EXAMINERS' REPORT ON 2004 TERTIARY ENTRANCE EXAMINATION

SUBJECT: PHYSICS

STATISTICS

Year	Number Who Sat	Non-Examination Candidates	Did Not Sit
2004	2975	33	208
2003	3154	45	209
2002	3001	29	181

This Examiner's report is written by the Chief Marker in collaboration with the Chief Examiner to comment on matters relating to the Physics Tertiary Entrance Examination. The opinions and recommendations expressed in this report are those of the Chief marker and Examiner and not necessarily representative of or endorsed by the Curriculum Council.

The Marking Guide provided at the end of this report was prepared for markers and has been substantially amplified by discussions held in the pre-marking meeting. It is not intended as a set of model answers, and is not exhaustive as regards alternative answers. Some of the answers are less than perfect, but represent a standard response that the examiners deemed sufficient to earn full marks. Teachers who use this guide should do so with its original purpose in mind.

SUMMARY/ABSTRACT

The markers felt that the paper gave good clear instructions to the students and provided good discrimination, with the early part of most questions in section B accessible to all students. A good variety of question styles was used. The Syllabus Committee agreed that the paper contained a good range of questions and was an acceptable representation of the course. The marking of the paper was mostly straightforward apart from Question B 6 and Question C 1.

The format of the paper was the same as last year except that the choice in section B was limited to only one part rather than a whole question. The majority of the students completed the paper in the time allowed. The mean 2004 raw exam score of 60.6 was slightly greater than 2003 (59), and the standard deviation of 15.6 was similar to that of 2003 (16). This suggests a slightly easier paper than last year but overall the level of performance is comparable.

The issue of significant figures was again raised and some clarification should be given to students and teachers, and it should also be made clear that calculation type questions require some working to be shown for full marks to be awarded.

GENERAL COMMENTS

Firstly thanks must go to the examining panel for their dedication in producing a paper that was well received by students, teachers and markers.

Several minor innovations were introduced in the design of the paper this year.

1. In part A especially, but also throughout the paper, there was a deliberate attempt to vary the question types and thus the way in which students were required to answer the question. A brief description of the types of question formats for Part A is given below. Overall, less than 50% of the allocated marks throughout the paper were for numerical or calculation-based answers.

2. There was a deliberate decision to not give alternative-context questions. This should not be taken as a permanent change and later examiners might still employ this option. However, there was a small element of choice offered several times to students in the way they answered a question.

3. In parts B and C, each question had an initial, short, low-value part-question to assist all students to make a start. This part-question was designed to focus students' attention on the diagram or illustration for the question to reduce the likelihood of them misinterpreting the question.

4. A more obvious change in the paper was the incorporation of a question on experimental design and the analysis of data in Part C rather than Part B or A. This enabled a greater range of part-questions related to the experimental task. This question also included an attempt to accommodate students who preferred to formulate a solution using manual graphing as well as those who preferred to use a graphics calculator.

5. A further innovation was to assist students to complete part (c) of a question when it depended on them determining an answer to part (b). In Part B, Q3, students were offered the chance to use an answer of 400N to carry on with the next part. This should also have made it easier for markers to fairly allocate marks when students make a numerical error and carry this through to a later part of the question.

6. In several questions (e.g. Part A Q9 and Part B Q2c), a small, but not essential graphic was used to enable students to better understand the situation or to give them a context or hint in formulating an answer. It was hoped that this extraneous material would be a help rather than a hindrance to some students.

Breakdown of Paper

On setting the paper, the breakdown by area of study was approximately:

Sound Waves:	15%
Electric power:	30%
Movement:	23%
Structures and Materials:	20%
Atomic Physics:	12%

This breakdown is not always easy to ascertain because many questions, particularly in Parts B and C, cover several areas and/or contexts.

The following illustrates the range of ways in which students were required to provide answers:
Part A:
1. Fairly straightforward numerical calculation but with one piece of unneeded data.
2. Interpret and add information to an existing diagram.
3. Interpret a graph and give a written answer.
4. Write an explanation for a well-known phenomenon.
5. A concept-testing item – make inferences based on several diagrams.
6. A question requiring a description and a diagram (for the context the student had studied).
7. Interpret a physical situation and write a physics explanation.
8. A straight-forward calculation.
9. Provide an explanation for a physical situation in either mathematical or written format.
10. Use supplied diagrams to infer a physical change.
11. Interpret a diagram of a physics demonstration and provide a written explanation for a given observation.
12. Estimate a numerical solution to a complex problem. Students had to derive one variable from a figure on their data sheet.
13. Explain in words a physical relationship of cause and effect.
14. Interpret data in a table, calculate trajectories of charged particles in an electric field and then draw these correctly on a diagram.
15. Interpret information and a diagram and infer what is happening and then select an appropriate graphical representation.

***COMMENTS ON SPECIFIC QUESTIONS*.**

These comments are offered by the Chief Marker after consultation with selected individual markers and the Chief Examiner.

SECTION A: *Short Answer*

Q1 Attempted 2929 Mean 80%

This was a good easy start to the paper. The main error here was the use of four seconds for the time for one way. The inclusion of the frequency resulted in a number of weaker students trying to use $v=f\lambda$ to solve the problem.

Q2 Attempted 2959 Mean 56%

The shape of the Earth's magnetic field was well understood, but many students are unclear about the distinction between the geographic poles of the Earth and the magnetic poles that must exist inside the Earth. Most students had trouble with the angle of dip. The main problem was showing the angle of dip clearly on the diagram with very few drawing tangents to the Earth's surface or the field lines. A number of students also gave the angle of declination rather than the angle of dip. Many students are also sloppy in the drawing of their diagrams.

