EXAMINERS' REPORT ON 2002 TERTIARY ENTRANCE EXAMINATION

SUBJECT: PHYSICS

STATISTICS

Year	Number Who Sat	Non-Examination Candidates	Did Not Sit
2002	3001	29	181
2001	3131	55	162
2000	3237	62	156

The Examiners' Report is written by the Chief Examiner to comment on matters relating to the Tertiary Entrance Examination in this subject. The opinions and recommendations expressed in this report are those of the Chief 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 may have 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 of 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

The format of the paper was the same as past years, except that only one passage was used in the comprehension section. One of the reasons for doing this was to reduce the amount of material the students were required to read. Special effort was put into framing questions in this section that required the student to interpret the material in the passage to arrive at an answer. The graphical analysis question was also included in section C.

The paper had a generally good reception from both students and teachers. A few commented that it was long and hard, but the average mark of 57% belies this assertion. The standard deviation of 17% shows that there was a wide spread of marks. Many student responses showed a high level of insight. The most significant aspects of student performance were that diagrams were not well done and that poor techniques were used in the explanation of physical concepts.

GENERAL COMMENTS

The basic structure of the paper was the same as in past years. There were three sections, comprised of short answer questions, problem solving and comprehension. There was only one passage in the comprehension section, in contrast to the two passages used in previous years, and the graphical interpretation was also included in this section. There was just one question with alternatives from different contexts, less than has been the case in the past. Instead, students were asked to select an example from the context they had studied in order to illustrate a particular concept. The examiners felt that this approach was a more even handed approach than that of providing contexts, since students could select an example they were familiar with and they would not be confronted by a context they may not have encountered previously. The end result was that although candidates did select a context, in many cases they did not state the context clearly and left the marker to try and work it out.

The questions in the comprehension section were designed, as far as possible, to require candidates to interpret and use the information provided in the passage. Candidates could not just draw from their background knowledge. Although it is not an easy task to absorb the principles involved in a context not previously encountered, many students are quite capable of achieving it. There were some questions that were not particularly well handled, but this is not surprising considering the candidates had relatively little time to digest the information provided.

Comment was made by some teachers and reported in the press that the paper was long and hard. To some extent this was true. However, the top mark of 98% shows that the best candidates were able to cope with the paper and the material in it. The majority of the responses to the paper were positive. Comment was made to the effect that the material was appropriate and a fair test of the work the students are expected to do. The average mark for the whole paper was 57%, the standard deviation 17% and the range of marks 1% to 98%. It was clear that students who had applied themselves to their studies were able to answer a large proportion of the paper.

The average marks were 67% for section A, 56% for section B and 47% for section C. This trend was expected. There were some difficult questions in section C, but, as has been the case in the past, many students gave remarkably good answers.

Two aspects of the answers given by candidates require comment. The first is that markers find it much easier to interpret the candidate's understanding if answers are accompanied with diagrams. Frequently there was no diagram at all. In some questions, diagrams were required, and those given were often poor. Since physics depends on the use of models, diagrams are a valuable aid in describing the context. Students are advised to practice drawing diagrams, as this will help them to understand the material, and will also assist in disclosing to the marker that they understand the concepts.

The second comment relates to the explanations of physical phenomena. The answers were frequently very poorly worded. Even worse, many responses did not address the main point. Again the drawing of diagrams is extremely valuable in assisting explanations. Students should practise drawing diagrams and devising explanations in order to prepare themselves for the examination.

Although these comments are applicable to many of the answers given, there were many responses that demonstrated a high level of insight.

It has been stated in previous reports that the examining panel regards the matter of significant figures as relatively inconsequential. It is recommended that in future papers, the statement on the second page suggesting that students quote answers to three significant figures be retained, and the rider *with the exception of questions for which estimates are required* be deleted. The examining panel recognises that using three significant figures for estimate questions is not meaningful, but there are plenty of things for students to think about, and it is not necessary to place extra burdens on them. At the level of understanding required, it is the principles that are the central issue. Those who take up a career in science will come to appreciate the role of significant figures at the appropriate time.

