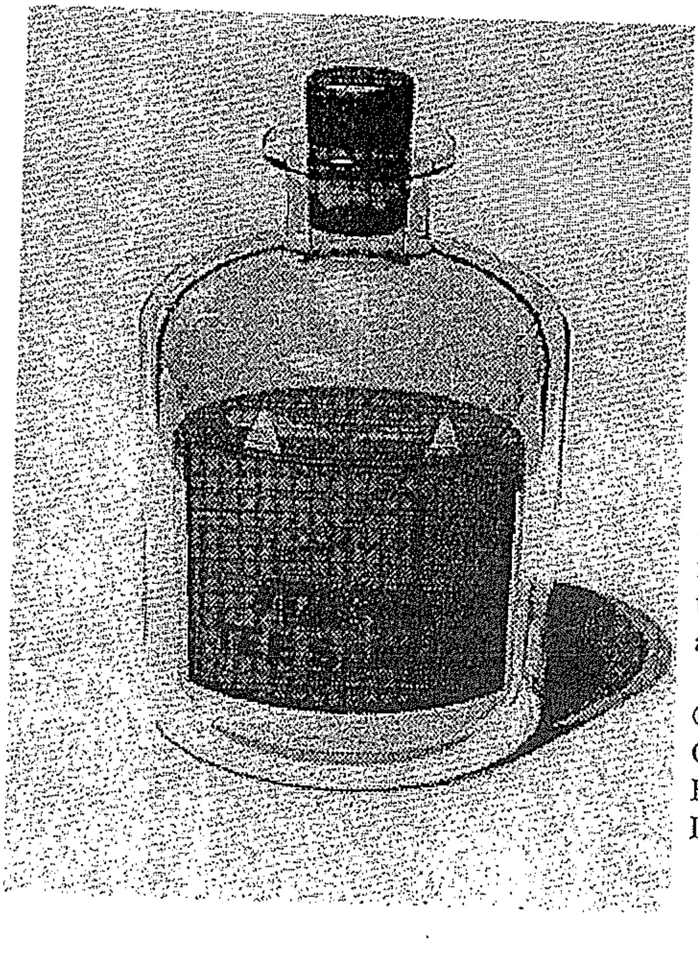
Prepared by the Science Teachers' Association of Western Australia (Inc).

ISSN 0725-6906

Physics

2005 TEE Solutions*



Production, Distribution and Sales:
Science Teachers' Association of Western Australia (Inc).
PO Box 1099
Osborne Park 6916

Question papers and solutions can be obtained from:
The Curriculum Council
27 Walters Drive
Osborne Park 6017

*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.

 STAWA acknowledges the support of the Curriculum Council and in particular the TEE Examining Panel members: Dr Shelley Yeo, Dr Dimitri Fursa, Mr Jeff Cahill.

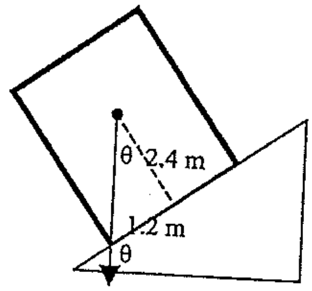
TEE physics Solutions 2005

Section A

1. Estimate the diameter of the rope circle as 0.8 m Periodic time = 0.5 s

$$\text{Speed} = \frac{2\partial r}{t} = \frac{2\partial \times 0.8}{0.5} = 10\ \text{ms}^{-1}\ \text{(2sf)}$$

2. Toppling will occur when the vertical line through the centre of mass goes to the left of the corner point (greater than angle θ).