Q3 Attempted 2963 Mean 79%

This was well answered with students giving clear and concise answers. This has obviously been well taught across the student cohort. There was some minor confusion by some students between elastic limit, proportional limit and yield point.

Q4 Attempted 2869 Mean 57%

This was a difficult question as it tested the understanding of a fundamental concept. Many explanations simply restated the given information that the frequency was constant, usually by saying that the velocity was directly proportional to the wavelength, keeping frequency the same. This achieved part marks but has in fact has missed the point entirely. A few good students stated that frequency was independent of the medium and only depended on the vibrating source.

Q5 Attempted 2965 Mean 46%

Amazingly, this proved to be the most difficult question in section A. In many cases weaker students answered this better than stronger students. Students have missed the simple concept that the spring balance must provide an equal but opposing force to the weight, which is true in all cases as the pulleys are frictionless.

Q6 Attempted 2732 Mean 72%

A very straightforward question but most students omitted at least one of the important requirements, namely forces on diagrams, material used or how the compressive strength gave the whole structure its durability or strength. A large number drew a beam situation which requires tensional strength.

Q7 Attempted 2955 Mean 62%

In hindsight it would have been better to have students also indicate a pivot point so that forces drawn on the diagrams were clearly opposing torques. Despite clearly being a moments problem (torque used in question) many students did not use this concept in their explanations. Explanations were often not clear and many students failed to realise the significance of the weight force acting at a greater distance from the vertical wall.

Q8 Attempted 2893 Mean 82%

This question was universally done well with students showing a clear understanding of resonance in pipes and beats. The major mistake students made was using an open pipe formula rather than a close pipe.

Q9 Attempted 2890 Mean 62%

Most students attained half the marks by calculating the speed of the ferris wheel and showing some working. However the clarity of their arguments left a lot to be desired. Very few drew a diagram to illustrate the forces acting and their direction. A large number used a formula that was applicable to a string pulling inwards and not a chair pushing upwards. Most students wanted to put the masses into the formulae immediately and failed to realise that the situation is independent of mass. This was an excellent discriminator.

Q10 Attempted 2961 Mean 67%

Surprisingly a large number of students did not put in the correct direction for conventional current on the diagram. Many students however correctly identified the direction of the induced current relative to that in Coil 1 and realised that it decreases to zero if the switched stayed closed.

Q11 Attempted 2946 Mean 50%

This was a difficult question. Many students correctly chose the solid but their explanations were not very clear. Eddy currents were often used in the explanations but how this resulted in a force was not well explained. Students who chose the annulus also received some credit depending on the clarity of their arguments. In fact the question was more subtle than the students realised. Although the force acting on the solid is clearly much larger than the annulus the question is asking about deceleration. Some students did mention the lighter mass of the annulus but did not elaborate much further.

Q12 Attempted 2722 Mean 58%

Many students answered this well. The students tended to get this question completely correct or only get one mark for understanding efficiency. There was also a small but significant group who used the charge on an electron to divide into the energy given out by the globe. It was not clear from their working whether they were estimating photon energy as 1 eV (infrared region) for visible light, or simply confusing photons and electrons. Given the lack of clarity in these answers the latter is suspected, rather than the former.

Q13 Attempted 2860 Mean 54%

Student answers lacked clarity and most did not state that the charged particle needed to move at right angles to the external field for it to move in a circle. This tended to be assumed by even the better students. Most students understood that the force was at right angles to the velocity and the good students stated this as a necessary condition of circular motion. This was another excellent discriminator.

Q14 Attempted 2950 Mean 60%

This was a simple but discriminating question. Most students got the direction correct, which shows that they know how the magnetic force relates to the motion of a charged particle. The better students used the grid effectively to draw the correct radius although many had trouble with the negatively charged particle.

Q15 Attempted 2950 Mean 64%

It was pleasing to note the large number of students choosing the correct answer B, but those choosing A, also received part marks for showing some understanding.

SECTION B: *Problem Solving*

Q1 Attempted 2955 Mean 53%

This was intended to be a fairly straightforward question but was in fact the hardest of the first five questions. It was a simple triangle of forces problem with a circular motion basis. The problems students have with circular motion were exposed here. Many students still do not realise that the resultant is the centripetal force. This was tested explicitly in part (c) which had a low average mark.

Q2 Attempted 2963 Mean 65%

Generally this question was handled well. Students showed an excellent grasp of loudness and logarithmic scales, and gave extremely good answers to part (d) on the attenuation of sound. The transmission line problem was not done very well, with many students putting incorrect values into electrical formulae. Some of the effects on the environment were a little unlikely but some latitude was given to students.

Q3 Attempted 2965 Mean 67%

Students answered this question well and demonstrated a good understanding of moment problems and tensile strength. The main error in part (b) was the failure to use appropriate angles in calculating moments, and many did not use the perpendicular distance that was give for the tension. A major error that some students made in part (c) was using Young's Modulus.

Q4 Attempted 2952 Mean 74%

Most students successfully solved parts (a) and (b) with some pleasingly deriving Kepler's law from first principles. Errors in part (c) were mainly due to the failure to convert units correctly (part (i)) and surprisingly many could not identify both the measurements required to estimate Sedna's mass.

Q5 Attempted 2954 Mean 74%

This proved to be the easiest question in Section B. Most errors were minor, which indicates that students have a good understanding of atomic spectra transitions. Reasons given in part (a) were not very lucid, although most could correctly identify the relevant spectra types.