One of the issues that creates enormous difficulty in setting the paper each year is the restriction that material presented in year 11 is not to be examined. However, material presented in year 11 provides a basis for year 12 studies. It is therefore quite unavoidable that year 11 material is examined implicitly, even if there are no explicit questions. A case in point is the knowledge of the units of density required for section C. Density is not treated in year 12. Not being able to assume such basic background knowledge would make it impossible to set any examination. This is a long-standing problem, and it is time that something was done to correct it.

The useful comments of the independent reviewer, Richard Meagher, and the final checker, Rod Manson, were appreciated.

COMMENTS ON SPECIFIC QUESTIONS

Section A: Short Answers

Question 1. *Attempted 2958* *Average 96%*
This was a straightforward calculation and there was a high average mark.

Question 2. *Attempted 2987* *Average 82%*
Most students indicated the correct direction of the force. Only a small number showed the force acting towards the pole of the magnet.

Question 3. *Attempted 2941* *Average 86%*
This was well handled, although a relatively large number of the answers quoted incorrect units for the torque.

Question 4. *Attempted 2818* *Average 83%*
Some candidates misinterpreted the question, but most were able to obtain a reasonable answer.

Question 5. *Attempted 2983* *Average 73%*
This was another question that was well handled. A few candidates read incorrect figures from the axes of the graphs

Question 6. *Attempted 2940* *Average 45%*
This question was not well done. A very common response was that there was no emf in the split ring because there was no current flowing. Clearly many did not recognize that a change in the amount of magnetic flux enclosed by the ring generates an emf, and whether or not this emf causes a current is irrelevant.

Question 7. *Attempted 2926* *Average 51%*
The majority of students were able to identify that the spectrum was continuous, but were not always able to give a good reason for this.

Question 8. *Attempted 2771* *Average 65%*
This was generally well done, although some candidates did not realize that there were 7 loops associated with the seventh harmonic. Some responses said that the string could be struck at the end where there is a node. This would not achieve anything, and candidates who responded in this manner showed they did not understand the principles.

Question 9. *Attempted 2783* *Average 64%*
The majority of candidates knew what the dual properties of light were and were able to give appropriate examples. Some did not appreciate the phrase “dual properties”.

Question 10. *Attempted 2958* *Average 87%*
Most candidates were able to do this.

Question 11. *Attempted 2897* *Average 60%*
A surprising number of candidates calculated the gravitational attraction for the position where the moons were closest. This will of course give the maximum force. It was impossible to discern what the students were thinking, since it was extremely rare to see a diagram and even more rarely any reasoning for the answer. Marks were given to these incorrect responses, probably more than they deserved. It could be conjectured that the candidates were distracted by the fact that when the moons are furthest apart Jupiter is in between them. The lack of explanation meant that there was no evidence for this conjecture.

Question 12. *Attempted 2715* *Average 57%*
The major errors here were of a mathematical nature. Many students were unable to carry through the algebraic manipulation.

Question 13 *Attempted 2950* *Average 68%*
Although the average mark was on the higher side, this question was generally not well done. It was just easy to get a few marks from the marking key. In many cases, it was quite possible that candidates who marked in the direction of motion considered that there was a force in this direction, but with the paucity of labels, this could not be verified.

Question 14. *Attempted 2819* *Average 48%*
This was generally answered poorly. Comments here relate to the previous question. Clearly there are still many who think that a force is required to maintain an object in motion with constant velocity. Many answers quoted $F = q\,v\,B$ and accompanied this with a statement indicating that a magnetic field was needed to make the charge move. This misses the point entirely.

Question 15. *Attempted 2970* *Average 71%*

This was better done, but there were cases where the slope for bone was shown as less steep than that for rubber. When drawn to scale, the slopes differed substantially, but there was no penalty as long as they were in the correct relationship. There were a number of responses with the axes the wrong way around.

Section B: Problem Solving

Question 1. *Attempted 2942* *Average 64%*

c) i) Attempted 613 Average 50%

ii) Attempted 1077 Average 65%

iii) Attempted 1196 Average 59%

Parts a) and b) were handled reasonably well. The main problem with part c) was that many responses did not describe the physics involved. The question explicitly asked for a description of the process. Many of the responses for sub-part ii) stated that gamma rays were used because they penetrated the body. Although this is one reason, it is not the most important one, the ionising ability of gamma rays.

