Government of **Western Australia**
**Curriculum Council**

WACE
Western Australian Certificate of Education

**Report on the 2009 Tertiary Entrance Examination in**

# Physics

*The TEE subject Physics was examined for the last time in 2009.*

This report was written by the chief examiner with the assistance of other members of the examining panel. The opinions and recommendations expressed are not necessarily representative of, or endorsed by, the Curriculum Council.

The marking key appended to the report was prepared by the examining panel and modified as appropriate at the pre-marking meetings. It is not intended as a set of model answers, and is not exhaustive as regards alternative answers. It represents a standard of response that the examiners deemed sufficient to earn full marks. Teachers who use this key should do so with its original purpose in mind.

## *Candidature*

| Year | Number who sat | Number of absentees |
|---|---|---|
| 2009 | 3,289 | 122 |
| 2008 | 3,243 | 142 |
| 2007 | 3,020 | 159 |

## *Summary*

The examination was well received by candidates and teachers, with the majority of candidates completing the paper in the allocated time. The mean raw exam score of 65.25% was higher than the desirable mean of 60% but comparable to that in previous years. The standard deviation at 16.64% was slightly higher than the desirable standard deviation of 15%.

In general, the high mean appears to reflect valid sampling of the syllabus, the consistency of the paper's design with those of recent years, and the thorough preparation of many of the candidates. It was also partly caused by an easier-than-usual Section C question. It is suggested that, in future, changes to examinations post-submission should be considered carefully, particularly in relation to how they affect the overall difficulty of the paper.

Many candidates demonstrated a good understanding across the breadth of the physics course. Fewer were able to describe physical processes in detail using clear logical statements. It is not enough to be able to perform calculations; candidates should also be able to offer high quality explanations. It is also a cause for concern that many candidates do not appear to have a sense of the 'rightness' of an answer; for example, too many candidates calculated the speed of a satellite to be greater than the speed of light. Candidates should be encouraged to check their responses in the light of the physics that they know.

There is still an issue for many candidates with respect to significant figures. Marks are not usually deducted for an excess of significant figures unless the question requires an estimate or is obtained from measurement (in the case of the gradient of a graph). Candidates should appreciate the importance of significant figures and the information they convey about the included accuracy of a measurement or final value calculated.

### *Comments on specific elements*

The examination structure was very similar to that of previous years. An estimate question was included this year, in contrast to 2008. Multiple-choice questions accounted for only 5 marks on the whole paper. There were no questions where candidates had a choice of alternate-context questions. One question in Section B had alternate answers provided for all parts so that candidates who had been unable to complete a previous part could attempt the rest of the question. This was well received by teachers and should be considered for future years. As in previous years, a question on the analysis of data was included in Section C and candidates were required to represent the data graphically. To determine the gradient from the data, however, candidates were allowed to use either the graph or their graphics calculator.

**Section A: Short Answers** Overall mean: 71%

Q1 Attempted 3,255 Mean 92%

This question was intended to be a straightforward question that would help candidates start the paper with confidence. It tested their understanding of beats.

Q2 Attempted 3,285 Mean 72%

Two marks were allocated to each part of this question designed to test understanding of the forces on electric charges moving in magnetic fields. The most common mistake was to identify particle one as having the larger magnitude.

Q3 Attempted 3,227 Mean 89%

A straightforward question designed to test candidates' ability to calculate sound levels.

Q4 Attempted 3,229 Mean 71%

Two marks were allocated to each part of this question designed to test understanding of the motion of satellites. A common mistake here was using an incorrect value of the radius of the orbit.

Q5 Attempted 3,219 Mean 68%

This was a calculation to test candidates' ability to resolve forces in a simple 2-dimensional case. Most mistakes were related to the use of the wrong trigonometric function.

Q6 Attempted 3,271 Mean 59%

This question was designed to test candidates' understanding of vertical circular motion. While almost all candidates could complete the calculation part of this question very few were able to offer a complete explanation in the qualitative part.

Q7 Attempted 3,236 Mean 86%

Very few mistakes were seen in this straightforward calculation involving breaking stress.

Q8 Attempted 3,199 Mean 72%

This question tested candidates' understanding of the atomic transitions leading to absorption and emission spectra.

Q9 Attempted 3,277 Mean 70%

This question tested candidates' ability to perform calculations relating to the energy of photons and the power of the light source emitting them. Some candidates indicated that they did not understand the relationship between power and energy.

Q10 Attempted 3,191 Mean 73%

This question required candidates to identify the phenomenon of fluorescence and then to explain how it arises. While most candidates were able to offer a reasonable explanation of how fluorescence occurs, few mentioned that the return to the ground state involves transitions of lower energy than the original excitation.

