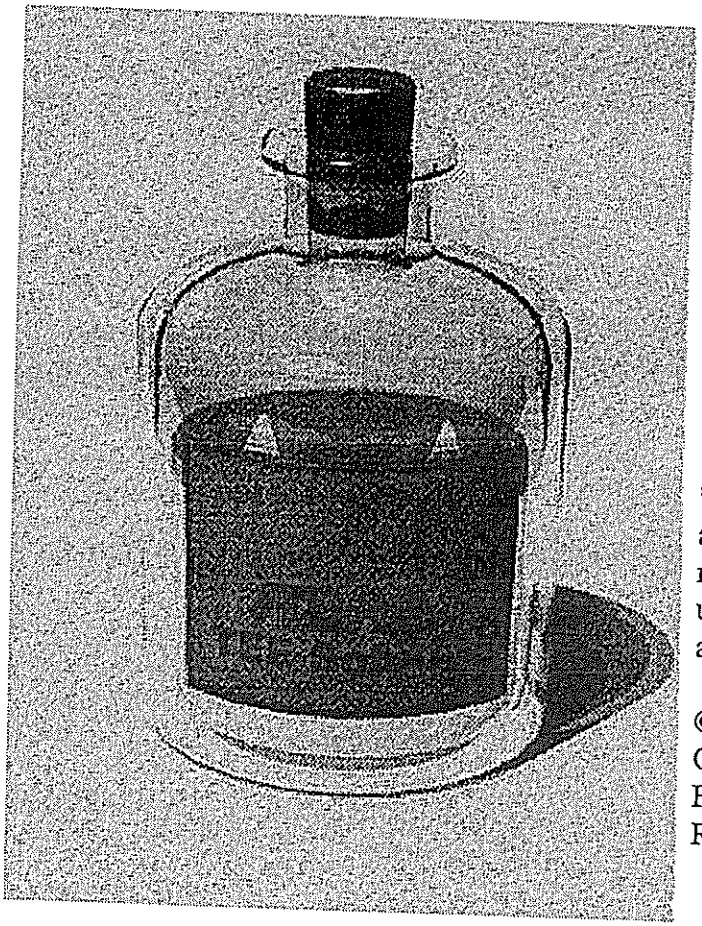
Prepared by the Science Teachers' Association of Western Australia (Inc).

ISSN 0725-6906

Physics

2002 TEE Solutions*



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*These solutions are not a marking key. They are a guide to the 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.

 acknowledges the support of the Curriculum Council and in particular the TEE Examining Panel members: Dr Ian Bailey, Dr Ralph James, Mr Jeff Cahill.

2002 Physics TEE solutions
Section A.

1. Turns ratio = 1 : 3 so $V_{out} = 120 \times 3 = 360$ V

2. RH grip rule: Force to the left ⟵⊗

3. Estimate the mass of child = 40 kg (weight = 40 x 9.8 N)
Estimate the distance from the pivot = 2.5 m
Torque = Fr = 40 x 9.8 x 2.5
= 980 Nm

4. From the data sheet, take IR frequency as 1×10^{13} Hz
$E = hf$
$= 6.63 \times 10^{-34} \times 10^{13}$
$= 6.63 \times 10^{-21}$
$1 \text{ eV} = 1.6 \times 10^{-19}$
so $E = 6.63 \times 10^{-21} / 1.6 \times 10^{-19}$
$= 0.04$ eV

5. a) A represents the period of the wave
b) B represents the wavelength of the wave
c) $v = \lambda/T = 2/4$
$= 0.5 \text{ ms}^{-1}$

6. Answer B is correct
A change of magnetic flux around a conductor always produces an emf in the conductor (Lenz's Law) In ring S there will be no current (broken circuit) but there is still a voltage.

7. A filament lamp emits a continuous spectrum (all wavelengths). This is because a filament is an incandescent solid and no specific energy levels, which might give rise to a line spectrum

8. There will be 7 x half waves in 1 metre so nodes will be 1/7 m apart. The hammer can hit any one of these nodes so striking distance will be 143 mm from one end (or 286 mm etc).

9. The dual properties light exhibits are the properties of both a particle and of a wave.
Light as a particle examples: photoelectric effect, Compton scattering.
Light as a wave examples: diffraction, polarisation, interference.

