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Physics

2004 TEE Solutions*

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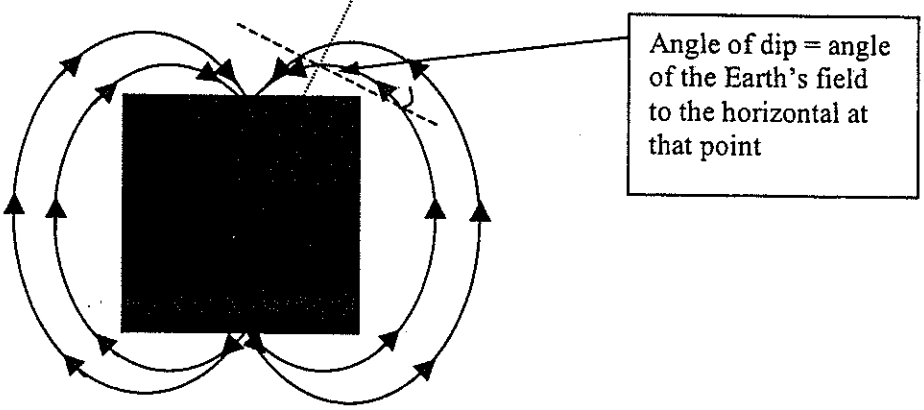
*These solutions are not a marking key. They are a guide to the possible answers at a depth that might be expected of Year 12 students. It is unlikely that all possible answers to the questions are covered in these solutions.

 acknowledges the support of the Curriculum Council and in particular the TEE Examining Panel members: Dr Ralph James, Dr Shelley Yeo, Miss Megan Wride.

TEE physics Solutions 2004

Section A

1. Velocity of sound in seawater = 1530 m s^{-1} (frequency is irrelevant)
   Distance there and back = vt = 1530 x 4 So depth = 3.06×10^3 m

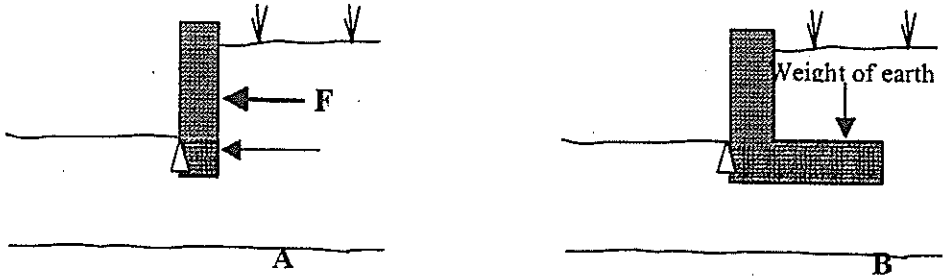
2. 

3. a) X is the **Elastic limit** of the wire.
   b) Whilst in the elastic region the wire can return to its original dimensions after stretching. On moving into the plastic region the wire can no longer return to its original shape and remains permanently deformed.

4. The frequency, or number of pulses per second arriving at an interface is determined solely by the frequency of the source, itself. As the wave moves through a different medium the velocity and the wavelength both change but the value of v/λ will always be a constant = frequency.

5. a) Balance reading is **equal to 9.8 N** (the weight of 1 kilogram) as this is the tension in the string
   b) Balance reading is **equal to 9.8 N** as the tension in the string is still 9.8 N.

6. Any example showing a structure where a compressive force maintains equilibrium is acceptable. E.g. supports of a bridge or the shin-bone of a human.
   A diagram is needed showing the compressive forces of the structure.

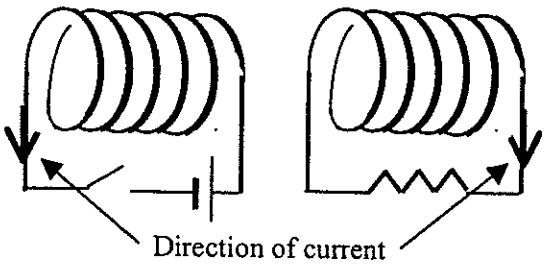
7. a) 

   b)
   The weight of the earth in B provides a clockwise torque about the fulcrum (Δ) shown, overcoming the tendency for the wall to rotate anticlockwise from the earth the wall is holding back. The greater overall force and the length of the lower arm both contribute to creating greater leverage.