Q11 Attempted 3,278 Mean 62%

This question required candidates to describe how a large mass held in two different positions required the body to generate opposing forces of quite different magnitudes. A common mistake was to suggest that the centre of mass of the body would be moved outside the body when the mass was held at right angles.

Q12 Attempted 3,169 Mean 79%

This question required candidates to make estimates relating to horizontal circular motion. Most candidates were able to make estimate the quantities within appropriate ranges and answer using only two significant figures. A common mistake was to include the mass of the gate.

Q13 Attempted 3,130 Mean 60%

This question tested candidates' ability to explain how a transformer works. Most explanations were of a high standard but some students confused terms such as flux and induction.

Q14 Attempted 3,198 Mean 72%

Most candidates demonstrated a good understanding of calculations relating to banked horizontal motion in this straightforward question.

Q15 Attempted 3,168 Mean 40%

This question tested candidate's ability to calculate the size and direction of a moment. Two common mistakes were to calculate the distance from the centre of mass to the pivot point incorrectly and to try to resolve a force rather than calculate a moment.

**Section B: Problem Solving** Overall mean 65%

Q1 Attempted 3,282 Mean 69%

This question related to the generation of notes in open and closed pipes. Most candidates were able to correctly identify the correct diagram of particle displacement and performed the calculations successfully. Part (c) of this question required a detailed explanation relating to the formation of waves in closed pipes. Most candidates were able to draw waveforms in closed pipes but many of the explanations lacked the appropriate detail and this helped to differentiate the most able candidates.

Q2 Attempted 3,257 Mean 77%

This question tested candidates' understanding of projectile calculations. It was very pleasing to see the range of approaches to solving this problem and most candidates had attempted this question with confidence. Many candidates made the initial error of not including the initial displacement of the bat in the first calculation but those who had made errors in one part were able to use the alternative values offered in the question. This approach to question writing is obviously successful in terms of testing student understanding in different aspects of projectiles and should continue in the future.

Q3 Attempted 3,189 Mean 55%

This question used an application of electromagnetic induction in a context which would have been unknown to almost all students. Many candidates failed to answer parts a and b satisfactorily. The explanation required in Part (b) often lacked detail and although many candidates indicated that eddy currents were induced in the metals they were unable to explain why. Part (b) was used to differentiate between the most able candidates. Most were able to correctly identify the materials in Part (c) although many failed to appreciate that it was the ratio of conductivity to density that was the important factor not simply the conductivity.

Q4 Attempted 3,243 Mean 54%

This question required candidates to describe how x-rays are generated and how an operator can reduce their dosage. Again the description required in part a often lacked the detail needed to gain full marks and many candidates lost marks in Part (c) by failing to justify why their suggested measures were appropriate ways of reducing dosage.

Q5 Attempted 3,200 Mean 61%

This question required candidates to solve a problem relating to loads and forces in a 2-dimensional context. Parts (a) and (c) were handled well but Part (b) had a mean of 46% with many candidates demonstrating a lack of understanding of the physics involved.

Q6 Attempted 3,225 Mean 67%

This was a simple question that required candidates to apply their knowledge of forces on a current carrying wire in a constant magnetic field. Most candidates approached the calculation successfully but fewer were able to properly determine the direction of the current in the wire.

Q7 Attempted 3,257 Mean 68%

This was a question about motion in a gravitational field in the unfamiliar context of two bodies orbiting each other around a central point. The mean mark for Part (a) was 84% which fell to 48% for Part (b), the most common mistake being to calculate the velocity of Pluto from its mass and distance to the barycentre without using the force calculated in Part (a). Part (b) was used to differentiate the most able candidates. Many used the alternative answer in Part (c) and went onto to complete the question successfully.

**Section C: Comprehension and Interpretation**

Q1 Attempted 3272 Mean 57%

This question involved plotting data and interpreting a graph to identify an unknown material. The first two parts to this question required detailed explanations and while most candidates demonstrated that they understood the physics of the application few achieved full marks on either part. Most were able to plot the graph although a surprising number incorrectly interpreted the word 'against' in the instructions for the graph plotting. Most candidates calculated the gradient of the graph correctly but many failed to quote its units.

Q2 Attempted 3217 Mean 70%

This question required candidates to read and interpret a passage about using wind turbines to generate electricity. Most candidates demonstrated that they are confident dealing with unfamiliar contexts and equations.

## *Issues for the course advisory committee to consider*

Nil

## *Acknowledgements*

Thank you to the examining panel for their consistent hard work and their commitment to producing a paper that examined physics in many different contexts. The marking of the paper was very efficiently organised and produced excellent consistency.