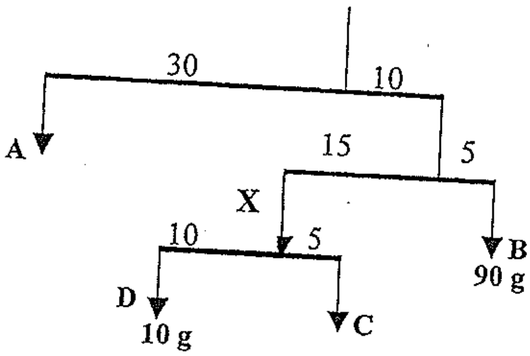
$\tan\theta = 1.2/2.4$
$\theta = 26.6°$

3. Pulse length = 0.1×10^{-6} s
Number of waves emitted per second = 3.3×10^{9}
Hence number of waves in the pulse = $3.3 \times 10^{9} \times 0.1 \times 10^{-6} = 330$

4. Acceleration at Q is towards the centre (upwards)
Acceleration at P must be tangentially down as this is the next direction of movement
Hence the answer is A

5. Starting at the middle rail:
$\Sigma ACT = \Sigma CT$
$5 \times 90 = 15X$, so $X = 30$ g
$B + X = 120$ g

Top rail: $10 \times 120 = 30A$
$A = 40$ g



6. $M_{Astronaut} = 780/9.8 = 79.6$ kg
$M_{mars} = 5.98 \times 10^{24} \times 0.107 = 6.40 \times 10^{23}$ kg
$R_{mars} = 6.37 \times 10^{6} \times 0.529 = 3.37 \times 10^{6}$ m

Weight of astronaut on mars = $\frac{GM_{astronaut} x M_{mars}}{R^2}$

$$= \frac{6.67 \times 10^{-11} x 6.4 \times 10^{23} x 79.6}{(3.37 \times 10^{6})^2} = 299\ \text{N}$$

7. Answer is B
Reason: Both balls have the same horizontal velocity as their original PEs are equal. The upper ball's gravitational acceleration has no effect on its horizontal displacement so the top ball lands on top of the lower ball.

8. At X (loud) there must be constructive interference, so the path difference between the two waves must be λ, 2 λ, 3 λ, …. Etc.

Length $S_2X = \sqrt{6^2 + 8^2} = 10$ m
Path difference $(S_2X - S_1X) = 10 - 6 = 4$ m, so λ must be 4 m or 2 m.

9. Voltage drop across the extension lead = IR = 4 x 0.5 = 2 V
Voltage supplied at lamp 2 = 12 – 2 = 10 V and its current = 4 A
So the power used by lamp 2 = VI = 10.0 x 4.0 = 40.0 W

10. The function of a transformer is to change the useable voltage to a higher or lower value (in this case to power the clock).
Transformers are designed to dissipate heat so for the transformer to be damaged some fault must be present e.g.
- coil has been shorted (break in a wire), so excessive current is drawn
- core has not been laminated properly, so excessive eddy currents can flow
- incorrect alloy used to make the core
- poor insulation so heat from the stove reaches the transformer

11. a) When the current is turned on in the primary coil a flux is generated which links the secondary coil. A momentary flux change in the secondary coil induces a voltage by Lenz's Law
b) With the switch closed a constant current flows and hence the flux in the secondary remains constant. By Lenz's Law, with no change of flux, no voltage will be induced and hence no current will flow.

12. Answer is B
Explanation: As the magnet is moved to the left at the back of the disc eddy currents will be set up in the disc that flow to oppose the motion of the magnet. This opposing magnetic force is repulsive at the front and attractive at the back and so it will push the disc backwards, to the left.

13. With the temple:
The many columns provide a large area of stone under compression
The lintel spans are small so the tensile force on underside is reduced
With the skeleton:
The thick vertical leg bones are only under compression
The neck of the femur is under tension but is short which reduces the shear stresses present.

14. Answer is A
Explanation: The castle and the ball are both in orbit around the Earth so when the ball is released it continues to orbit at the same height adjacent to the castle.
C is wrong because a satellite cannot be in geosynchronous orbit unless it rotates around the equator.

15. a) Assuming two pins on each side of the walkway supporting it:
Weight supported by each = $\frac{2000 \times 9.8}{2} = 9800\ N$

b) With two separate posts pin Y must now support the upper and the lower walkways i.e. must exert a force of 19600 N. hence it will be less safe.