Q6 Attempted 2924 Mean 54%

This question highlighted a fundamental error in the students' understanding of this area of sound. The difference between pressure standing waves and displacement standing waves was not well understood, and the understanding of loud and quiet sounds depending on pressure fluctuations was virtually non-existent. Unfortunately most texts do not make this distinction very clear and often glibly draw displacement graphs when dealing with standing waves in air. Some even incorrectly imply that displacement nodes are quiet. There needs to be some corrective teaching of this area of the course if these misconceptions are to be addressed. Students also had trouble explaining standing waves and giving clear diagrams. Part (c) was a disaster, with extremely few students getting part marks let alone full marks (average about 15%).

Q7 Attempted 2923 Mean 66%

Students demonstrated a good understanding of projectile motion. Many students could perform the calculation correctly in (a) but could not work out the points this displacement gave. In part (b) students had trouble clearly explaining the effect of the change given. Although students knew that air resistance caused the path to change few gave a correct trajectory for both balls.

Q8 Attempted 2905 Mean 50%

Electromagnetic principles usually cause students some difficulty and this was evident in this question. Students continue to confuse motors and generators when describing how they function. Most students missed the most important factor in (a) which was that slip rings provide constant contact with the external circuit and allow free rotation. Many students talked about current going into the coils! Part (b) allowed students to calculate an average emf using a linear approximation over a ¼ of a turn (Faradays law), an rms value or a maximum. Many errors were made here, but the most surprising was that students did not know whether the value calculated was a maximum or an average. Most students constructed sinusoidal graphs but the scales were often poorly marked or incorrect.

SECTION C: *Comprehension and Interpretation*

Q1 Attempted 2942 Mean 47%

This question was not handled very well. It has been some years since a curve straightening type question was in the exam and many students do not appear to have developed this skill. Circuit diagrams were generally poor with ammeters in parallel, voltmeters in series and incorrect symbols used. Reading and drawing basic circuit diagrams is a fundamental concept which Physics students should master. The correct units posed a problem for many students and although the graphing question specifically asked for the slope of the line of best fit, students do not give the units. Despite many students realizing the correct relationship in part (b) they were unable to extract what was needed to plot a linear graph. Those that tried to use their graphics calculator tended to do disastrously. They plotted the wrong values, often the variables were in the incorrect order and they wrote equations without meaningful symbols. The danger is that little working is shown as opposed to drawing a graph and hence few marks can be awarded for an incorrect answer. The explanations in part (c) were again not very clear although most knew that it would run hotter and be less efficient.

Q2 Attempted 2922 Mean 61%

Students did parts of this question well and others poorly. In part (a) most got the symbol G but N was often generalized to reaction force of the road which is incorrect. Part (b) was difficult as it combined circular motion and moments. Most students' answers were poor. The top students gave excellent answers and this was a very good discriminator. In part (c) students did not use the diagram well to make estimates of heights and widths. Some used the total width of the car and yet others interpreted w as the weight!! They clearly did not read the article carefully enough. Part (d) was well done, but the majority did not state the significance of a rollover SSF factor of more than 1.2, but otherwise gave good comments.

POINTS FOR CONSIDERATION BY THE SYLLABUS COMMITTEE

No major difficulties were faced. However some areas of concern may be highlighted.

• As stated last year: "Although the opportunity for students to guess answers was limited the ability to obtain full marks for a question by giving the correct answer even though the working is incorrect or non-existent should be removed. This could easily be addressed by changing the wording at the front of the paper." An example of this was Section B 7(a). The question asked to calculate the number of points scored. The word **calculate** could be used at the front of the paper to indicate that at least some working needs to be shown to gain full marks otherwise students could guess the number of points as in this example.

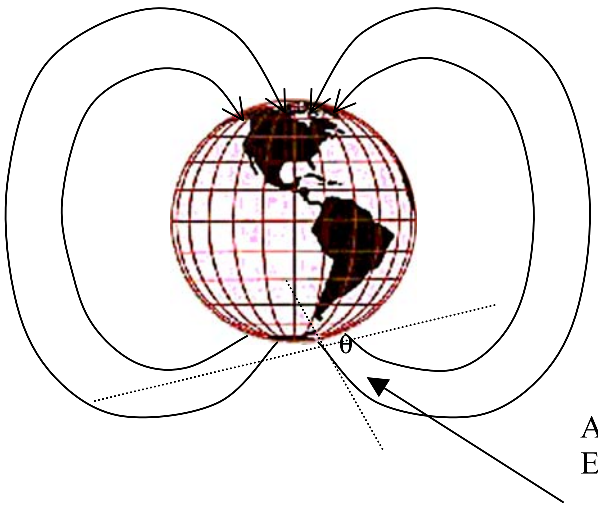
• The issue of **significant figures** is always raised at the markers meeting, especially in relation to estimation questions. The policy adopted has been that marks will not be deducted for use of incorrect numbers of significant figures, except in the case of estimation questions, where more than 3 significant figures will be penalised one mark. I would like to see a policy adopted across the physical sciences as to what is to be expected in this area as there are conflicting views on the importance of this area of the course and I am sure not all teachers are treating significant figures in the same way.