Sarah Harrison
December 2009

**2009 examining panel**

Chief examiner: Sarah Harrison
Examiner: Ralph James
Examiner: Salim Siddiqui

Chief marker: Bill Biffin

# 2009 TEE Physics

## Marking key

As a general guide, for questions requiring a numerical answer **full credit** should be given **unless** the question has specifically stated that candidates must show their working.

In all cases if the units are incorrect or missing, or if more than 3 significant figures are given, then marks should be deducted. In estimate questions, a mark should be deducted if more than 2 significant figures are given.

**Section A: Short Answers** **60 Marks**

1.

$$f_b = |f_1 - f_2|$$ (1 mark)

$$f_2 = 256 - 6$$ (1 mark)

$$f_2 = 250\ \text{Hz}$$ (2 marks)

NB: working must be shown, otherwise maximum of 2 marks

2. (a) 2 (2 marks)

(b) Positive (2 marks)

3.

$$60 = 10\log_{10}\left(\frac{I}{I_o}\right)$$

$$I_{1fp} = 10^6 \times 10^{-12}$$ (1 mark)

$$I_{5fp} = 5 \times 10^6 \times 10^{-12}$$ (1 mark)

$$\text{sound level} = 10\log_{10}\left(\frac{5\times 10^6 \times 10^{-12}}{10^{-12}}\right)$$ (1 mark)

$$\text{sound level} = 67\,\text{dB}$$ (1 mark)

4. (a) Orbital height above surface = 790 km = 7.90 x $10^5$ m

$$\frac{m_s v^2}{r} = G\frac{m_s m_e}{r^2}$$ (1 mark)

$$v^2 = G\frac{m_e}{r}$$

$$v = \sqrt{\frac{6.67\text{x}10^{-11}\text{x}5.98\text{x}10^{24}}{[6.37\text{x}10^6 + 7.90\text{x}10^5]}}$$

$$v = 7.46\text{x}10^3\ \text{m s}^{-1}$$ (1 mark)

NB: -1 mark if R = 6.37 x $10^6$ m is used

(b) $v = \dfrac{2\pi r}{T}$ (1 mark)

$$T = \frac{2\pi r}{v}$$

$$= \frac{2\pi[6.37\,x10^{6} + 7.90\,x10^{5}]}{7.46\,x10^{3}}$$

$$= 6.03\,x10^{3}\ \text{s}$$

(1 mark)

5. resolving vertically $2T\sin 15° = mg$ (2 marks)

$$2T\sin 15^{\circ} = 65 \times 9.8$$

$$T = 1230\ \text{N}$$ (2 marks)

NB: maximum 2 marks if cos or tan used instead of sin 15°

6. (a) A centripetal force, $F_c$, is required for water to move in a circular path.
At the top of swing the $F_c$ is provided by mg + N (1 mark)
The water remains in contact with the bucket as the bucket provides the force inwards required to overcome the inertia of the water and make it move in a circular path with a centripetal acceleration ≥ g (1 mark)

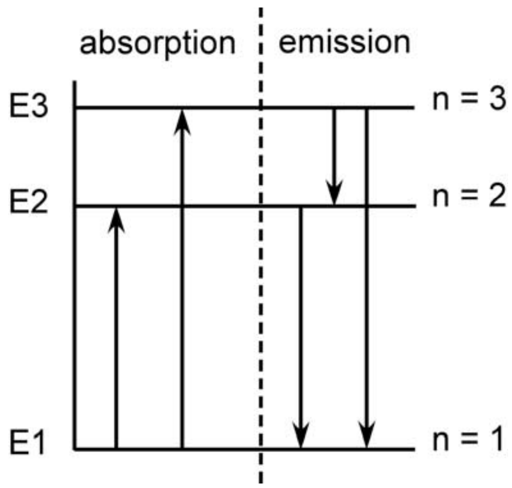
(b) $N + mg = \dfrac{mv^2}{r}$ (1 mark)

$$v_c = \sqrt{rg}$$

$$v_c = \sqrt{1.1 \times 9.8} = 3.28\ \text{m/s}$$ (1 mark)

7. Stress = F/A, So force = stress × area (1 mark)
force = $214 \times 10^{6} \times (8.5 \times 10^{-3} \times 10^{-2} \times 2 \times 10^{-2})$ (2 marks)
force = 364N (1 mark)

8.