Section B

1. a) $$\text{Power} = \frac{E}{t} = \frac{1.5 \times 10^6 \times 2}{5} = 6.0 \times 10^5 \text{ W}$$

b) $$I = \frac{P}{A} = \frac{6 \times 10^5}{4\pi(50)^2} = 19.1 \text{ Wm}^{-2}$$

$$\text{Level} = 10 \log\left(\frac{19.1}{10^{-12}}\right) = 133 \text{ dB}$$

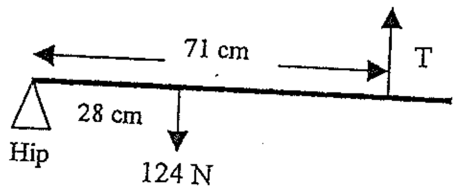
c) (i) $$I = \frac{P}{A} = \frac{6 \times 10^5}{4\pi(3000)^2} = 5.31 \times 10^{-3} \text{ Wm}^{-2}$$

$$\text{Level} = 10\log\left(\frac{5.31 \times 10^{-3}}{10^{-12}}\right) = 97.2 \text{ dB}$$

(ii) At 3 km the absorbed sound will be 3 x 7 = 21 dB
Hence actual sound level will be 97.2 – 21 = 76.2 dB

d) The two different sounds from the engines form beats and the passengers will hear a throbbing sound. Beats are formed because of alternating constructive and destructive interference produced between the waves.

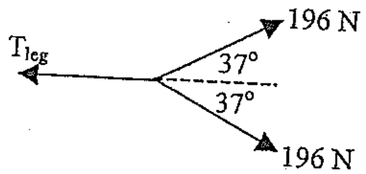
2. a) Forces diagram:



ΣACT = ΣCT
124 x 28 = 71 T (using centimetres)
T = 48.9 N
So mass = 48.9/9.8 = 5.0 kg

b) The tension throughout the rope is the same at all points and equals the weight of the 20 kg mass
So T = 20 x 9.8 = 196 N

Vector diagram:



ΣF = 0
$T_{leg} = 2T\cos 37 = 2 \times 196 \times \cos 37$
T = 313 N

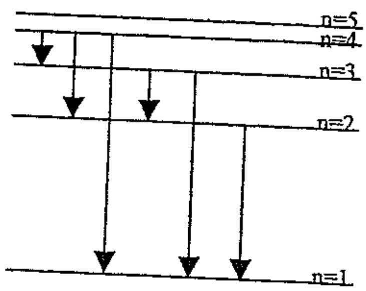
c) Cross-sectional area of cord = $\pi r^2 = \pi(2.5 \times 10^{-3})^2 = 1.96 \times 10^{-5}$ m^2

Breaking stress of cord = $\dfrac{1000}{1.96 \times 10^{-5}} = 5.09 \times 10^7$ Pa (Superope is eliminated)

Young's Modulus of cord = $\dfrac{\frac{400}{1.96 \times 10^{-5}}}{\frac{1}{100}} = 2.04 \times 10^9$ Pa(Newire is eliminated)

This leaves only Magicord as the only rope that conforms to the requirements.

3. a) (i) Possible transitions shown in diagram:



(ii) Level 3 to 1 transition

ÄE = $\frac{hc}{ë}$ = $\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{102.6 \times 10^{-9}}$

= 1.939×10^{-18} J

Level 2 to 1 transition

ÄE = $\frac{hc}{ë}$ = $\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{121.5 \times 10^{-9}}$

= 1.637×10^{-18} J

Level 3 to 2

$\Delta E = 1.939 \times 10^{-18} - 1.637 \times 10^{-18} = 0.302 \times 10^{-18}$ J

ë= $\frac{hc}{\Delta E}$ = $\frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{0.302 \times 10^{-18}}$ = 659 nm

b) Spectrum C is hydrogen because it has a 659 nm line. Also the emission line pattern is the simplest one expected from an atom with a single electron and the lines are getting closer.

c) (i) The phenomenon is fluorescence

(ii) Electrons are excited by the UV light to higher energy levels. These excited electrons fall to lower levels in a series of transitions. At least one of these transitions gives a photon in the visible region.

(iii) The peak of the emitted wavelengths is at about 510 nm. From the spectra graphs shown in the question this wavelength corresponds to the colour GREEN.