10. $g = GM/r^2 = \dfrac{6.67 \times 10^{-11} \times 1.48 \times 10^{23}}{(2.63 \times 10^{6})^2}$
$= 1.43 \text{ ms}^{-2}$

11. Minimum force when moons are furthest apart

$r = 1.07 \times 10^9 + 4.22 \times 10^8$

$= 1.492 \times 10^9$ m

$$F = Gm_1 m_2 / r^2 = \frac{6.67 \times 10^{-11} \times 8.89 \times 10^{22} \times 1.48 \times 10^{23}}{(1.492 \times 10^9)}$$

$= 3.96 \times 10^{17}$ N

12. Assume mass of Io $= 300 \times 5.98 \times 10^{24}$

$= 1.794 \times 10^{27}$ kg

$$v^2 = GM/r = \frac{6.67 \times 10^{-11} \times 1.794 \times 10^{27}}{4.22 \times 10^8}$$

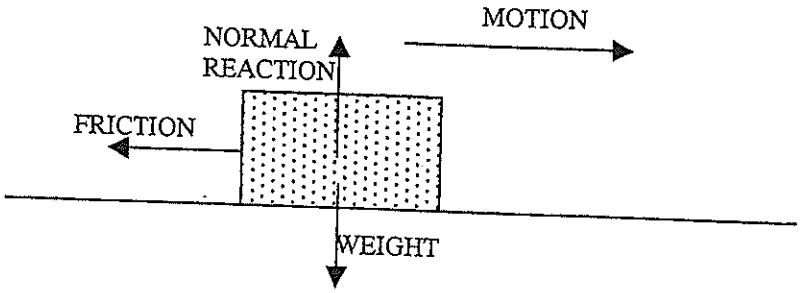
$v = 1.684 \times 10^4$ ms^{-1}

$= 2\pi \times 4.22 \times 10^8 / T$

So $T = 1.575 \times 10^5$ s

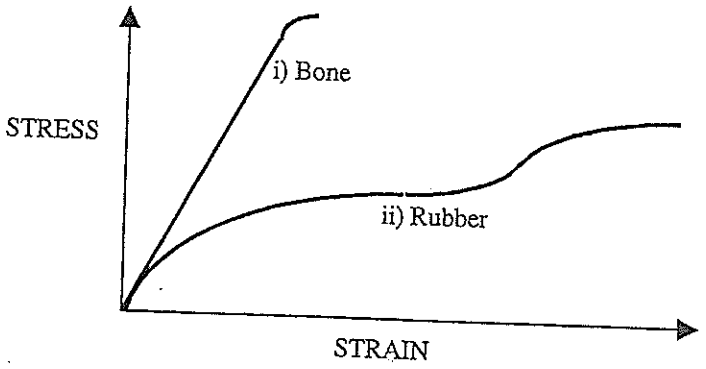
$= 43.7$ h

13.



14. The statement is FALSE. A charge moving constitutes a current. Any current flowing will produce its own magnetic field (circular around it).

15.



Section B

1. a) i) $0.23\ \text{MeV} = 2.3 \times 10^5 \times 1.6 \times 10^{-19}\ \text{J}$

$= 3.68 \times 10^{-14}\ \text{J}$

$= 1/2\ mv^2$

so, $v = 3.68 \times 10^{-14} \times 2 / 1.67 \times 10^{-27}$

$= 6.65 \times 10^6\ \text{ms}^{-1}$

$$r = mv/Bq = \frac{1.67 \times 10^{-27} \times 6.65 \times 10^6}{0.35 \times 1.6 \times 10^{-27}}$$

$= 0.198\ \text{m}$

ii) r will increase because r is directly proportional to v, which is directly related to kinetic energy - from $r = mv/Bq$

b) i) $E = hc/\lambda$ $\quad 3.68 \times 10^{-14} = \dfrac{6.63 \times 10^{-34} \times 3 \times 10^8}{\lambda}$

$\lambda = 5.40 \times 10^{-12}\ \text{m}$

ii) This wavelength is in the γ ray region.

c) i) The atmosphere absorbs photons and slows down particles, reducing their energy. The energy absorbed will ionise the atoms of air and re-emit less harmful radiation that will later reach the Earth's surface.

ii) Gamma rays have very high energy due to their short wavelength and hence are very ionising. When a cancerous cell is ionised it will be destroyed but if the radiation is in a narrow beam normal body cells will survive.

iii) X-rays are used because they have a high energy and can penetrate metals (also less diffraction). The amount of absorption of the rays depends on the density of a material so the welds with cracks will absorb less rays. In an x-ray photograph this will show up as a light area.