1 mark for absorption and emission correctly labelled
Maximum 3 marks if not labelled
-1 mark for every transition missing or incorrect
-1 mark if excited state shown without justification

9. (a) 1.0mW = 1 × $10^{-3}$ J/s

$$E_{photon} = \frac{hc}{\lambda}$$

$$\text{photons / second} = \frac{E_{light}}{E_{photon}} = \frac{1\times10^{-3}\times633\times10^{-9}}{6.63\times10^{-34}\times3\times10^{8}}$$ (2 marks)

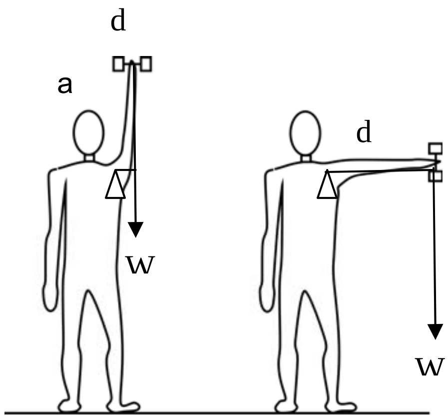
3.18 × $10^{15}$ photons hit the screen every second (1 mark)

(b) **C.** More photons hit the screen every second. (1 mark)

10. (a) Fluorescence or phosphorescence (1 mark)

(b) Incident ultraviolet light excites electrons to a higher energy level in one transition. (1 mark)
The electrons then return to the lower energy level via a series of lower energy transitions (1 mark)
Some of which emit photons of visible light (1 mark)
The frequency of the emitted photons depends on the size of the transition.
Appropriate diagram should be given credit. up to 3 marks if fully labelled and explains fluorescence correctly

11. (b) At right angles to body (1 mark)




Because in position (a) the perpendicular distance, d, from the dumbbell to the pivot point is small so the torque, Wxd, acting on the arm is small. (1 mark) In (b) d is large so a much larger torque is exerted on the arm which must be counteracted by the torque produced by the muscles in the arm. (1 mark) In a horizontal position the forces act over a small perpendicular distance and hence must be very large to provide sufficient countertorque. To earn full marks, must mention that arm has to produce a greater **force** in position b. Diagram must have appropriate annotations. (1 mark)

12 Estimate child has mass 10 kg to 50 kg
Length of gate 1 m to 3 m
Time to swing on gate 1 s to 5 s
OR speed at launch 1 m $s^{-1}$ – 2 m $s^{-1}$ (2 marks for appropriate estimates)

$v = \frac{d}{t}$ where d = ¼ ×2πr (1 mark)

then use $F = \frac{mv^2}{r}$

which should give F in range 1.0 N to 370 N (1 mark)

13. For a voltage to be induced in the secondary coil, a changing magnetic field must cut the secondary coil. (2 marks)

The input current is DC so there is no change in the magnetic field and hence no induced voltage in the secondary. (2 marks)

14.

$\sum F_y = N\cos\theta - mg = ma = 0$ (1mark)

$N = \frac{mg}{\cos\theta}$

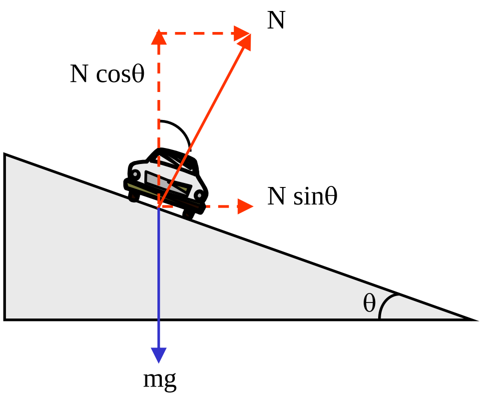
$\sum F_x = N\sin\theta = ma = m\frac{v^2}{r}$ (1mark)

$N\sin\theta = m\frac{v^2}{r}$

$\frac{mg}{\cos\theta}\sin\theta = m\frac{v^2}{r}$

$v^2 = gr\tan\theta$ (1mark)

$v = 37.6\ m/s$ (1mark)




Appropriate diagram 1 mark

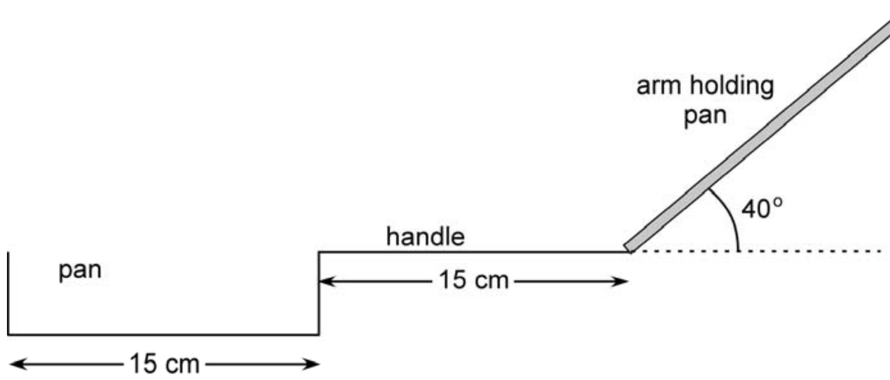
Allow for estimating friction (N cos θ or N sinθ) → 95.2 m $s^{-1}$ with friction at μ = 1

OR

$\tan\theta = \frac{v^2}{rg} \rightarrow 37.6\ m\ s^{-1}$

(2 marks) (2 marks)

15.