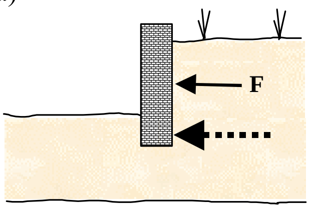
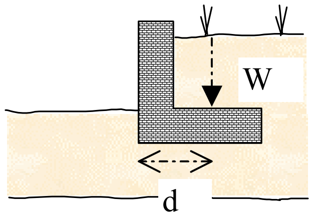
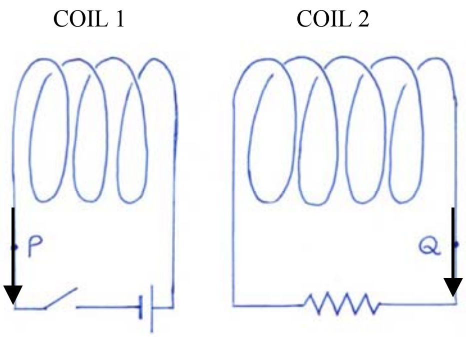
Bill Biffin
December 2004

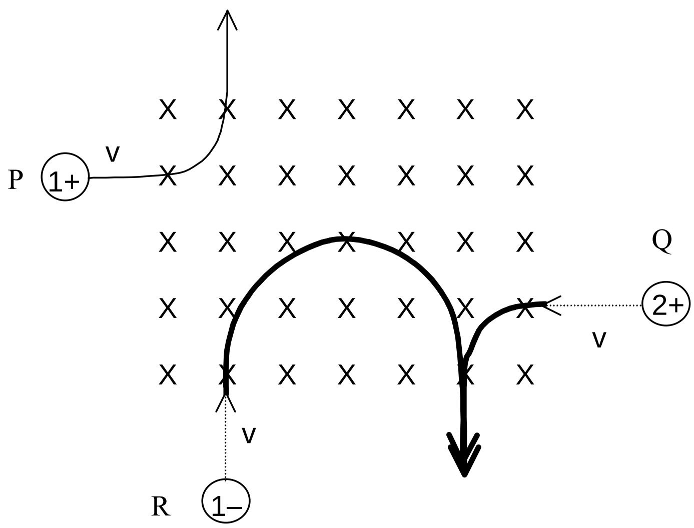
Chief Examiner: Dr Shelley Yeo
Deputy: Mr Jeff Cahill
Third Member: Dr Dmitry Fursa

Chief Marker: Bill Biffin

SECTION A: Short Answers (60 Marks)

1	$v = \frac{s}{t}$ $\quad$ $v(\text{in seawater}) = 1530\text{ms}^{-1}$ $\therefore s = v.t = 1530\text{x}2.0 = 3.06\text{x}10^{3}\text{m} \quad (= 3.1\text{km})$	**2 marks** **2 marks**
2		Shape and direction **2 marks** Angle of dip **2 marks** (must indicate tangents to earth and field lines)
3	a) Elastic limit b) Elastic – wire returns to original shape after deformation (stretching) Plastic – wire remains permanently deformed after stretching	**2 marks** **2 marks**
4	Principle: The frequency of sound is determined by the frequency of vibration of the source and is thus unaffected by the medium that the wave moves through. (Changing medium does not affect the frequency of the wave (only the speed and wavelength change; directly proportional).	**4 marks** (2 marks only)
5	Equal to Equal to	2 marks 2 marks
6	Bridges and Buildings: Examples: arches or buttresses of stone, load-bearing struts of wood or steel, pre-stressed concrete Diagram: showing compressive forces Human and Animal Frames: Examples: load-bearing bones of large animals, skulls, Diagram: showing compressive forces (must mention material to gain full marks)	Example **2 marks** Diagram showing forces **2 marks**

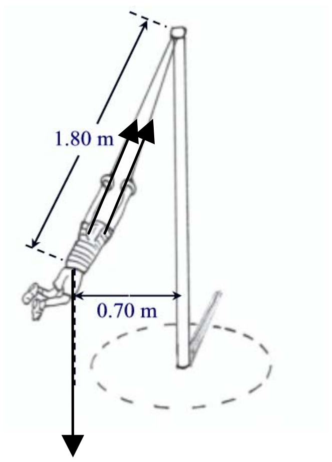
7	a)  . b)  The weight of the earth provides a force at a greater distance (d) from point of rotation of wall which gives a **greater counter torque**. Weight of lower section of the wall would also contribute.	**1 mark** for force shown in diagram a) **1 mark** for force shown in diagram b) **2 marks** for explanation
8	Closed pipes $\therefore L = \frac{\lambda}{4}$ $f_1 = \frac{v}{\lambda} = \frac{346}{4(0.57)} = 152 \text{ Hz}$ $f_2 = \frac{346}{4(0.61)} = 142 \text{ Hz}$ $v_b = \lvert f_1 - f_2 \rvert = 10 \text{ Hz}$ i.e. 10 beats are heard per second	**1 mark** **2 marks** **1 mark**
9	Reaction force on students at the top **R = mg – mv²/r** (should show forces on a diagram for clarity) $v = \frac{2\pi r}{T} = \frac{2\pi(14)}{10.5} = 8.38 \text{ ms}^{-1}$ $ma_R = mg - \frac{mv^2}{r}$ $\therefore \quad a_R = g - \frac{v^2}{r}$ $\therefore \quad a_R = 9.8 - \frac{(8.38)^2}{14} = 4.8 \text{ ms}^{-2}$ The resultant acceleration is independent of mass thus both students remain seated.	**1 mark** **1 mark** **1 mark** **1 mark**
10	a)  b) It decreases to zero	Both arrows at P & Q in same direction **1 mark** P in correct direction **1 mark** **2 marks**