8. For closed pipes $L - \lambda/4$ So $\lambda_1 = 2.28$ m and $\lambda_2 = 2.44$ m
   $f_1 = 346/2.28 = 152$ Hz and $f_2 = 346/142$ Hz
   Beats frequency = 152 – 142 = 10 Hz

9. Velocity of students = $(2\pi \times 14)/10.5 = 8.38$ m s^{-1}
   Centripetal acceleration $a_c = 8.38^2/14 = 5.01$ m s^{-2}
   Normal force from seat at top = mg - ma_c For the 2 students: $R_1 = 568$ N $R_2 = 646$ N
   As a reaction force exists which is greater than zero, both students will remain in their seats at the top.

10. a)



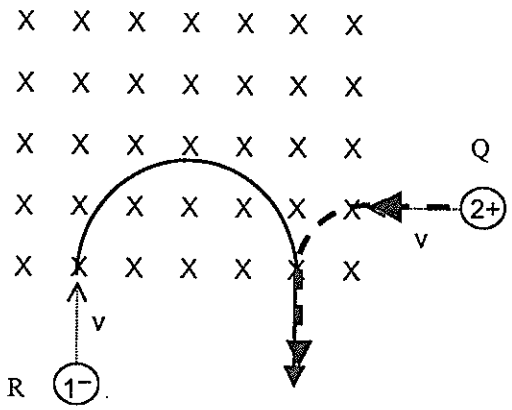
b) It decreases to zero because once there is no change in current in coil 1 there will be no induced emf. in coil 2.

11. a) The **solid** bob will slow down most rapidly.
b) Because the bob experiences a changing flux an induced emf causes eddy currents to flow. This current produces a magnetic field which opposes the motion and slows the bob. The larger area solid bob will have a larger induced current and hence a larger retarding force acting.
(NB It could also be argued that the annulus slows fastest as, although the current is less, its inertia is also less - so it may decelerate more.)

12. 3% of 100 W = 3 watts output
Average λ = 500 nm so f = 5×10^{14}
$n = \frac{3}{6.63x10^{-34} x5x10^{14}}$ $= 10^{19}$ photons

13. There is a force acting on the charged particle due to the magnetic field (F = Bqv) if the field has a component perpendicular to the direction of motion.
This force is perpendicular to the particle's motion and provides centripetal force towards the centre of a circle.

14. Q: Doubling the mass and doubling the + charge will cause the radius to remain the same and to move anticlockwise.
R: Doubling the mass will cause the radius to double and the negative charge will cause the movement to be in a clockwise direction.

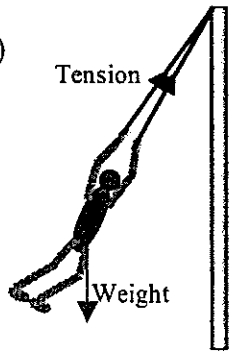


15. **B** is the correct answer, although A is close to being the correct shape.
The thickness of the annulus-shaped pipe varies in a complex way, viewed from the top, being thickest where the x-rays just emerge into the central hole. The thicker the metal, the lower the detected intensity.

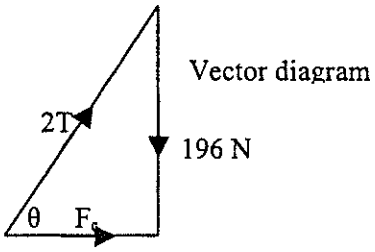
Section B

1.

a)



b)



Cos θ = 0.70/1.8 So θ = 67.1° Weight = 196 N
2T = 196/sin 67.1° So T = 106 N

c) The net force = centripetal force F_c
Fc = 196/tan 67.1° = 82.8 N towards the pole.