(Note: this is a simplification of the forces acting on the handle from the arm. There have to be two forces; one which acts upwards counteracting the weight forces downwards, plus the clockwise torque provided by the arm.)

Assume upwards force acts at end of handle and take moments about this point.
Use sum of clockwise moments = sum of anticlockwise moment
pan, handle and water are all causing an anticlockwise moment, so arm has to create a CLOCKWISE MOMENT. (1 mark)

Total ACW moment = $\text{moment}_{pan}$ + $\text{moment}_{handle}$ + $\text{moment}_{water}$ (1 mark)

ACW moment = (0.225)(0.45)(9.8) + (0.075)(0.05)(9.8) + (0.225)(2)(9.8) = 5.44 N m (1 mark)

So arm must supply moment of 5.44 N m (1 mark) in a clockwise direction (1 mark)

**Section B: Problem Solving** **100 Marks**

1. **(14 marks)**

(a) Answer: **B** (4 marks)
Answer: **A** (2 marks)
Answer: **C** (1 marks)

(b)

$$f_n = \frac{nv}{2L}$$ (1 mark)

$$L = \frac{nv}{2f_n} = \frac{1 \times 346}{2 \times 300}$$ (1 mark)

$$= 0.58\text{m}$$ (1 mark)

(c)

1. An open end of an air column reflects a sound wave with a change of phase (1 mark)
– creating a pressure node (displacement antinode).
2. A closed end reflects with no change of phase creating a pressure antinode (displacement node). (2 marks)

So standing waves in a closed pipe have a node at one end and an antinode at the other which means that the length $L = \frac{n\lambda}{4}$ where n is the harmonic. This can only be odd as an even number would give a multiple of half a wavelength which is impossible as it would imply both ends were nodes or antinodes (1 mark)

NB: 1 and 2 from above = 2 marks
showing understanding of ¼ $\lambda$ plus correct diagram = 2 marks

(d) for pipe Y n=2, for pipe B n=3

$$f_{Yn} = \frac{nv}{2L_Y}$$

$$f_{Xn} = \frac{nv}{2L_X}$$

$$\frac{2v}{2L_Y} = \frac{3v}{4L_X}$$ (2 marks)

$$L_X = \frac{3L_Y}{4} = \frac{3 \times 0.58}{4}$$ (1 mark)

$$= 0.43\text{m}$$ (1 mark)

2. NB: working must be shown.

**(14 marks)**

(a) max height occurs when vertical velocity = 0. Vertically u = 47 sin30° (1 mark)

$$v^2 = u^2 + 2as \Rightarrow s = \frac{v^2 - u^2}{2a}$$ (1 mark)

$$s = \frac{-(47 \times \sin 30^o)^2}{2 \times 9.8}$$ (1 mark)

$$s = 28.2\text{m} + 1.2\text{m}(1\text{mark}) = 29.4\text{m}$$ (1 mark)

(b)

$$v^2 = u^2 + 2as \Rightarrow v = \sqrt{2as}$$ (1 mark)

$$v = \sqrt{2 \times 9.8 \times 29.4}$$ (1 mark)

$$v = 24.0\text{ms}^{-1}$$ (1 mark)

*Alternative answer* 23 m $s^{-1}$

(c)

$$t = \frac{v - u}{a}$$ (1 mark)

$$t = \frac{-24 - (47\sin 30)}{-9.8}$$ (2 marks)

$$t = 4.85\text{s}$$ (1 mark)

*Alternative answer* 4.74s $v_v$ = 20m $s^{-1}$ → 4.44s

(d) $s_h = u_h t$ = 47 cos 30° × 4.85 (2 marks)
$s_h$ = 197m (1 mark)

*Alternative answer* 122 m
If a candidate has used the alternative value in part (b) and then carried this through, then c = 4.74s, d = 193m
If a candidate has used the alternative value in part (c) and then carried this through, then d = 181 m

3. **(13 marks)**

(a) the piece of iron would be attracted to the first magnet it crossed (1 mark)
and stay there (1 mark)

(b) non magnetic metals have a current induced in them (1 mark)
when they pass over changing magnetic fields (N to S to N),Faraday's Law (2 marks)
this induced current produces a field opposite in direction to that inducing it (1 mark)
and therefore the metal experiences a repulsive force, Lenz's Law.. (1 mark)

(c) X glass – it is non-conducting and therefore unaffected by the magnets (2 marks)

Y copper - this has the lower value of conductivity/ density so is affected by the magnets but not as much as the material with the greatest value (2 marks)

Z aluminium – this has the greatest value of conductivity/density so will be the most affected (2 marks)

1 mark each material correctly identified 1 mark each reason

NB: to gain full marks, students need to refer to the ratio of conductivity to density, not just conductivity.