2. a) Intensity level $= 10 \log(10^2/10^{-12}) = 140\ \text{dB}$

b) For 60 dB intensity $= 10^6 \times 10^{-12}$

$= 10^{-6}\ \text{Wm}^{-2}$

With inverse square law: $I_1/I_2 = d_2^2 / d_1^2$

so $10^2 / 10^{-6} = r^2 / 1^2$

so $r^2 = 10^8\ \text{m}^2$

Therefore $r = 10^4\ \text{m}$

c) 60 dB gives $I = 10^{-6}\ \text{Wm}^{-2}$

so for 6 parrots $I = 6 \times 10^{-6}\ \text{Wm}^{-2}$

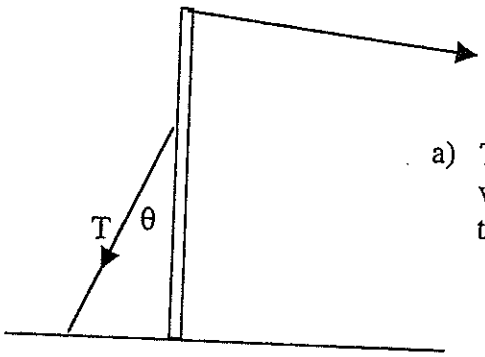
$L = 10 \log (6 \times 10^{-6} / 10^{-12})$

$= 10 \log (6 \times 10^6)$

$= 67.8\ \text{dB}$

d) Energy is transferred to the bell by forced oscillations. The sound frequency matches the natural frequency of the bell so it will be caused to resonate.

3.



a) The clockwise torque about the base from the electric wire is balanced by the anticlockwise torque provided by the cable in the ground.

b) $\tan\theta = 10/4$

$\text{so } \theta = 21.8°$

$\Sigma ACT = \Sigma CT$ about the base:

$T \sin 21.8 \times 10 = 1500 \sin 87 \times 12$

$T = 4840\ N$

c) $E = 9 \times 10^9$

take radius of pole = 0.25 m [area = 0.196 m^2]

F compressing pole = $4840 \cos 21.8$

$= 4494\ N$

$$e = Fl / EA = \frac{4494 \times 10}{9 \times 10^9 \times 0.196}$$

$= 25.5\ \mu m$

4. a) The rod has to pull inwards to provide the centripetal force on the balls. The tension in the rod will make it stretch and fracture when this value exceeds the tensile strength. This will occur when the frequency of rotation is large.

b) Copper breaking stress = 4.9×10^8

$= F/\pi(3.4 \times 10^{-3})^2$

$\text{so } F = 1.78 \times 10^4\ N$

$= mv^2/r$

$$\text{so } v^2 = \frac{1.78 \times 10^4 \times 8 \times 10^{-2}}{0.18} = 7.91 \times 10^3$$

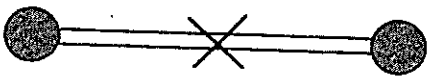
$\text{so } v = 88.9\ ms^{-1}$

$v = 2\pi rf$

$\text{so } f = 88.9/2\pi \times 0.08$

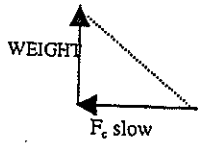
$= 177\ Hz$

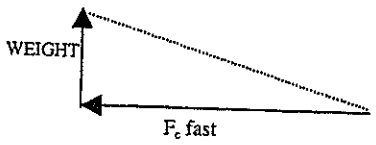
c) i)



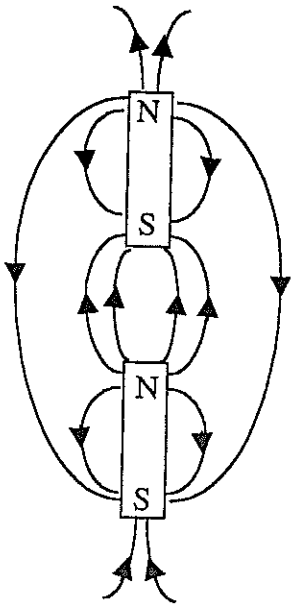
ii) The centripetal force on the ball equals the tension in the rod. This tension creates a torque on the shaft which is constantly changing direction, bending the shaft in different directions and causing a vibration.

d) With a faster rotation more centripetal force is exerted, making the horizontal vector in the triangle of forces larger.
The string hangs along the resultant of these two forces and so the angle will get smaller as the vector triangle changes.

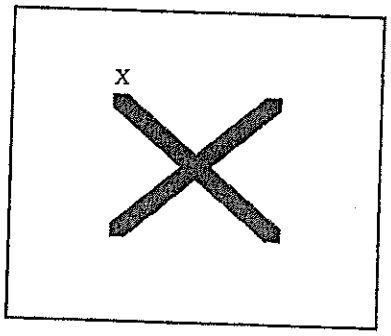




5. a)



b)



A is the correct answer
Reasons: Maximum flux change occurs when the poles are in the centre
The emf reverses as opposite poles pass through.

