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PHYSICS
2007 TEE SOLUTIONS*

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QUESTION PAPER AND SOLUTIONS
CAN BE OBTAINED FROM:
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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.

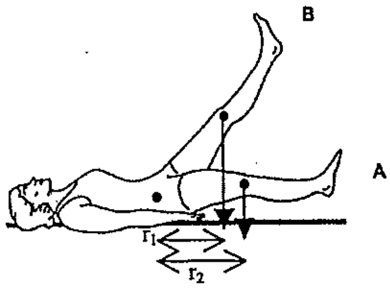
 STAWA ACKNOWLEDGES THE SUPPORT OF THE CURRICULUM COUNCIL AND IN PARTICULAR THE TEE EXAMINING PANEL MEMBERS, DR. MICHAEL STARR, DR. GEOFF SWAN, DR. RALPH JAMES, ASSOC. PROF. IAN MCARTHUR, MR. PHILLIP JENNINGS, DR. SARAH HARRISON, DR. SHELLEY YEO, MR GEORGE PRZYWOLNIK AND DR. ROBERT LOSS

STAWA 2007 Physics Solutions

A1

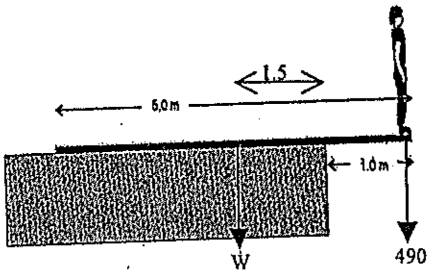
The acceleration vector [gravity] will always act downwards and the velocity vector is always tangential to the path.

A2 The clockwise torque from the leg when in position A is larger than at B due to the greater horizontal distance from the pivot (hip). $\tau = F.r$
Therefore the tension in the hip muscle providing the anticlockwise torque needs to be larger. This makes it harder to hold the leg up.



A3 (Take the mass of the boy as 50 kg)
The weight of the plank will act through its centre which is 1.5 m from the wall's edge.

Taking torques about the end of the wall:
$W_{plank} \times 1.5 = 50 \times 9.8 \times 1$
Hence mass of plank = 327 N (÷ 9.8) = 33 kg.

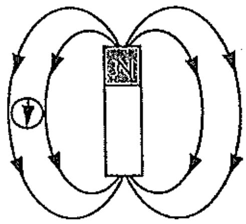


A4 Orbital radius = $(2.0 \times 10^7 + 6.37 \times 10^6) = 2.637 \times 10^7$ m
Time = 12 x 3600 = 43200 s

$$v = \frac{2\pi r}{t} = \frac{1.657 \times 10^7}{43200} = 3.84 \times 10^3 \text{ m s}^{-1}$$

A5 Vertical component of the magnetic field = $2.70 \times 10^{-5} \times \cos 25° = 2.45 \times 10^{-5}$ T
$E = BLv = 2.45 \times 10^{-5} \times 59.5 \times 270 = 0.394$ V

A6 B is correct
Because the arrow of the compass needle is a north-seeking pole that will align with the direction of the field lines of the magnet. The field is downwards (N to S) in the position shown



A7 Area of coil = $0.3 \times 0.3 = 0.09$ m^2
For 1 flux change in the coil $\varphi = BA = 1.2 \times 10^{-5} \times 0.09 = 1.08 \times 10^{-6}$ Wb
For 180° rotation there are 2 flux changes, so $\Delta\varphi = 2 \times 1.08 \times 10^{-6} = 2.16 \times 10^{-6}$ Wb

A8 Large wave period T = 1559 – 1549 ms = 10 ms
$F_1 = 1/T_1 = 100$ Hz
Smaller wave period T = 1 ms
$F_2 = 1/T_2 = 1000$ Hz

A9

Wave nature (any <u>one</u> of the following)	Particle nature (any <u>one</u> of the following)
* Double slit experiment where an interference pattern is seen. * Diffraction of light around small objects * Polarisation of waves through a polaroid sheet.	* Rayleigh scattering, where a photon causes a change of momentum of an electron. * Photoelectric effect, where photons cause electrons to be emitted from a charged metal plate.

A10 a) This is an AC generator

b) Reasons: (any <u>two</u> of the following)

- Current is being produced (ammeter)
- Slip rings are being used
- There is no power source
- Energy is being transferred through the winding handle

A11 a) The voltage reverses because the direction of the flux that is cut reverses: First the S-pole passes through and then the N-pole passes through.

b) The voltage generated depends on the rate at which the flux is being cut i.e. the speed of the magnet. The magnet accelerates under gravity as it passes through the coil ($E = BLv$), so flux is cut at a faster rate when it emerges and the induced voltage is therefore larger.