4. **(13 marks)**

(a) Heated filament emits electrons (1 mark)
Electrons accelerate towards the anode target and gain a high kinetic energy (1 mark)
due to the high potential difference applied across the cathode and the anode. (1 mark)
When these high energy electrons hit the target, their energy is converted into a continuous spectrum of X-rays as they rapidly decelerate (bremsstrahlung) or (1 mark)
the electrons remove inner electrons from the target heavy metal anode and X-rays are produced as outer shell electrons emit radiation as they fall into these vacant inner shells. (1 mark)

(b) Maximum kinetic energy of electron = 100 keV (1 mark)
Therefore maximum energy of X-ray photon in the beam is also 100 keV (1 mark)

(c) (i) Wavelength of X-ray is shorter than UV, more penetrating (1 mark)
X-ray photons have higher frequency and thus energy than UV photons and therefore have greater ionizing ability, damaging cell contents. (1 mark

(ii) Any 2 of:
Operator stays behind a shield when X-ray machine is on; shield absorbs X-rays. (1+1)
Stay at a distance from the X-ray tube; attenuation increases with distance. (1+1)
Spend less time in the radiation area; radiation damage is cumulative. (1+1)
Wear lead clothing; lead absorbs X-rays (1+1)
NB: maximum of 2 marks if no justification

5. **(15 marks)**

(a) $\Sigma\tau = F_2 \times L - Mg \times \frac{L}{2} = 0$ (2 marks)

$F_2 = \frac{Mg}{2}$ (1 mark)

$F_1 = F_2 = (6.0\times10^5)9.8 = 5.88\times10^6\,\text{N}$ up (or shown on diagram) (2 marks)

or by symmetry $F_1$ = $F_2$ = ½ mg= 5.88 x $10^6$ N up, since weight in middle (5 marks)

(b) Forces acting on pin A.

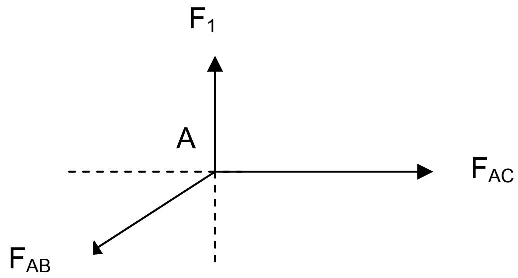
$\Sigma F_y = F_1 - F_{AB}\sin 60^\circ = 0$ (2 marks)

$F_{AB} = \frac{F_1}{\sin 60^\circ} = 6.79\times10^6\,\text{N}$ (2 marks)

$\Sigma F_x = F_{AC} - F_{AB}\cos 60^\circ = 0$

$F_{AC} = 3.39\times10^6\,\text{N}$

Compression (1 mark)




(c) Allowing for a safety factor of 5, the breaking stress will be 1/5th of the value given in the Data table

$\frac{1}{5}(\text{Breaking stress}) = \frac{F}{A}$ (2marks )

$A = \frac{(6.79\times10^6)}{\frac{1}{5}(11\times10^8)}$ (2marks )

$= 0.03\,\text{m}^2 = 3.0\times10^{-2}\,\text{m}^2$ (1mark )

Alternative answer: $1.59 \times 10^{-2}$ $m^2$

6. **(14 marks)**

(a) use emf = $\ell vB$ (1 mark)
= 0.3 × 6 × 0.5 (1 mark)
= 0.9 V (1 mark)

(b) use $I = \frac{V}{R} = \frac{0.9}{2} = 0.45\,\text{A}$ (2 marks)
in direction S to R (2 marks)
Size of current: 0.45 A Direction: S to R, OR anticlockwise

(c) use F = I$\ell$B = 0.5 × 0.45 × 0.3 = 0.0675N (2 marks)
to the right (2 marks)

(d) 0.0675N (2 marks)
to the left (1 mark)

7. **(16 marks)**

(a) $$F=\frac{Gm_1m_2}{r^2}=\frac{6.672\times10^{-11}\times1.305\times10^{22}\times1.52\times10^{21}}{(19570\times10^3)^2}$$ (3 marks)

$$F=3.45\times10^{18}\,\text{N}$$ (1 mark)