11	a) Solid b) As the conductor cuts flux lines a current is induced in the plane of the bob. The solid bob allows a greater current (more surface area, more mass, more electrons) as there is less resistance and therefore a greater induced magnetic field will be created which provides an opposing force to the swinging pendulum.	**1 mark** **3 marks**
12	100W 3% efficient means 3J of light energy produced per second. Estimate average frequency = $5x10^{14}$ Hz (range 3-7 x 10^{14} Hz) $P = \frac{E}{t} = \frac{n(hf)}{t} = 3$ $n = \frac{3t}{hf} = \frac{3x1}{6.63x10^{-34}(5x10^{14})} \approx 10^{19}$ photons	**1 mark** **1 mark** **2 marks**
13	There is a magnetic force acting on the moving charge if there is a component of the velocity perpendicular to the field. The force is always perpendicular to the velocity of the moving charge and the magnetic field. These are the conditions necessary for circular motion (not linear motion).	**1 mark** **1 mark** **1 mark** **1 mark**
14		**2 marks** each path (1 mark for direction and 1 mark for radius of curvature)
15	Answer: **B** (Incorrect answer of **A** is worth 2 marks)	**4 marks**

SECTION B: Problem Solving (100 Marks)

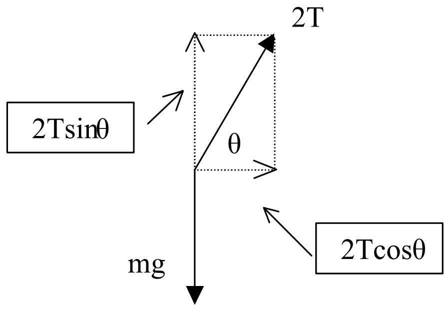
Question 1 (10 marks)

a)



2 marks
(1 mark each for T & W - 1 mark for each incorrect forces)

b)



$\cos\theta = 0.70/1.80$
$\theta = 67.1°$

1 mark Diagram (or triangle of forces)

$$2T\sin\theta = mg$$

$$T = \frac{mg}{2\sin\theta} = \frac{20(9.8)}{2\sin 67.1} = 106\text{N}$$

(in each supporting arm)

1 mark

2 marks

c) Net force is centripetal – towards centre of rotation (or show on diagram)

1 mark

$$F_c = 2T\cos\theta = 2(106)\cos 67.1 = 82.8\text{N}$$

3 marks

Question 2 (14 marks)

a)

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \quad \therefore \quad N_s = \frac{V_s N_p}{V_p} = \frac{6000 \times 1000}{500} = 12000 \text{ turns}$$

1 mark Ratio formulae
2 marks

b)

$$P_{transmitted} = VI \quad \therefore \quad I = \frac{P}{V} = \frac{20\text{x}10^3}{6\text{x}10^3} = 3.33\text{A}$$

1 mark

$$P_{loss} = I^2R = (3.33)^2 \times 10 = 111\text{W}$$

$$V_{drop} = \frac{P}{I} = \frac{111}{3.33} = 33\text{V} \qquad \text{alt}: \quad V_{drop} = IR = 3.33 \times 10 = 33\text{V}$$

2 marks

1 mark

$$V_{delivered} = 6000 - 33 = 5967\text{V} \approx 5970\text{V}$$

[Students may use R=20Ω]

c) Any three of noise, fossil fuel collection, heat, carbon dioxide, fumes

3 marks

d) Intensity of sound (P/A) decreases with r^2

$$\text{dB change} = 10\log_{10}\frac{I}{I_0}$$

$$120 = 10\log\frac{I_{out}}{10^{-12}} \quad \therefore \quad I_{out} = 10^{12}\times 10^{-12} = 1\,\text{Wm}^{-2} \quad \text{(1 m from source)}$$

$$\text{Intensity 2 km away} = \frac{1}{(2\text{x}10^{3})^{2}} = 2.5\text{x}10^{-7}\ \text{Wm}^{-2}$$ **1 mark**

1 mark

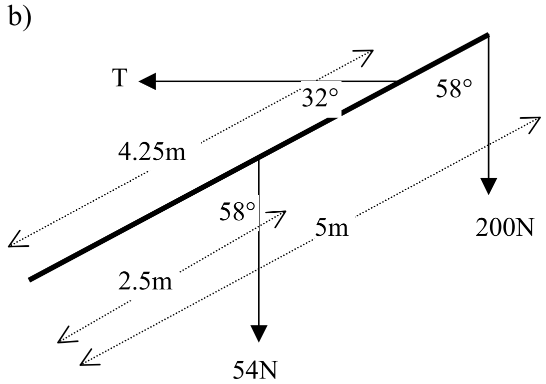
$$\text{dB change} = 10\log_{10}\frac{2.5\text{x}10^{-7}}{10^{-12}} = 54\,\text{dB}$$ **1 mark**

Yes, sound will be heard as it is above the hearing threshold of 20 dB **1 mark**

Question 3 (12 marks)

a) A = Tension
B = Compression **2 marks**

b)



$$\sin 32 = \frac{2.25}{x} \quad \therefore \quad x = 4.25\text{m}$$

(not necessary as only require perpendicular component of 2.25m)