2. a) $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ $N_s = \frac{6000x1000}{500}$ = 12000 turns

b) $P_T = VI$ So $I = 2.0 \times 10^3/6000 = 3.33$ A
$P_{LOSS} = I^2R = 3.33^2 \times 10 = 111$ W
$V_{DROP} = P/I = 111/3.33 = 33$ V drop
So $V_0 = 6000 - 33 = 5967$ V

c) CO_2 emissions contributing to the Greenhouse Effect
CO poisonous gas emission, Noise pollution, Smoke fumes, heat, etc

d) Power threshold of 20 dB = $10^2 \times 10^{-12} = 10^{-10}$ W m^{-2} (lowest intensity to be discerned)
Sound power emitted from generator = IA = $10^{12} \times 10^{-10} \times 4\pi \times 1^2 = 1257$ W at source
At 2000 m: $I = \frac{1257}{4\pi x2000^2}$ = 2.5×10^{-5} W m^{-2}
L at 2000 m = 10 log $(2.5 \times 10^{-5})/10^{-10} = 54$ dB
Yes it will be heard as this level is greater than 20 dB.

3. a) Bracket at A is under **tension**
Bracket at B is under **compression**

b) Torques about point B: 2.25 x T = (2.5 x cos 32° x 54) + (5 x cos 32° x 200)
so T = 428 N

c) Breaking stress for copper= 4.9×10^8 Pa
Maximum force must be < 10 x 428 = 4280 N
Required stress is $4.9 \times 10^8 = 4280/A$ So A = 8.73×10^{-6} m^2
$r^2 = 8.73 \times 10^{-6}/\pi$ So r = 1.67 mm or diameter = 3.34 mm

4. a) T^2/R^3 values:
Mercury - 2.97×10^{-19} s^2 m^{-3}; Venus - 2.98×10^{-19} s^2 m^{-3}; Earth - 2.95×10^{-19} s^2 m^{-3}
$T = 11.8 \times 365 \times 24 \times 3600 = 3.721 \times 10^8$ s

b) $2.95x10^{-19} = \frac{(3.721x10^8)^2}{R^3}$ $R^3 = 4.70 \times 10^{35}$ m^3 $R = 7.56 \times 10^{11}$ m

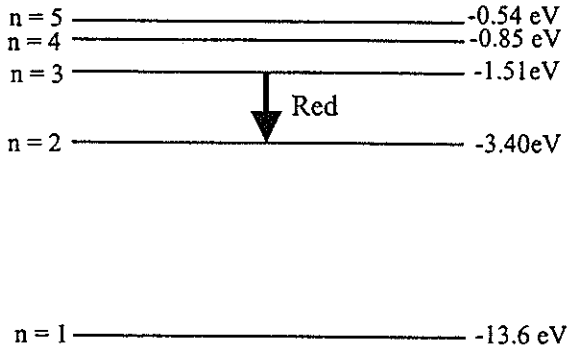
c) (i) $\frac{GM}{R^2} = g = \frac{6.67x10^{-11}x1.99x10^{30}}{(7.1x10^{13})^2}$ So g = 2.63×10^{-8} m s^{-2}

(ii) Measurements needed: **period of the satellite's orbit** and the **radius of the satellite's orbit**.

5 a) (i) A is the spectrum of a **torch** because a filament lamp will give a non-monochromatic beam containing a band of wavelengths.

(ii) B is the spectrum of a **laser** because lasers only emit a single visible wavelength.

b) (i)



(ii) Ionisation energy = 13.6 eV

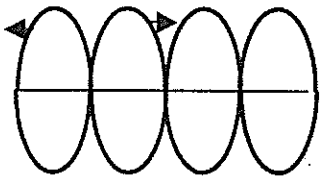
(iii) $\Delta E = (13.6 - 3.4) = 10.2$ eV or 1.63×10^{-18} J
$f = (1.63 \times 10^{-18})/(6.63 \times 10^{-34}) = 2.5 \times 10^{15}$ Hz (or $\lambda = 1.22 \times 10^{-7}$ m)
This frequency is in the ultraviolet region of the spectrum

c) (i) Arrow shown on diagram

(ii) Red has a longer wavelength and less energy than blue/green
n = 3 to n = 2 is a smaller transition.

