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Physics

1999 TEE Solutions*

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The Curriculum Council
27 Waters Drive
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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.

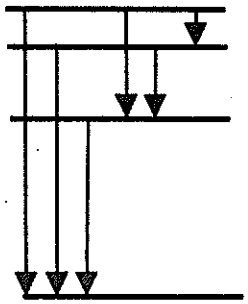
 STAWA appreciates the support of the Curriculum Council, which provided the marker's guides used a basis for these solutions.

1. Mechanical Waves: Sound, Water
Electromagnetic Waves: Radio, Microwaves, x-rays.

2. Floating magnet rotates or oscillates until its axis is aligned parallel to the Earth's magnetic North-South line.
Reason: Attraction by the earth's poles on the poles of the magnet produces a torque that rotates it until alignment is reached.

3. A: Neutral
B: Stable
C: Unstable

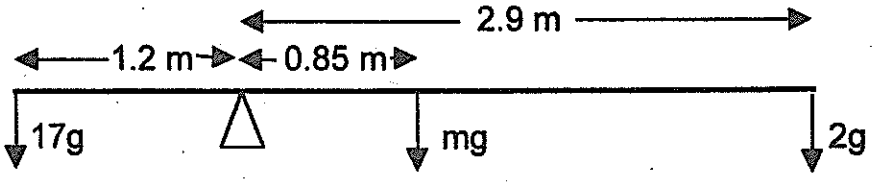
4. **6 lines**



5. Typically 100 m is covered in approximately 10 s then estimate average velocity to be 100/10 = 10 ms^{-1} and estimate maximum velocity is reached 10 m from the start.
Using $v^2 = u^2 + 2as$:
$10^2 = 0 + 20a$

$a = 5\ ms^{-2}$

6.



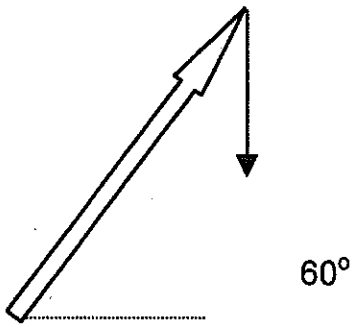
$mg \times 0.85 + 2g \times 2.9 = 17g \times 1.2$

$m = 17.2\ kg$

7. Strain = 4.2% = 0.042
Stress = $100 / 10^{-4}$
Young's Modulus = stress/strain = $10^6 / 0.042$

$E = 2.38 \times 10^7\ Pa$

8.



Torque = $0.098 \times 0.4 \sin 60^0$

$T = 3.39 \times 10^{-2}$ N

0.098 N

9. The switch turns current on in the coil, which makes it into an electromagnet. The soft iron core becomes magnetised attracting the iron armature. As it moves the contacts at C are pushed together completing the lamp circuit.

10. Light X is brighter than Y because it has more current flowing through it. The lamps are in parallel and therefore have the same voltage applied but due to the extended length of wires connected to it Y has more resistance in series and hence the current through it is less.

11. There would be a difference in the lamps compared with question 10. As the power drawn is the same but with higher voltage, the current flowing though each parallel circuit is less. The long wires connected to Y will have less voltage drop across them as there is less current and so Y will be brighter than before, but it is still less bright than X.

12. Energy is transferred to the atoms from the flame, which causes electrons to be promoted into higher energy levels.
When these electrons fall down they emit electromagnetic radiation with particular frequencies depending on the energy difference between levels. These energy differences are characteristic for each element and hence different wavelengths are produced by different elements.

13. The characteristic shapes, structures and materials of different instruments means that for the same pitch different harmonics will be present. The number and intensities of these overtones produce different complex wave forms which is perceived by the ear as a different timbre of note. Different instruments also have quite different attack and decay characteristics and this also causes us to recognise different instruments

14. Estimate radius of rotation as 1.5 m and a period of 1 second.

$V = 2\pi \times 1.5/1$

$= 9.42 \text{ ms}^{-1}$

$F = \frac{mv^2}{r} \qquad = \frac{7 \times (9.42)^2}{1.5}$

$F = 415$ N

15. $E = hc/\lambda$

$$= \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{680 \times 10^{-9}}$$

$$= 2.925 \times 10^{-19} \text{ J}$$

Number $= 100 / 2.95 \times 10^{-19}$

$$\mathbf{N = 3.42 \times 10^{20} s^{-1}}$$

Section B

1. a) Centripetal force is $\frac{mv^2}{r} = \frac{GMm}{r^2}$

$$v^2 = \frac{6.67 \times 10^{11} \times 5.9 \times 10^{24}}{(6.37 \times 10^{6} + 350 \times 10^{3})}$$

$$\mathbf{v = 7.70 \times 10^{3} ms^{-1}}$$

b) Force $F = \cancel{mg} = GM\cancel{m}/r^2$

$$g = \frac{6.67 \times 10^{11} \times 5.9 \times 10^{24}}{(6.37 \times 10^{6} + 350 \times 10^{3})^2}$$

$$\mathbf{g = 8.83 ms^{-2}}$$

This value is quite close to the value of g at the Earth's surface so the statement is quite justified.