1 mark for diagram if no calculation done

System is in equilibrium, so ΣCWM = ΣACWM. **1 mark**

Taking moments (rFsinθ) about B:

$$(200 \times 5 \times \sin 58) + (54 \times 2.5 \times \sin 58) = T \times 2.25$$ **3 marks**

$$T = 428\ N$$ **1 marks**

[Students may do this in several steps]

c) max stress = $4.9\text{x}10^{8}$ Pa **1 mark**

$$10T = 4280\text{N}$$

$$4.9\text{x}10^{8} = \frac{T_b}{A} = \frac{T_b}{\pi r^2}$$ **2 marks**

$$r^2 = \frac{T_b}{4.9\text{x}10^{8}(\pi)} = 2.78\text{x}10^{-6}\,\text{m}^2$$ **1 mark**

$$r = 1.67\text{x}10^{-3}\,\text{m}$$

$$d = 3.3\text{x}10^{-3}\,\text{m} \quad (= 3.3\text{mm})$$ **1 mark**

[=3.2mm if T = 400N used]

Question 4 (12 marks)

a)

$$Mercury: \quad \frac{T^2}{R^3} = \frac{(7.60x10^6)^2}{(5.79x10^{10})^3} = 2.97x10^{-19}\, s^2 m^{-3}$$

$$Venus: \quad \frac{T^2}{R^3} = \frac{(1.94x10^7)^2}{(1.08x10^{11})^3} = 2.98x10^{-19}\, s^2 m^{-3}$$

$$Earth: \quad \frac{T^2}{R^3} = \frac{(3.16x10^6)^2}{(1.50x10^{10})^3} = 2.95x10^{-19}\, s^2 m^{-3}$$

3 marks

The solutions for these three planets are constant (to 2 sig figures)
Students can also do a theoretical solution equating F_c to F_g

b) Two ways of solving:

$$\frac{{T_E}^2}{{R_E}^3} = \frac{{T_J}^2}{{R_J}^3} \quad \therefore \quad 2.95x10^{-19} = \frac{(11.8 \times 365 \times 24 \times 3600)^2}{{R_J}^3}$$

2 marks

$${R_J}^3 = 4.68x10^{35}$$

1 mark

$$R_J = 7.6x10^{11}\, m$$

1 mark

OR

$$\frac{{T_E}^2}{{R_E}^3} = \frac{{T_J}^2}{{R_J}^3} \quad \therefore \quad {R_J}^3 = \left(\frac{T_J}{T_E}\right)^2 (R_E)^3 = \left(\frac{11.8}{1}\right)^2 \left(1.50x10^{11}\right)^3 = 4.70x10^{35}$$

$$R_J = 7.6x10^{11}\, m$$

Value can vary depending on constants used 7.5 to 7.8 $x10^{11}\, m$

c)

(i) $$g = G\frac{M_{Sun}}{r^2} = 6.67x10^{-11}\left(\frac{1.99x10^{30}}{(7.1x10^{13})^2}\right) = 2.6x10^{-8}\, ms^{-2}$$

3 marks

(ii) Assume a circular orbit (as approximation): $g = v^2/r$, $\frac{v^2}{r} = G\frac{M}{r^2}$, $M = \frac{v^2 r}{G}$

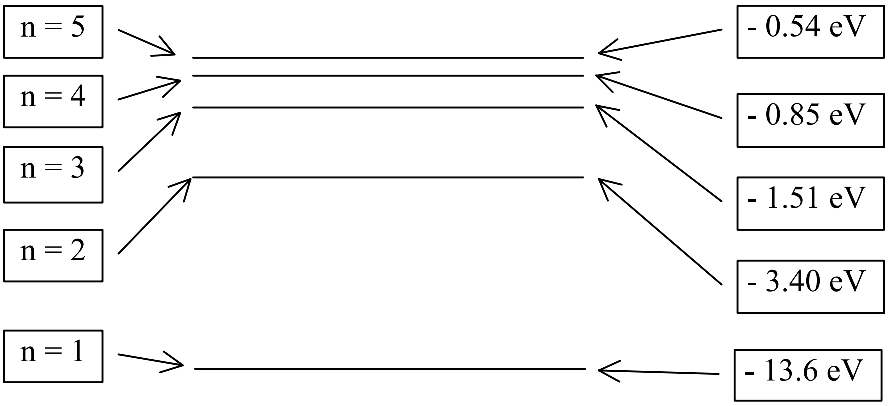
The two required measurements are period and radius of orbit

2 marks

Question 5 (15 marks)

a) A = torchlight Reason – large' band' of absorbed or transmitted wavelengths (max intensity of transmitted light in red/orange region)	**1 mark** names
B = red laser Reason – single frequency emitted (in red region)	**2 marks** Explanation

b) (i)



1 mark
for n = 1 to 5

3 marks
for energy values must be negative

(ii) 13.6 eV

1 mark
(not negative)

(iii)

2 marks

$$\Delta E = \left|-13.6 + 3.4\right| \text{ eV}$$

$$= 10.2(1.6x10^{-19}) = 1.63x10^{-18}\,\text{J}$$

$$f = \frac{\Delta E}{h} = \frac{1.63x10^{-18}}{6.63x10^{-34}} = 2.5x10^{15}\,\text{Hz}$$

1 mark

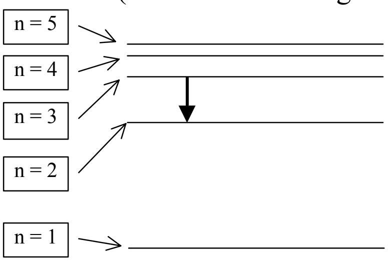
This frequency is in the ultraviolet (UV) region

1 mark

[There may be a carried error here]

c) (i) Transition from n = 3 to n = 2 (Must show on diagram):

1 mark



(ii) Red is lower energy photon therefore must be smaller energy transition.
OR equivalent calculation that justifies answer

2 marks

Question 6 (13 marks)

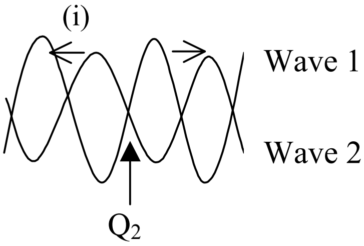
a) Standing wave: 0.5 λ = 0.60m, therefore λ = 1.20m

1 mark

$$f = \frac{v}{\lambda} = \frac{346}{1.20} = 288\text{Hz}$$

2 marks

b) (i)



Standing wave is produced in which destructive interference **always** occurs at all Q points – which are pressure nodes – positions of least amplitude of the resultant wave.
[Students may comment that sound is quiet not silent because the waves have different intensities at point Q_2.]