6. a) Distance between each Q is $\lambda/2 = 0.6$ m So $\lambda = 1.20$ m
$f = 346/1.20 = 288$ Hz

b) Q is a nodal point of destructive interference where the wave from the left speaker and the wave from the right speaker interfere to form a minimum point in a standing wave pattern.



c)

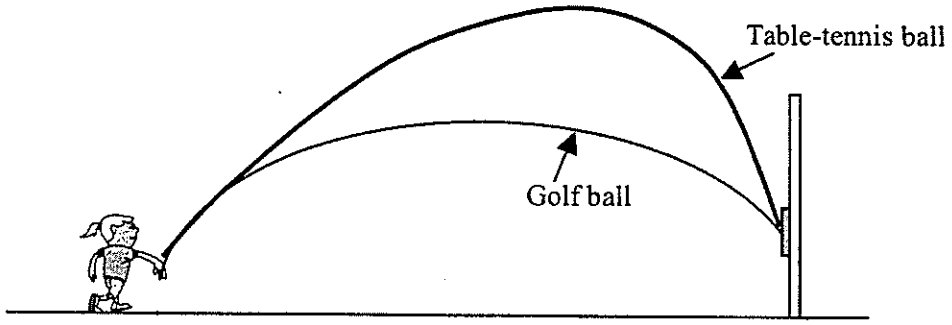
Air pressure:	Particle displacement:
The pressure variation is a maximum, that is, the pressure varies between a minimum and a maximum, which is why L_3 is a loud point.	The particles are stationary because of the standing wave pattern. Displacement nodes are pressure antinodes.

d) The student will hear beats at a frequency of 5 Hz.

7. a) Vertical velocity = $11.9 \sin 20° = 4.07$ m s^{-1} Horizontal velocity = $11.9 \cos 20° = 11.18$ m s^{-1}
Horizontally: $t = s/v = 10/11.18 = 0.894$ s
Vertically: $s = ut + \frac{1}{2}at^2$ So $s_v = 4.07 \times 0.894 - 4.9(0.894)^2$
$s_v = -0.28$ m (negative indicates below the centre) So 5 points scored.

b) Change 1: Throw the ball faster
Explanation 1 : Horizontal component is larger so time of flight is less, so s_v is less
Change 2: Throw the ball at a larger angle to the horizontal
Explanation 2: More vertical velocity given so the ball reaches a higher maximum height before falling.

c) (i)



(ii) The surface areas of the balls are similar, so they will experience similar air resistances. For the same amount of air resistance, the table – tennis ball will be affected more as it has less mass and inertia and so it must be thrown faster and higher. It will follow a non-parabolic path.

8. a) The slip rings allow constant contact so that current to be drawn from the coil for the load. Being slip rings they will allow Alternating Current to flow.

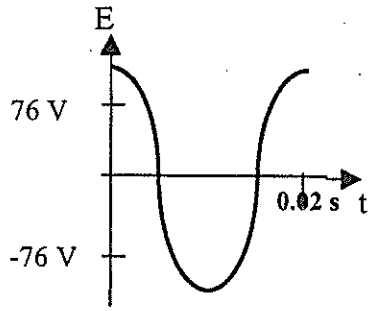
b) (i) Coil area = 0.14 x 0.09 = 0.0126 m^2 t = 0.005 s for a quarter turn

$$E = -N\Delta\Phi/\Delta t = \frac{200x0.15x(0.0126)}{0.005}$$

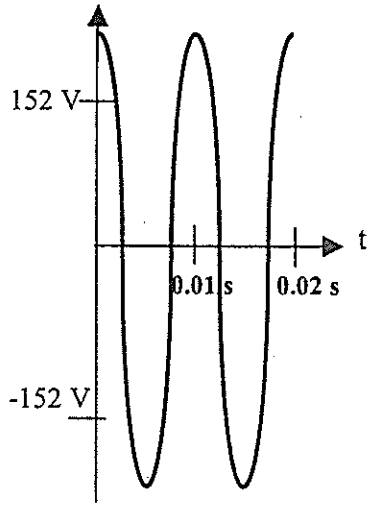
E = 76 V

(ii) This formula gives the **average** voltage.

c) (i)