Question 2. *Attempted 2983* *Average 69%*

Part b) was not easy, but many of the answers arrived at the correct answer. In part d), the question again asked explicitly for the process to be described. The essential feature of the process is that the bell rings due to a forced vibration, which many responses did not mention. The majority of answers described resonance in great detail, yet this is not a prerequisite for the bell to ring.

Question 3. *Attempted 2977* *Average 60%*

The topic of torques and stable equilibrium is demanding, and the application of the principles to particular situations needs careful treatment. This problem was no different. Many students worked through to the correct answer, but others had difficulty. However, almost all made a start.

Question 4. *Attempted 2952* *Average 44%*

There were some very good explanations for part a) and some very poor ones. A common statement was that the rod was under compression. Although quite wrong, it must be admitted that the concepts of rotational motion are not easy to explain. This is the most probable reason for many explanations being inadequate. Far too many students referred to an “outwards” force due to the rotational motion, thus placing tension in the rod. The average for part b) was only 42%. Since it required several steps to get to the final result, this is not entirely surprising. Part c) involved another situation that is difficult to put into words, and many students were struggling. In part d), it was a surprise to see many diagrams showing the balls rising above the rod. This was a question where diagrams were required, and many were inadequate.

Question 5. *Attempted 2967* *Average 61%*

This was well done, and there was no consistent error. Again, the worst feature was the explanations.

Question 6. *Attempted 2917* *Average 58%*

Projectile motion is a more complicated topic, but the question was handled reasonably well. In part b), many answers did not clearly state the context of the example they were asked to provide. Candidates should be careful to answer the question. Here they were asked to state two factors that would *increase* air resistance. Responses that simply stated the cross section area affected air resistance were inadequate, as it must be explicitly stated that an *increase* in cross section area causes an *increase* in air resistance. A significant number of candidates stated that mass or weight would affect air resistance. Further, many students did not show air resistance as being in the opposite direction to the velocity – i.e. tangential to the path.

Question 7. *Attempted 2769* *Average 48%*
Students have always found the topic of the induced emf the most difficult in the syllabus, and this is reflected in the marks for this question, especially part b). It was a surprise to see so many students feel the compulsion to manipulate the figure given for rotational speed to get the frequency. A rotational speed of 83.3 revolutions per second corresponds to a frequency of 83.3 Hz. No trick was intended here. Despite the difficulty of part b), many answers arrived at the correct result. The diagrams could have been done better in part c), and the explanations provided were not always good.

Section C: Comprehension and Interpretation

Question (a). *Attempted 2921* *Average 61%*
There were a variety of answers to this question, some better than others. Many did not use the information given in the paragraph to predict the velocity of sound at higher altitudes, instead making some argument about the pressure of the air and the molecules changing their distance apart. A surprising number stated that the air pressure increased as the altitude increased. Those students who knew from their studies that the speed of sound in air actually depends on temperature rather than density (because the bulk modulus depends on pressure) were given full credit. There is a connection between this question and part g) in that many students stated there that sound travels faster when the molecules are travelling faster. The speed of the molecules has nothing to do with the propagation of sound; the velocity depends only on the bulk modulus and density, as stated in the passage.

Question (b). *Attempted 2800* *Average 67%*
This was well answered by many, but some candidates clearly experienced difficulty in converting decibels to a fraction.

Question (c) *Attempted 2686* *Average 46%*
This was poorly handled. Many candidates used the expression with the numerical constant (which was only provided to enable them to carry out the graphical calculations) to work out units, not recognizing that constants can have units. Those who used the basic expression involving velocity and density often gave the incorrect unit for density.

Question (d). *Attempted 2900* *Average 45%*
Graphical analysis usually gives difficulty. This example was no exception. Note that the figures given for the graph were contrived and such results would not be obtained in practice.

Question (e). *Attempted 2771* *Average 51%*
This was better handled, although many candidates could not carry out the calculation for the width of the beam.

Question (f). *Attempted 2295* *Average 37%*

The context was, in hindsight, more difficult that the examiners anticipated. The average mark of 37% reflected this. However, some answers demonstrated considerable insight.