2 marks
Diag

2 marks
Explanation

c) (i) Pressure is constantly changing from a minimum to a maximum value. This is a pressure antinode.

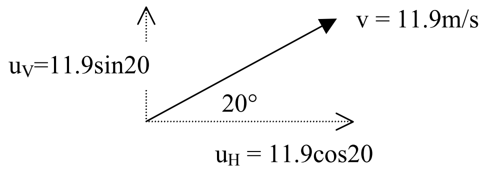
c) (ii) Particles of air are stationary – hence displacement is zero. Particles on each side move in and out with increasing amplitude as displacement approaches half a wavelength.

3 marks (Students answer one only)

d) The sound heard by the student will develop a throbbing effect (increases and decreases in loudness) known as **<u>beats</u>** which ---- will increase in frequency until the student hears five 'beats' per second. **1 mark** **2 marks**

Question 7 (12 marks)

a)



$$\text{time} = \frac{s_H}{u_H} = \frac{10.0}{11.9\cos 20} = 0.894\text{s}$$ **2 marks**

Assuming down is positive:

$$s_v = ut + \tfrac{1}{2}at^2 = (-11.9\sin 20)(0.894) + \frac{9.8}{2}(0.894)^2$$ **2 marks**

$$= 0.28\text{m}$$ **1 mark**

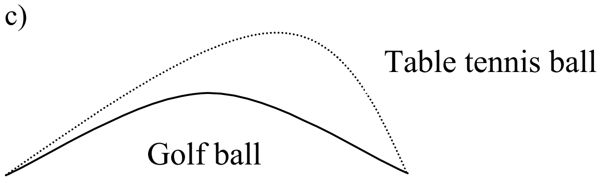
Hence ball lands 0.28m below the target centre and girl scores 5 points.

b)

Throw ball faster – ball travels horizontal distance in shorter time therefore strikes target higher. **2 marks**

Increase launch angle – ball reaches highest point in its trajectory a bit later in time, therefore lands further up the wall. **2 marks**

c)



2 marks

Trajectory is 'skewed' to the right because <u>air resistance</u> causes greater deceleration of the tennis ball reducing the velocity (or KE). **1 mark**

Question 8 (12 marks)

a) Enables alternating current to be withdrawn from the generator. Maintains constant contact between a particular side of the coil and a given terminal for the external circuit. [Students might indicate this on the diagram.] **3 marks**

b) (i) 3000 rpm = 50 Hz

Using 'quarter turn' method A = 0.14 x 0.09 = 0.0126m^2 and t = 0.005s **2 marks**

$$V = -N\frac{(\Phi_2 - \Phi_1)}{t} = -N\frac{B(A_2 - A_1)}{t} = -200\frac{0.15(0 - 0.0126)}{0.005} = 76\text{V}$$ **2 marks**

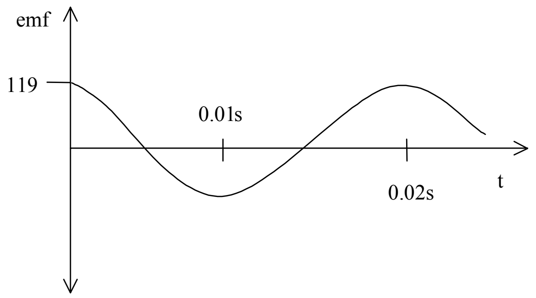
(ii) This is an 'average' voltage. (must agree with above method)

[Maximum voltage would be given by NAB(2πf)] **1 mark**

Students can also calculate rms value given by $\sqrt{2}\pi$BANf

c) (i)

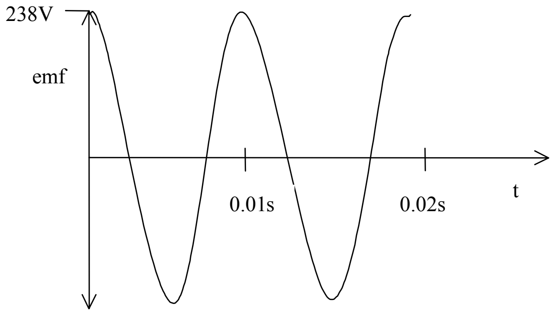
2 marks



1 mark for sinusoidal variation and 1 mark for correct period

2 marks

(ii)



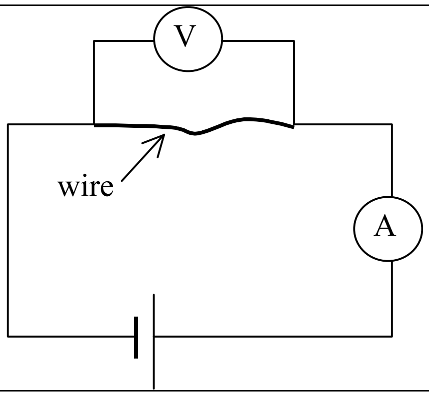
1 mark for doubled emf and 1 mark for half period