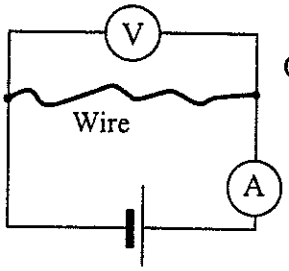


(ii)



Section C

1. a) (i)



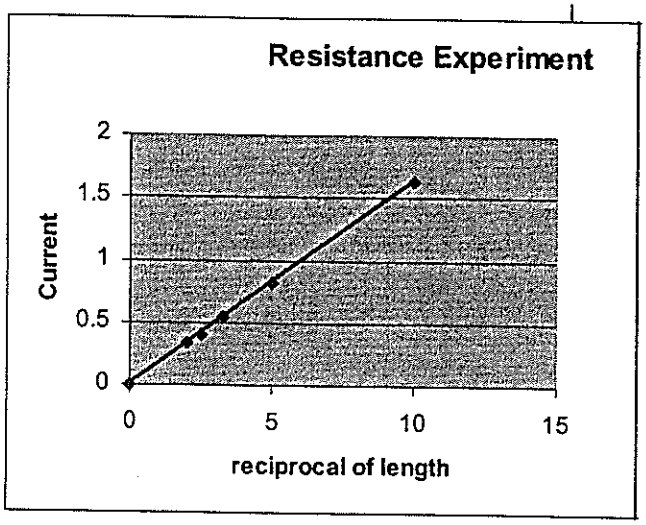
Circuit

(ii) $\frac{V}{I} = \frac{l}{k \times \pi \times r^2}$ $k = \frac{0.33 \times 0.5}{2\pi(0.2 \times 10^{-3})^2}$ $= 6.6 \times 10^5$ A V^{-1} m^{-1}

b) (i) $I = \frac{kV\pi r^2}{l}$

(ii) To get a straight line the best variable to plot is the reciprocal of length ($1/l$)

(iii)



I versus $1/l$ values:

Current I (A)	Recip. of length (m^{-1})
1.63	10.0
0.82	5.0
0.55	3.3
0.40	2.5
0.33	2.0

$$Gradient = \frac{1.63 - 0.25}{10 - 1.6}$$

$= 0.164$ A m

The graphics calculator gives the equation of the line as: $I = 0.164(1/l) + 1.72 \times 10^{-3}$

(iv) $0.164 = kV\pi r^2$
So $k = 6.54 \times 10^5$ A V^{-1} m^{-1} **or** (using diameter = 0.2 mm) $k = 2.60 \times 10^6$ A V^{-1} m^{-1}

c) (i) Because the resistance of the alloy would be higher, more energy would be wasted as heat and so the motor would run slower.

(ii) The resistance of the alloy coil would be higher and so it would be less efficient because a greater loss of energy as Joule heating would mean less energy is available as kinetic energy.

2. a) (i) G is the centre of gravity
(ii) Normal reaction of the road on the tyre.

b) Taking moments about the centre of gravity, in equilibrium, the anticlockwise torque from the normal reaction on the inner tyre will be balanced by the clockwise torque provided by the frictional force. If the velocity is higher (or the radius is smaller) then friction becomes larger and the clockwise torque rises. The normal reaction is a maximum at the weight of the car and cannot increase any more, so the frictional clockwise torque will exceed the normal force torque and the vehicle will rotate and roll over.

c) (i) $h_{unloaded}$ is about 0.5 m and h_{loaded} is about 0.9 m

$SSF_{unloaded} = 1.8/(2 \times 0.5) = 1.5$ $SSF_{loaded} = 1.8/(2 \times 0.9) = 1.0$

(ii) $V = \sqrt{SSF.rg}$ $= \sqrt{1x10x9.8rg}$ $= 10 \text{ m s}^{-1}$ or 36 km h^{-1}

d) (i) Vehicles recommended will have a SSF < 1.2 i.e Jeep 5, Bronco, Jeep 7, Blazer.

(ii) An SSF of 1.2 is the critical value – so the unloaded RV in the picture seems quite safe but the loaded RV, having a value below 1.2, is problematic. Loading the RV raises the centre of gravity and decreases the SSF value to a dangerous level.