2. a) Horizontal velocity $v_H = u_o \cos 50$
Vertical velocity $v_v = u_o \sin 50$

b) (i) $S_H = u_o \cos 50 \times t$ constant velocity

(ii) $S_v = u_o \sin 50t - 4.9t^2$

(iii) $x = D - S_H$ (D = distance to the green)

c) Horizontally $S_H = 100$ m
$t = 100/ u_o \cos 50$

Vertically $S_v = u_o \sin 50t - 4.9t^2$ (On impact $S_v = 0$)
Sub for t:

$$0 = u_o \sin 50 \times \frac{100}{u_o \cos 50} - 4.9\left[\frac{100}{u_o \cos 50}\right]^2$$

Solving for u_o

$$u_o = \left[\frac{118636}{11912}\right]^{-}$$

$$\mathbf{u_o = 31.5\ ms^{-1}}$$

d) Horizontally $S_H = 70$ m

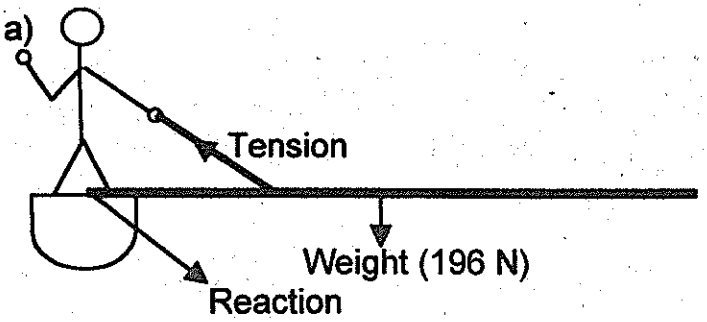
$$t = 70/31.5\cos 50 = 3.46\ s$$

Vertically $S_v = v_v t + \_\ at^2$

$$S_v = 31.5 \sin 50 \times 3.46 - 4.9(3.46)^2$$

S_v = 24.8 m high where the tree is - so the ball will pass over it.

3. a)



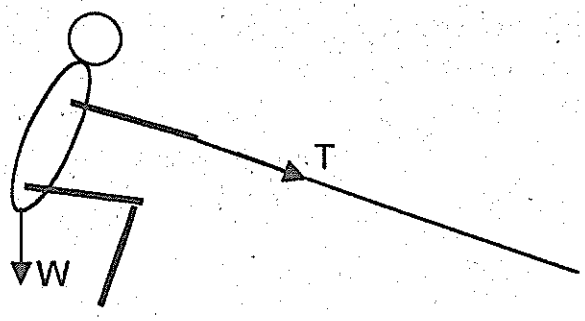
b) Taking torques about the joint:

$$(T\sin 68) \times 1.5 = 196 \sin 45 \times 2$$

T = 199 N

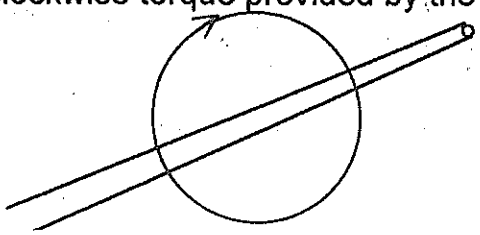
c) As the mast is raised the clockwise torque decreases horizontal distance from the joint to the weight becomes less. Also the angle the rope makes gets greater, making the effective distance of the rope to the joint greater hence less tension is required as the mast is raised.

d)



The wind surfer must lean back to provide an anticlockwise torque which balances the clockwise torque provided by the tension in the rope.

4. a)



c) Super conducting magnets under the train carrying alternating current induce eddy currents in the rails which tend to repel the electromagnet. This upward repulsive force is sufficent to support the weight of the train above the rails.

d) The tape contains small magnetic particles of iron or other magnetic alloys randomly oriented. As the tape passes through the record head the particles become magnetised to an amount dependent of the strength of the signal. On Playback mode the magnetised tape passes over the Playback head and the stored magnetic pattern induces currents dependent on the magnitude of the field present.

7. a) 88.5 dB = $10^{8.85} \times 10^{-12}\ Wm^{-2} = 10^{-3.5}\ Wm^{-2}$

$= 7.08 \times 10^{-4}\ Wm^{-2}$ with all 3 speakers

One speaker would give a power output of 1/3 of this value

$= 2.36 \times 10^{-4}\ Wm^{-2} / 10^{-12}$ in bels

= **83.7 dB**

b) The two waves travel different distances and so there is a path difference between them which may put the waves out of phase with each other. Destructive interference causes the total sound level to be less than with just one speaker.

c) i)As you move around the room there would be points of high and low sound intensity.