6. a) i) $s_h = u\cos 50 \times t$
s_h = horizontal displacement, u = initial launch velocity, t = elapsed time.
ii) $s_v = u\sin 50 \times t - 4.9t^2$
iii) Vertically
$u_v = u\sin 50$
$a = -9.8$
$t = 20/u\cos 50$
$s = (12 - 3.2) = 8.8$ m

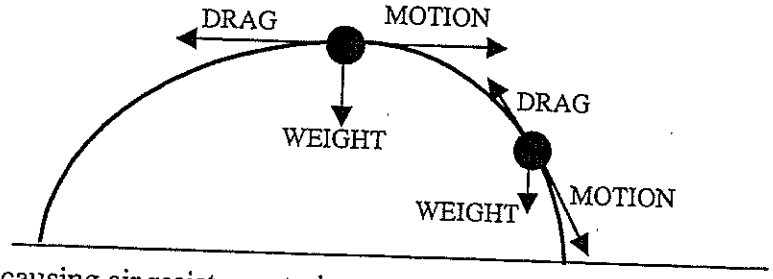
$s = ut - 4.9t^2 \longrightarrow 8.8 = \frac{20\,usin50}{ucos50} - 4.9\left(\frac{20}{ucos50}\right)^2$

$8.8 = 23.83 - 4744/u^2$

$u = 17.8\ ms^{-1}$

iv) The speed is about 64 kmh^{-1} which seems reasonable for a motorcycle, although the angle is very steep for a m/c to hit at that speed.

b) Example given (golf ball, footy ball, etc)
(Diagram must show asymmetry)



Factors causing air resistance to increase: area of ball, velocity, density of air, etc.

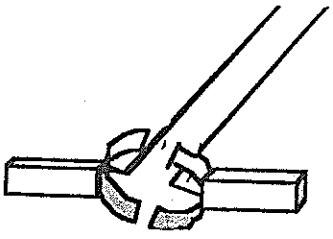
7. a) i) Frequency f = 83.3 Hz

ii) $P = V^2/R$
$= 4.4^2/1.1$
$= 17.6$ W

b) $\mathcal{E} = -Nd\phi/dt$

so $4.4 = 400\phi(4 \times 83.3)$ [flux changes 4 x 83.3 times per second]
$\phi = 3.3 \times 10^{-5}$ Wb = BA [$A = 1.4 \times 10^{-4}$]
B = 0.236 T

c)



Split rings and brushes system

The split ring system causes the induced current to be transferred to a brush and just as it is about to reverse it disconnects. The split ring/brushes system causes the current to be reversed every 180° so the polarity of the current at one brush is always the same.

Section C. Comprehension

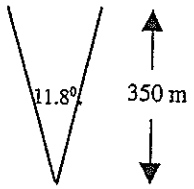
a) i) About 1.2 s $2d/1.2 = 346$
so $d = 208$ m (estimate)
ii) There and back: 900/346
$= 2.6$ s (or 1.3 s if just back)
iii) v will be greater as $v \propto 1/\rho$

b) $I_0 = 10^2\ Wm^{-2}\ I$
$= 3.16 \times 10^{-7}$
so ratio $= 3.16 \times 10^{-9}$

c) i) $B = v^2\rho$ Units $= (ms^{-1})^2 \times (kg/m^3) = kgm^{-1}s^{-2}$
ii) $\rho = 1.2\ kgm^{-3}$ (data sheet) and $B = v^2\rho = 346^2 \times 1.2 = 1.4 \times 10^5\ kgm^{-1}s^{-2}$

d) i) Line of best fit does not go through (5, 5)
ii) Slope $= 1.02 \times 10^{10}$
iii) $1.02 \times 10^{10} = \frac{v^2}{1/\rho} = 8.45 \times 10^4 \times B$
$B = 1.21 \times 10^5\ kgm^{-1}s^{-2}$

e) i) Diffraction
ii) θ decreases as $\theta \propto {}^1/a$
iii) $\lambda = 346/1650 = 0.21$ m so $\theta = \frac{140 \times 0.21}{2.5} = 11.8^0$
so width at top $= 350\sin 11.8^0 = 71$ m



f) i) An uncertainty in measuring the inversion height would lead to a variation in the times for the sound to return (echo times on graph are not all on the same straight line). A variation in times can come about in various ways eg if the density of the air varies over the day then this will affect the speed of sound and the time for the pulses to return which will lead to some uncertainty in the time value.

ii) (Some kind of calculation is required here as an estimate).
Example: If the density of air varies from 1.2 kgm^{-3} (on data sheet) to 1.3 kgm^{-3}, say, then, using $v = (B/\rho)^{1/2}$, the new value of v will be $(1.4 \times 10^5/\ 1.3)^{1/2}$ [using the value of B found in question d (iii)]. This gives $v = 328\ ms^{-1}$ which is a 5% change in the velocity of sound value and will lead to a 5% change in the time to be reflected from the inversion layer.

g) The intermolecular forces in steel are large as it is a solid so the bulk modulus will be large. This leads to a higher velocity of sound than in air.