A12 At the top of the loop $\frac{v^2}{r} \geq 9.8$, so $v^2 \geq 0.4 \times 9.8$ $v \geq 1.98\ m\,s^{-1}$

Let mass of car = m and height of A be h

KE + PE at top of loop = PE at A

$\frac{1}{2}\cancel{m} \times 1.98^2 + \cancel{m} \times 9.8 \times 0.8 = \cancel{m} \times 9.8 \times h$

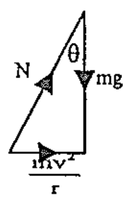
h = 1.0 m

A13 Power output = 130 x 0.85 = 110.5 W

Energy in 1 photon: $\frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{590 \times 10^{-9}} = 3.37 \times 10^{-19}$ J

$N = \frac{110.5}{3.37 \times 10^{-19}} = 3.28 \times 10^{20}\ s^{-1}$

A14 From the vector triangle:



$\tan\theta = \frac{mv^2}{r} \div mg = \frac{mv^2}{mgr} = \frac{v^2}{rg} = \frac{15.5^2}{35 \times 9.8} = 0.7$

$\theta = 35°$

A15 When the motor turns, the coils cut flux and produce a back emf. This emf opposes the applied voltage and the reduced voltage reduces the current in the coil.
When the motor is jammed, no back emf is induced and the full voltage is applied to the coil. The resulting current is much larger than when the motor is turning. This increased current can burn out the coil if it is stationary for too long.

Section B

B1 a) Downward forces (baby + swing) = (3 + 3.6) x 9.8 = 64.7 N
This force is supported by 2 arms therefore tension in each arm = 32.3 N.

b) $v = \frac{s}{t} = \frac{0.9}{1.6} = 0.563\ m\,s^{-1}$

$a_c = \frac{v^2}{r} = \frac{0.563^2}{0.6} = 0.527\ m\,s^{-2}$

c) Total force $= mg + ma_c = 6.6 \times 9.8 + 6.6 \times 0.527 = 68.2$ N

Force in each arm = 34.1 N

d) Tension in each arm when swinging is given by:

$$T = \frac{mg + ma_c}{2} = \frac{18 \times 9.8 + 18 \times 0.527}{2} = 92.94\ N$$

Area of each arm: $A = \pi r^2 = \pi(7.5 \times 10^{-3})^2 = 1.74 \times 10^{-4}\ m^2$

Stress produced: $\sigma = \frac{T}{A} = \frac{92.94}{1.74 \times 10^{-4}} = 5.34 \times 10^5\ Pa$

This is less than 1% of the breaking stress of 55 x 10^6 Pa, so the swing is unlikely to break.

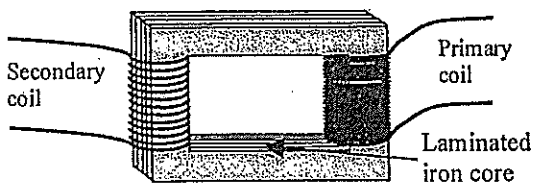
B2 a) The 3rd conductor is the earth wire. It is there for safety and will conduct the current to earth in the event of a fault with the apparatus.

b) $P = VI$ so $I = \frac{P}{V} = \frac{346 \times 10^3}{240} = 1.44 \times 10^3$ A

c) $R = (\frac{543}{10}) \times 1.74 \times 10^{-5}\ \Omega = 9.448 \times 10^{-4}\ \Omega$ for each wire, or $1.89 \times 10^{-3}\ \Omega$ total.

$P_{LOSS} = I^2R = 1441^2 \times 1.89 \times 10^{-3} = 3.93 \times 10^3$ W

d)



(diagram or description must include coils and details of the core)

Turns ratio (primary to secondary) is 66,000 to 240 = 1 to 275.

e) Voltage transmission is high to reduce power loss in the wires because:
Power loss is reduced: P = VI. So if V is increased I will be reduced to maintain the same power.
Power loss $P_L = I^2R$, so if I is reduced then power loss in the wires is also reduced

B3 a) Shortest wavelength will come from the largest energy transmission (3.85 – 0.55) eV.
Energy in joule = 3.3 x 1.6 x 10^{-19} = 5.28 x 10^{-19} J

$ÄE = 5.28 \times 10^{-19} = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{ë}$

$\lambda = 3.77 \times 10^{-7}$ m (377 nm)

b) Emission is caused by a downward transition. Shortest wavelength will come from the largest transition from -2.05 to -3.85 eV so $\Delta E = 1.80$ eV

$$\lambda = \frac{hc}{\Delta Eq} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{1.8 \times 1.6 \times 10^{-19}} = 6.91 \times 10^{-7} m$$

At 691 nm the colour will be RED.

c) UV radiation has a very short wavelength which means is has a very high energy. The energy in a UV photon is sufficient to ionise the atoms in human cells and disrupt the DNA, causing cell death or cancers.

d) Interpolation from the graph at $\lambda = 377$ nm gives a transmission value of about 60% which is sufficient for fluorescence to occur in the coral.