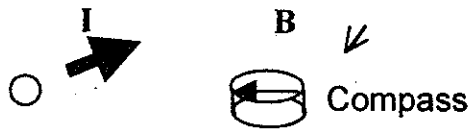
ii)Two waves of equal amplitude and frequency meet whilst travelling in opposite directions. These two waves interfere to produce a standing wave with nodes and antinodes.

iii)Antinodes must be identified by the position of maximum loudness (decibel meter). The distance between two adjacent antinodes equals half a wavelength. Doubling this distance will give the wavelength of the note.

d)i) There will be points where the string appears to be vibrating up and down at a maximum amplitude (antinodes) and points where the string appears to be stationary (nodes).

ii) Two waves of equal amplitude and frequency meet while travelling in opposite directions (eg reflected off the bridge). These two waves interfere to produce a standing wave with nodes and antinodes.

iii)Antinodes can be identified by the position of maximum vibration. The distance between two adjacent antinodes (or nodes) equals half a wavelength. Doubling this distance will give the wavelength of the note.



b) Assume spoon length = 0.1 m and mass = 0.1 kg (say 1.0 N)
Upward force must equal weight ($F = I\,l\,B$)

$I = 1/\ 0.1 \times 0.5 =$ **20 A**

c) Possible examples:

Method 1	Coal fired power station
Environmental consequence	Global warming
Caused by	CO_2 emissions enhancing the greenhouse effect
Method 2	Hydroelectric turbines
Environmental consequence	Changes to flora and fauna population
Caused by	Altering of water levels

5. a) A force is exerted at right angles to the electron beam (F = qvB) which is the centripetal force causing the electrons to move in a circle.
r = mv/Bq so as B rises r will become smaller (inversely proportional).

b) Line of "best fit" drawn through the points has a gradient of
0.2/4000 = **5×10^{-5} T**

c) gradient = rB = mv/q

$$v = \frac{5 \times 10^{-5} \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}}$$

$v = 8.8 \times 10^{6}$ ms^{-1}

d) A line of best fit is a simple way of averaging data and of recognising anomalous results.

6. a) The coil is continuously cutting lines of magnetic flux hence a varying emf is generated (Faraday's Law).
The rate of change of flux varies with the sine of the angle to the field.

b) i) A sinusoidal voltage is produced with the same frequency but double the magnitude. This is because the rate of change of flux has been doubled and $E \propto d\varphi/dt$.

ii) A sinusoidal voltage is produced with the same frequency but double the magnitude. This is because the number of turns has been doubled and $E \propto N$.

iii) A sinusoidal voltage is produced with twice the frequency and double the magnitude. This is because the rate of change of flux and the frequency of rotation have both been doubled.

Section C

1. a) Total mass = **1.85×10^6 kg**
   Most of the mass is fuel.

   b) The rocket boosters have used all their fuel and would use up available kinetic energy if they were lifted higher. This uses unnecessary fuel.

   c) No, the acceleration is not uniform. As the rocket gets higher there is less mass to lift with the same accelerating force therefore the acceleration will increase (gravitational pull is also less).

   d) The ground near the equator is moving faster than anywhere else hence the rocket already has an initial speed and so less fuel will be required to become fast enough to go into orbit.

   e) The Earth rotates towards the East and so the rocket will be propelled naturally in that direction (slingshot effect) which ultimately reduces the amount of fuel required.

   f) The only force acting is gravitational attraction towards the Earth. As the shuttle is already moving tangentially, the gravitational attraction provides the centripetal accelerating force inwards and makes the shuttle move in a circular path.

2. a) The fluctuating magnetic field from the cooker induces eddy currents in the metal which, in turn, heat in the pan.

   b) Free electrons are required for eddy currents to form and metals have the largest number of free electrons per unit volume. Hence induced currents can create heat.

   c) The magnitude of the induced current in the pan is proportional to the rate of change of flux so the faster the field fluctuates the greater the current produced. 25000 Hz would produce a larger induced current and hence heat food quicker.

   d) The further the pan is from the cooker the less induced current is produced as the field lines diverge with distance. Hence when the pan is removed the fluctuating field from the cooker is too weak at that distance to cause any significant eddy currents in the metal – it is effectively switched off.

   e) Very little heating would occur in your hand as flesh is quite a poor conductor and so only small eddy currents would be available for heating. If, however, a ring was worn it would get hot.

   f) A thicker base would have less resistance and hence more current would be induced. The pan would heat up quicker.