4. a) Tap-turner radius is about 15 cm and the tap prong radius is about 1.5 cm

$\Sigma ACT = \Sigma CT$

$15F_1 = 1.5F_2$

$\frac{F_1}{F_2} = \frac{1.5}{15} = \frac{1}{10}$

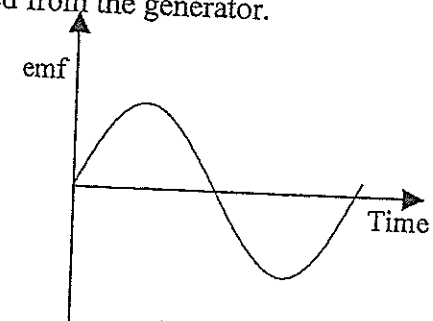
b) Torque on tap-turner = 2 x 0.15 = 0.20 Nm

F_{handle} will be 0.20 x 10 = 20 N on all prongs

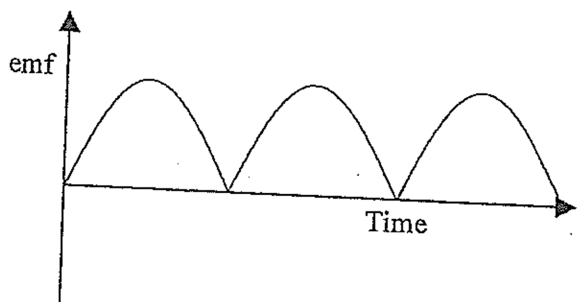
Force on one prong = 20/4 = 5 N

5. a) The brushes provide a sliding electrical connection to an external circuit so current can be extracted from the generator.

b)



Generator P



Generator Q

c) With an AC system transformers can be used to step voltages up or down without wasting much energy.

d) $\varphi = BA = 0.2 \times 120 \times 10^{-4} = 2.4 \times 10^{-3}$ Wb

$$å = -N\frac{d\varphi}{dt} \quad \text{so } dt = \frac{300 \times 2.4 \times 10^{-3}}{240} = 3.0 \times 10^{-3}\text{s}$$

This flux change occurs every ¼ of a rotation, so for a whole rotation $t = 4 \times 3 \times 10^{-3}$

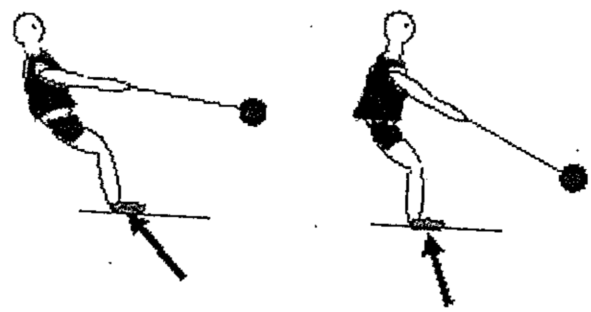
$$T = 0.12\text{ s} \qquad f = \frac{1}{0.12} = 83.3\text{ Hz}$$

6. a) W: The Earth

F_x: The ball or wire

R: The ground

b) As the thrower's velocity increases the centripetal force to the left must increase.



In order to increase the force to the left the thrower must obtain more frictional force from her feet which can only be obtained by leaning back at a greater angle to the vertical.

At a greater angle the horizontal component of her reaction force on the ground then becomes greater.

c) $$T = \frac{mv^2}{r} = \frac{6 \times 28^2}{1.4} = 3360\text{ N}$$

d) Horizontal component of velocity = 28cos42 = 20.8 ms^{-1}

Vertical component of velocity = 28sin42 = 18.7 ms^{-1}

<u>Vertically:</u> the hammer is falling to a displacement of -1.2 m

$s = ut + ½at^2$: $-1.2 = 18.7t - 4.9t^2$

time of flight, t = 3.89 s

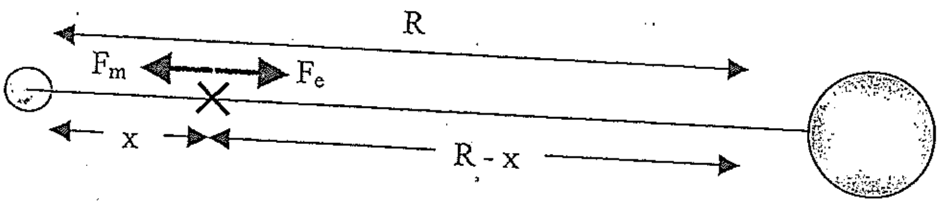
<u>Horizontally:</u> Range, s = ut = 20.8 x 3.89 = 80.9 m