(b) $$v^2=\frac{Fr}{m}$$ (1 mark)

$$v=\sqrt{\frac{Fr}{m}}=\sqrt{\frac{3.46\times10^{18}\times2034\times10^3}{1.305\times10^{22}}}$$ (2 marks)

$$v=23.2\text{ms}^{-1}$$ (1 mark)

NB: Max 1 mark if use $v=\sqrt{\frac{Gm}{r}}$

(c) (i) $$t=\frac{2\pi r}{v}$$ (1 mark)

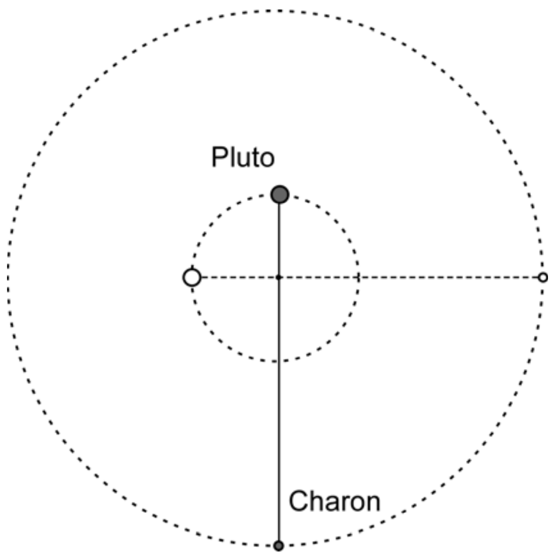
$$=\frac{2\pi\times2034\times10^3}{23.2}$$ (1 mark)

$$=550\times10^3\text{s}$$ (1 mark)

$$t=6.4\text{days}$$ (1 mark)

6.16 days if use 24 m $s^{-1}$.

(ii)




2 marks each. May go beyond 90° but must still be in line with one another.

**Section C: Comprehension and Interpretation** **40 Marks**

(a) The hollow box is a resonant cavity with a large air volume; (2 marks)
this air resonates when the string is plucked, so the sound volume is increased; (1 mark)
energy transfer is string → box → air (1 mark)

(b) A current in a conductor generates a magnetic field around it.
An alternating current generates a magnetic field which changes direction. (1 mark)
When the conductor is placed in a permanent magnetic field the two fields repel and attract. (1 mark)
Since there is an alternating current in the wire the wire is being continually repelled and attracted by the permanent field (1 mark)
The AC thus causes the wire to oscillate. (1 mark)

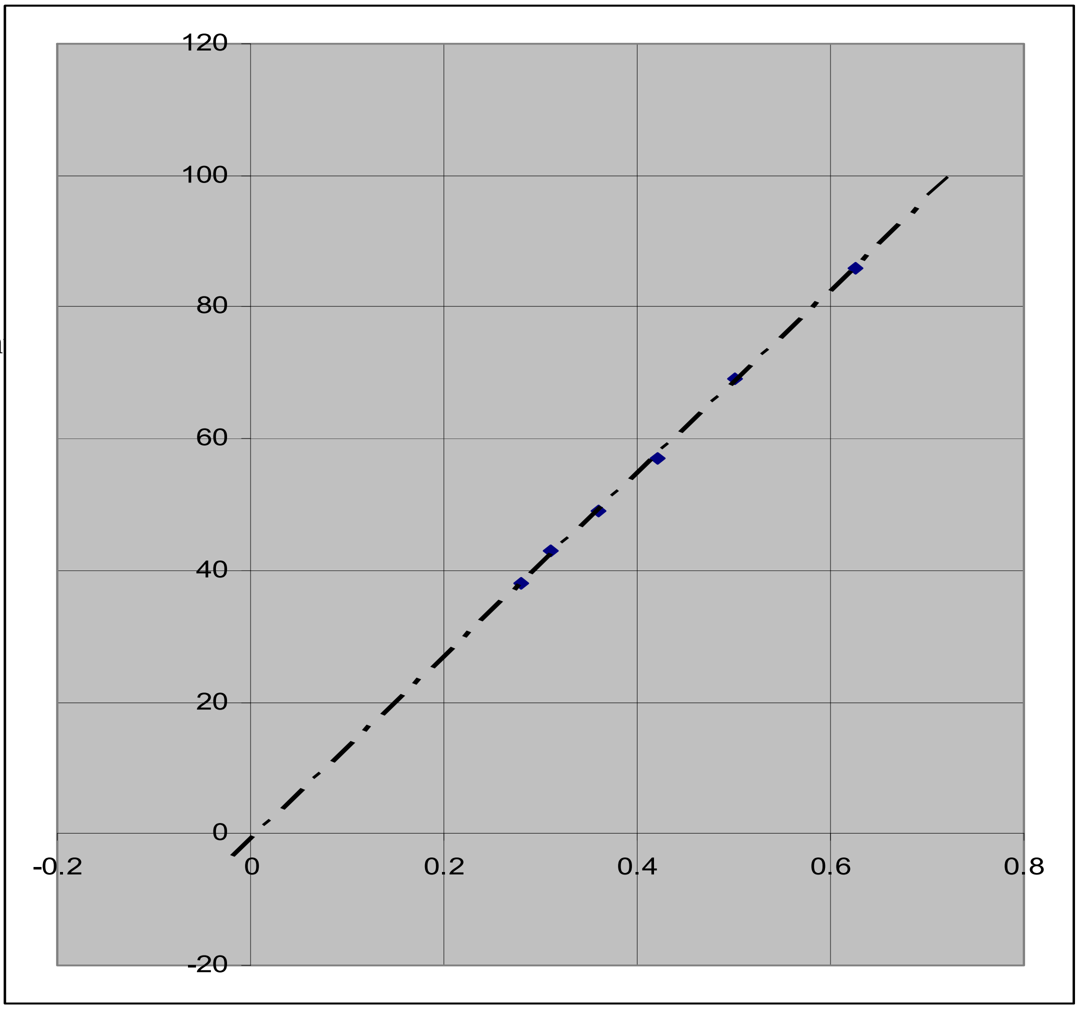
(c)