B4 a) An open pipe fundamental frequency occurs for $L = \frac{\lambda}{2}$ so $\lambda = 2 \times 1.45 = 2.90$ m

$$f = \frac{v}{\lambda} = \frac{346}{2.90} = 119 \text{ Hz}$$

b) $\text{speed} = \sqrt{\frac{(273+37)}{0.0296}} = 349 \text{ m s}^{-1}$

$$f = \frac{c}{2L} = \frac{349}{2 \times 1.45} = 120 \text{ Hz}$$

c) (i) Pipe length is given by: $L = \frac{c}{2f} = \frac{349}{2 \times 88} = 1.98$ m

Extra length needed for 88 Hz = 1.98 – 1.45 = 0.53 m

(ii) (Two possible answers here)

- 0.53 m is fairly close to an acceptable level for the distance from the lips to the bottom of the lungs.
- 0.53 m is too large a distance, so the more likely explanation is that the pipe and lung combination is acting like a closed pipe whose fundamental is $\frac{\lambda}{4}$.

B5 a) Horizontal velocity of jet B is given by $u_H = \frac{2.4}{0.7} = 3.43 \text{ m s}^{-1}$

$u_H = u \cos 45°$ so total velocity $u = \frac{343}{\cos 45°} = 4.85 \text{ m s}^{-1}$

b) At maximum height v = 0 and t = 0.35

$s = ut + ½ at^2$ so $s = 4.85 \sin 45° \times 0.35 + ½(-9.8)(0.35)^2$

s = 0.60 m

c) Wind will only affect the horizontal velocity of the jet.
Extra distance moved due to the wind will be 0.28 x 0.7 = 0.196 m
The radius of the hole is 0.10 m so this will put the jet outside the hole by 9.6 cm.

d) (Note: there is an inconsistency in this question, so there are 2 possible answers)

Answer 1 (using vertical velocity components)
Jet A, time to reach to top: v = u + at
0 = 5.83 sin 60° -9.8t t = 0.62 Time of flight, t = 2 x 0.62 =1.24 s

Jet B, time of flight = 0.70 s (part a)

Jet C, time to reach to top: $v = u + at$
$0 = 4.52 \sin 30° + -9.8t$ $t = 0.24$ Time of flight, $t = 2 \times 0.24 = 0.48$ s
Order will be: C, B, A

Answer 2 (using horizontal velocity components)

Jet A, time to reach to hole $= \frac{s}{v} = \frac{1.8}{5.83 \cos 60°} = 0.617$ s

Jet B time to reach to hole = 0.7 s (part a)

Jet C, time to reach to hole $= \frac{s}{v} = \frac{1.8}{4.52 \cos 30°} = 0.766$ s

Order will be: A, B, C.

B6 a) Electromagnetic force will be upwards (right hand palm rule)

$F = Bqv = 1.6 \times 10^{-19} \times 1.10 \times 10^3 \times 0.20 = 3.52 \times 10^{-17}$ N

b) $F_c = \frac{mv^2}{r} = Bqv$ hence $B = \frac{mv}{qr}$

$$B = \frac{1.67 \times 10^{-27} \times 10 \times 10^3}{1.6 \times 10^{-19} \times 0.015} = 6.96 \times 10^{-3} \text{ T}$$

c) From part b: $v = \frac{rqB}{m}$ and $v = \frac{2\pi r}{T}$ then $\frac{rqB}{m} = \frac{2\pi r}{T}$ so $T = \frac{2\pi m}{qB}$

In this equation T can be seen to be independent of r

B7 a) Possible answers: (two differences required)

Dolphins can hear high frequencies much better than goldfish
Goldfish have a higher hearing threshold at their most sensitive frequency
Goldfish have their maximum hearing sensitivity at a much lower frequency.

b) (i) $\lambda = \frac{v}{f} = \frac{1500}{50 \times 10^3} = 3.06 \times 10^{-2}$ m

(ii) Shad: about 140 dB
Dolphin: about 40 dB

c) Shad intensity: $140 = 10 \log\left(\frac{I_s}{10^{-12}}\right)$ $I_S = 100 \text{ W m}^{-2}$