7. a) (i) $$v = \frac{2\pi r}{T} = \frac{2\pi(1.85 \times 10^2)}{119 \times 60} = 1.63 \times 10^3\ ms^{-1}$$

(ii) $$\frac{M_{module}v^2}{R} = \frac{GM_{moon}M_{module}}{R^2}$$ (R and M_{module} cancel)

$$M_{moon} = \frac{v^2R}{G} = \frac{(1.63 \times 10^3)^2 \times 1.85 \times 10^6}{6.67 \times 10^{-11}} = 7.35 \times 10^{22}\text{ kg}$$

b)



At point X required : $F_m = F_e$

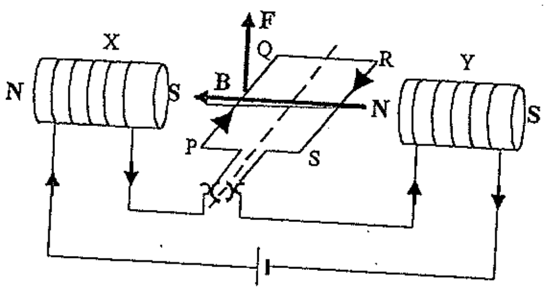
$$\frac{GM_m}{x^2} = \frac{GM_e}{(R-x)^2}$$

$$\frac{M_e}{M_m} = \frac{(R-x)^2}{x^2} \qquad \frac{5.98 \times 10^{24}}{7.35 \times 10^{22}} = 81.4 = \frac{(R-x)^2}{x^2}$$

$$\sqrt{81.4} = 9.022 = \frac{R-x}{x}$$

$$9.022 = \frac{R}{x} - 1 \qquad \frac{x}{R} = \frac{1}{10.022} = 9.97\%$$

8. a)



Coil will rotate clockwise.

b) $F = BIlN = 0.095 \times 0.75 \times 0.05 \times 150$

$F = 0.534$ N

c) (i) $\tau = 2Fr = 2 \times 0.02 \times 0.534 = 0.0214$ Nm

(ii) τ is zero at the top

d) Several ways to obtain a greater torque:

Use a greater v oltage

More armature coils

More field coils

Add an iron core to coils/ armature

Increase armature area, etc.

e) The field coils are is series with the armature so if the current reverses in the armature, the current will also reverse in the field coils. When B reverses the torque stays in the same direction because the armature current has also reversed so the coil will always rotate in the same direction, regardless of current direction.

Section C

1. a) (i) Fast-moving electrons are rapidly decelerated in the target causing short-wavelength photons to be emitted of various wavelengths (Bremsstrahlung). Electrons in the inner shells of the target atoms are also promoted and when they fall back again they emit specific wavelengths corresponding to the energy jump (line spectrum)