| Length (m) | Tension (N) | Resonant frequency (Hz) | $\frac{1}{2L}$ |
|---|---|---|---|
| 0.8 | 7.6 | 86 | **0.62 or 0.63** |
| 1.0 | 7.6 | 69 | **0.5** |
| 1.2 | 7.6 | 57 | **0.42** |
| 1.4 | 7.6 | 49 | **0.36** |
| 1.6 | 7.6 | 43 | **0.31** |
| 1.8 | 7.6 | 38 | **0.28** |

1 mark for each of:
*table completed
*axes scale
*axes labels
*correct points
*line of best fit

If axes reversed, -1 mark

(No further penalty if gradien calculated correctly)



(d) gradient = 138 (2 marks) Hz m (1 mark)

(e) $\text{gradient} = f\,2L = \sqrt{\frac{T}{\mu}}$ (1 mark)

$\text{gradient}^2 = \frac{T}{\mu}$ (1 mark)

$\mu = \frac{T}{\text{gradient}^2} = \frac{7.6}{138^2} = 4 \times 10^{-4}\ \text{kgm}^{-1}$ (1 mark)

so string is an E. (1 mark)

Alternative value gives a D

**2. Wind turbine generator** **(20 marks)**

(a) $\text{turns ratio}\ \frac{N_s}{N_p} = \frac{V_s}{V_p} = \frac{20 \times 10^3}{1000}$ (2 marks)

$= 20$ (1 mark)

NB: just 20 or $^1/_{20}$ = 1 mark only

(b) Any reasonable response, for example (4 marks)

The power extracted by a wind turbine is proportional to the radius$^2$ so increasing the diameter of the turbines increases the power extracted. (2 marks)
Large scale turbines may require specialised materials to be developed before they can be viable, OR large turbines cost more, so they are developed at a small scale, then scaled up for sale. (2 marks)

(c) $P = \frac{1}{2} C_p\, A\, \rho\, v^3 = \frac{\pi}{8} C_p\, \rho\, D^2\, v^3$

$C_p = \frac{8P}{\pi \rho D^2 v^3} = \frac{8(15 \times 10^3)}{(\pi)(1.22)(10)^2(10)^3}$ (2 marks)

$= 0.313$ or $31.3\%$ (1 mark)

(d) $V_G = \frac{XP_{em}}{3V_T}$ (1 mark)

$= \frac{10 \times 3000 \times 10^3}{3 \times 1000}$ (1 mark)

$= 10\ \text{kV}$ (1 mark)

(e) Note: error in paper as it should have given radii or asked for ratio of frequencies
generator solenoid has frequency 50Hz,
rotor has frequency 16 rpm = 0.26 Hz (1 mark)

$$v = 2\pi rf$$

therefore

$$\frac{v_2}{v_1} = \frac{f_2 r_2}{f_1 r_1} = \frac{f_2}{f_1} x \frac{r_2}{r_1}$$

$$\frac{f_2}{f_1} = \frac{50}{0.26} = 185$$ (1 mark)

therefore

$$\frac{v_2}{v_1} = 185\frac{r_2}{r_1}$$ (1 mark)

(f)

$$B = \frac{V_G}{2\pi f\,NA}$$ (2 marks)

$$= \frac{10 \times 10^3}{2\pi \times 50 \times 10000\pi(0.2)^2}$$ (1 mark)

$$= 0.025\,T$$ (1 mark)

**End of marking key**