SECTION C: Comprehension and Interpretation **(40 Marks)**

1 (20 marks)

a) (6 marks)

(i)



Circuit diagram or picture representation
Key features: Ammeter in parallel
Voltmeter in series
Source of emf
Wire

3 marks

(ii)

$$R = \frac{L}{kA} \rightarrow \frac{V}{I} = \frac{L}{k\pi r^2}$$

$$\therefore \quad k = \frac{IL}{V\pi r^2} = \frac{0.33 \times 0.50}{2.0\pi(0.20\text{x}10^{-3})^2} = 6.6\text{x}10^5 \ \text{AV}^{-1}\text{m}^{-1} \quad \text{or} \quad 7\text{x}10^5 \ \text{AV}^{-1}\text{m}^{-1}$$

3 marks

b) (10 marks)

(i)

$$I = \frac{kV\pi r^2}{L}$$

1 mark

(ii) $\frac{1}{L}$ or $\frac{V}{L}$

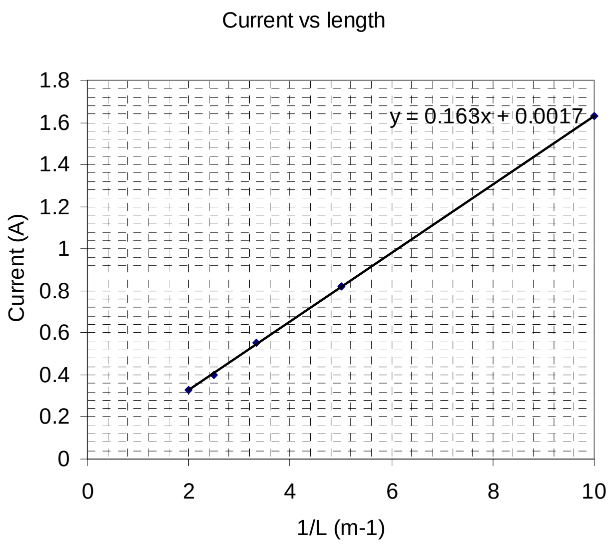
1 mark

(iii)

Current, *I* (A)	Wire length, *L* (m)	1 / L (m^{-1})
1.63	0.1	10
0.82	0.2	5.0
0.55	0.3	3.3
0.40	0.4	2.5
0.33	0.5	2.0

2 marks for calculating 1/L and plotting points 2 marks for scale & units and line of best fit

4 marks



Equation of line: y = 0.163x + 0.002 → I = 0.163/*L* + 0.002
(2 for correct equation & 2 for showing correct symbols)

2 marks

	$gradient = \frac{1.63 - 0.25}{10 - 1.6} = 0.164\ Am$	
(iv)	$k = \frac{0.164}{2\pi(0.2x10^{-3})^2} = 6.54x10^5\ AV^{-1}m^{-1}$ or $k = 2.62\ x\ 10^6\ AV^{-1}m^{-1}$ (if incorrectly quoted value of 0.2mm for diameter used)	**2 marks**
c)	(4 marks)	
(i)	Motor would run slower as maximum current is reduced. Less torque generated.	**2 marks**
(ii)	Less efficient … because of resistive heating (I^2R), less electrical energy is available for conversion to mechanical energy	**2 marks**

2 (20 marks)

(a)	(2 marks)	
(i)	G – centre of gravity	**1 mark**
(ii)	N – normal force (of road on tyre)	**1 mark**
(b)	(4 marks)	
	Key points are: Friction provides centripetal force and clockwise torque Friction acts only on tyre/s If speed is too high, vehicle will rotate or roll about outer wheel as anticlockwise torque provided by vehicles weight is insufficient to counteract clockwise torque	**4 marks**
(c)	(9 marks)	
(i)	Unloaded: w = 2.6 cm(1.8m) h = 1.0 cm(0.5m) → $SSF = \frac{w}{2h} = \frac{2.6}{2} = 1.3 \pm 0.2$ Loaded: w = 2.6 cm (1.8m) h = 1.6 cm (0.9m) → $\mathrm{SSF} = \frac{\mathrm{w}}{2\mathrm{h}} = \frac{2.6}{3.2} = 0.8 \pm 0.2$ Could also use height of person as a rough scale.	**3 marks** **2 marks**
(ii)	Using SSF for loaded condition: $\frac{\mathrm{w}}{2\mathrm{h}} = \frac{\mathrm{v}}{\mathrm{rg}}$ $\mathrm{v} = \sqrt{(\mathrm{SSF})\mathrm{rg}} = \sqrt{0.8 \times 10 \times 9.8} \approx 8.6\mathrm{ms}^{-1}$ i.e. about $31\ \mathrm{kmh}^{-1}$	**2 marks** **2 marks**
(d)	(5 marks)	
(i)	Jeep 5, Bronco, Jeep 7 and possibly Blazer	**2 marks**
(ii)	SSF of 1.2 appears to be the critical factor in likelihood of friction rollover. Loading the vehicle in such a way that raises the C of G significantly makes this vehicle more likely to have a friction rollover. OR Unloaded, the RV is stable – SSF is greater than 1.2 – and therefore appears to have a low chance of friction rollover. Loaded, the RV has an SSF less than 1.2, and therefore has a much higher likelihood of friction rollover.	**1 mark** **2 marks**

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