(ii) From the graph the cut off wavelength is about 0.035 nm

Energy: $W = Vq = \frac{hc}{\lambda}$

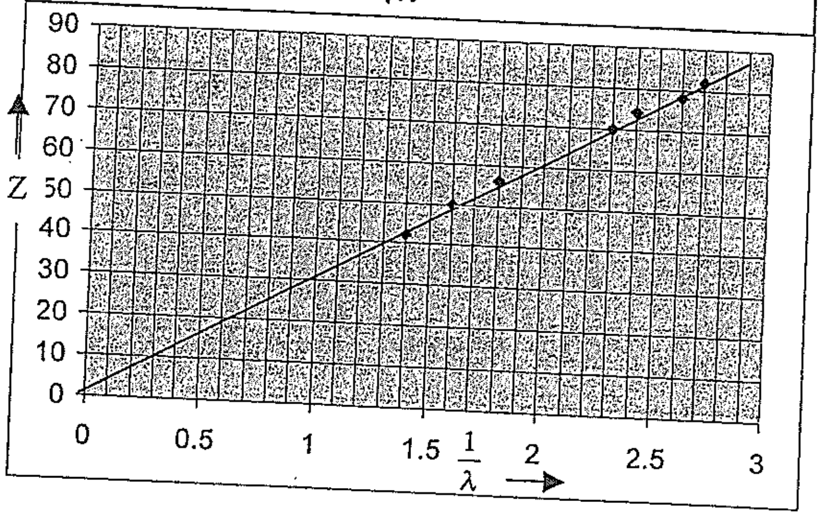
So $V = \frac{hc}{q\ddot{e}} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{0.035 \times 10^{-9} \times 1.6 \times 10^{-19}} = 3.55 \times 10^{4}\ V$

b) (i)

Element	Atomic Number (Z)	Wavelength (pm)	Wavelength (m x 10^{-11})	$\frac{1}{\sqrt{\lambda}}$ ($m^{-1/2} \times 10^{5}$)
Molybdenum	42	54	5.4	1.4
Tin	50	38	3.8	1.6
Barium	56	30	3.0	1.8
Ytterbium	70	19	1.9	2.3
Tungsten	74	17	1.7	2.4
Platinum	78	15	1.5	2.6
Lead	82	14	1.4	2.7

(ii)

Graph plot of Z versus $\frac{1}{\sqrt{\lambda}}$



c) (i) Gradient $= \frac{(82 - 50)}{(2.7 - 1.6) \times 10^{5}} = 2.9 \times 10^{-4}\ m^{1/2}$

So equation of the line is $Z = \frac{2.9 \times 10^{-4}}{\sqrt{\lambda}} + 1.2$

(ii) Only 2 sig figs should be used as values for Z and λ are both quoted to 2 sf.

d) Gradient $= Z\sqrt{\lambda} = 6.60 \times 10^{8}\sqrt{hc} = 2.9 \times 10^{-4}$

$hc = \left(\frac{2.9 \times 10^{-4}}{6.6 \times 10^{8}}\right)^{2}$ So $h = \frac{2.1 \times 10^{-25}}{3 \times 10^{8}} = 6.9 \times 10^{-34}\ Js$

2. a) (i) f_0 is the fundamental frequency

(ii) R_2 is the second (higher) resonant frequency

b) (i) Resonance occurs when the frequency of sound waves from a vibrating source corresponds to the natural frequency of vibration of another object. Energy is absorbed by the object, causing it to vibrate with a rapid increase in amplitude.

(ii) Resonance in the vocal tract causes an increase in the loudness of certain harmonics. The resonant frequency of our vocal tract can be adjusted by changing the shape of our mouth and jaws.
Being able to produce different resonant frequencies in this way affects our ability to produce different vowel sounds.

c) (i) From the graph, the lowest resonant frequency for the word "hoard" sung at 200 Hz is about 540 Hz

(ii) From the graph, the lowest resonant frequency for the word "hoard" sung at 200 Hz is about 930 Hz

(iii) The resonant frequency needed for "who'd" sung at 1000 Hz is only about 860 Hz so the singer cannot make the words sound different because she cannot produce the higher harmonics: She has reached the limit of the resonant frequencies that can be used to increase their loudness.

d) (i) The next two overtones produced will be 2x and 3x the fundamental i.e. 1020 and 1530 Hz

(ii) For a closed pipe, length $L = \lambda/4$ so the resonant wavelengths will be between pipe lengths of 4 x 15 cm and 4 x 20 cm i.e $\lambda_1 = 0.60$ m and $\lambda_2 = 0.80$ m

Therefore the range of frequencies will be between frequencies f_1 and f_2:

$$f_1 = \frac{v}{\lambda} = \frac{346}{0.6} = 580 \text{ Hz}$$

$$f_2 = \frac{v}{\lambda} = \frac{346}{0.8} = 432 \text{ Hz}$$

(iii) Opening the mouth to a flared shape decreases the effective resonant length. This will increase the singer's capacity to produce the higher resonant frequencies as L will be shorter.