Dolphin intensity: $40 = 10 \log\left(\frac{I_d}{10^{-12}}\right)$ $I_D = 1 \times 10^{-8} \text{ W m}^{-2}$

Ratio of intensities: $\frac{I_S}{I_D} = \frac{100}{10^{-8}} = 10^{10}$

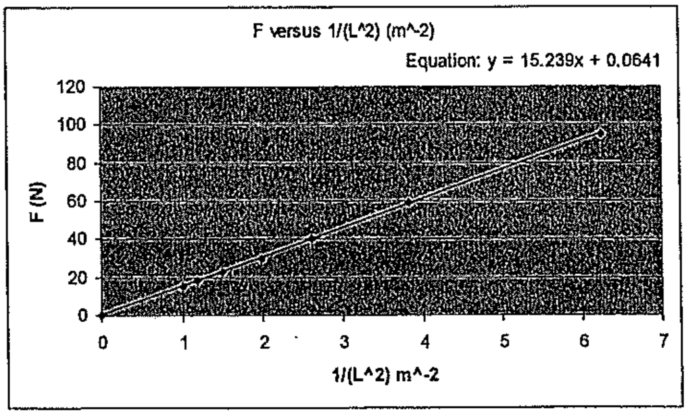
Inverse square law states that the ratio of intensities is inversely proportional to the square of the distances.
If unknown distance = x, then: $\frac{x^2}{10^2} = 10^{10}$ so $x = \sqrt{10^{12}} = 10^6$m

Section C

C1 a) Constant is given by: $k = \dfrac{\partial^2 \mathrm{WT}^3}{12} = \dfrac{\partial^2 \mathrm{x}\ 0.0286\ \mathrm{x}\ (0.004)^3}{12} = 1.51\mathrm{x}10^{-9}\mathrm{m}^4$
(*note units*)

b)

Force F_b (N)	$\frac{1}{L^2}$ (m^{-2})
15	1.00
18	1.18
23	1.49
30	1.98
40	2.60
59	3.84
95	6.25



c) Gradient $= \dfrac{(95-0)\ \mathrm{N}}{(6.25-0)\ \mathrm{m}^{-2}} = 15.2\ \mathrm{N\ m}^2$ (*note units*)

d) $F_B = \dfrac{1.51\mathrm{x}10^{-9}\mathrm{x}Y}{1} \mathrm{x} \dfrac{1}{L^2}$

$Y = \dfrac{F_B \mathrm{x} L^2}{1.51\mathrm{x}10^{-9}} = 1.0\mathrm{x}10^{10}\mathrm{Pa}$

e) The wood is possibly maple which has a Young's Modulus closest to 1 x 10^{10} Pa. (Using the default value of 2 x 10^{10} Pa, the suggested wood is jarrah.)

f) Ashley's statement is not correct because an elastic material is one that will not undergo permanent deformation when the load is reduced again (ie an elastic material is one that returns to its original length)

C2 a) $g = \dfrac{GM}{R^2} = \dfrac{6.67\mathrm{x}10^{-11}\mathrm{x}8.94\mathrm{x}10^{22}}{(1.82\mathrm{x}10^6)^2} = 1.80\mathrm{ms}^{-2}$

b) Distance between the centres of mass of Io and Jupiter = 4.22 x 10^8 – 1.82 x 10^6 = 4.201 x 10^8 m

$g = \dfrac{GM}{R^2} = \dfrac{6.67 \mathrm{x} 10^{-11} \mathrm{x} 1.90 \mathrm{x} 10^{27}}{(4.201 \mathrm{x} 10^8)^2} = 0.718\ \mathrm{m\ s}^{-2}$ (towards Jupiter)

c) Net acceleration = a_I - a_J = 1.80 – 0.718 = 1.08 m s^{-2} (towards Io)

d) The pull of Jupiter remains fairly constant but the other moons orbiting Jupiter also exert a force on Io, the magnitude of which depends on their relative positions. This will cause Δg to vary, as shown on the graph.

e) R_{Io} = 1.82 x 10^6 m.
Δg (from graph) = (1.2 x 10^{-4} - 1.5 x 10^{-5}) = 1.05 x 10^{-4} m s^{-2}
Average g_o (from part c and text) = $\dfrac{(1.08 + 2.51)}{2} = 1.80\ \mathrm{m\ s}^{-2}$

$h = \dfrac{1.05\mathrm{x}10^{-5}\mathrm{x}1.82\mathrm{x}10^6}{1.80} = 110\mathrm{m}$

f) Answer is diagram 2 (by estimating the angles moved through by each moon per day.)