Question (g). *Attempted 2581* *Average 53%*

It was thought that this question would be quite difficult, since it required careful appraisal of the material in the passage plus basic knowledge about the properties of iron. The most common answer was that atoms were closer together, which causes sound waves to travel faster. No reason was given for this incorrect assertion. Some answers recognized that steel was denser than air, but failed to take the next step and appreciate the bulk modulus for steel is much greater than that for air. It was anticipated only the best students would arrive at the correct conclusion, unless they had been taught or had read the correct physics, which is clearly expressed in most of the textbooks in current use in this State. So many students stated, incorrectly, that increased density increases the speed of sound that the examiners suspect that this must be being taught as true by some teachers.

POINTS FOR CONSIDERATION BY THE SYLLABUS COMMITTEE

Nil

Ian Bailey
December 2002

2002 Examining Panel

Chief Examiner: Dr Ian Bailey
Deputy: Dr Ralph James
Third member: Mr Jeff Cahill

Chief marker: Dr Ian Bailey

TEE PHYSICS 2002

MARKING GUIDE

NOTE: The primary purpose of this guide is to provide assistance to markers in the allocation of marks to student responses to questions. The objective is to achieve the greatest possible consistency in the marks allocated. It is important to appreciate that it is NOT a set of model answers, rather is a presentation of the principles of which students should demonstrate understanding. Note too that the guide as presented here is a draft version only. After discussion at the markers' meeting, modifications could be made.

Where the symbol ⚐ appears in this guide, it indicates that the statement following is a key concept which should be used in the explanation of a phenomenon.

SECTION A

1. Vout $= \{N_{out} / N_{in}\} \times V_{in}$ (1 mark)

   $= {}^{600}/_{200} \times 120 = 360$ V (3 marks)

   (1 mark only if the ratio is the wrong way round).

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2. Magnetic field is perpendicular to wire

   F $\longleftarrow$ $\otimes$

   Direction of force

   - perpendicular to wire (2 marks)
   - correct direction (2 marks)

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3. $\tau = r\ F$ (1 mark)

   $= r\ m\ g$

   Estimate $m = 40$ kg (range 20 - 200)

   $r = 3$ m (range 2 - 10) (2 marks)

   $\tau = 3 \times 40 \times 10 = 1200$ N m (1 mark)

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4. Estimate wavelength $\lambda = 3 \times 10^{-5}$ m (Range 10^{-3} to 10^{-6} m) (1 mark)

$E = {}^{hc}/_{\lambda}$ (1 mark)

$= (6.626 \times 10^{-34} \times 3 \times 10^{8}) \div (3 \times 10^{-5} \times 1.6 \times 10^{-19})$

$= 0.04$ eV (2 marks)

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5. a) Period (1 mark)

b) Wavelength (1 mark)

c) $c = f\lambda = \lambda / T$ (1 mark)

$= {}^{2}/_{4} = 0.5 \text{ m s}^{-1}$ (1 mark)

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6. Correct choice is B (2 marks)

Change in magnetic flux induces an emf (2 marks)

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7. Continuous spectrum (2 marks)

Atomic energy levels are not involved in the generation of light (2 marks)

{Give full credit for any answers which point out incandescent materials emit light of all wavelengths. Best answer would introduce black body emission, but this can't be expected.}

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8. Seventh harmonic has seven loops (1 mark)

Thus striking position is 1/7 of the distance along the string (1 mark)

This puts the striking position 143 mm from one end. (2 marks)

{Can also accept other factions of 7, but one is the best}

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9. Dual properties of light are wave properties and particle properties (2 marks)

Examples (1 mark each)

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10. $g = {}^{GM}/_{r^2}$ (1 mark)

$= 6.67 \times 10^{-11} \times 1.48 \times 10^{23} \div (2.63 \times 10^{6})^2$

$= 1.43 \text{ m s}^{-2}$ (3 marks)

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11. Minimum possible force is exerted when they are furthest apart (1 mark)

i. e., $d = 4.22 \times 10^{8} + 1.07 \times 10^{9}$ m (1 mark)

$F = G\, m_1\, m_2 / r^2$

$= \{ 6.67\ 10^{-11} \times 8.93 \times 10^{22} \times 1.48 \times 10^{23} \} / (1.492 \times 10^{9})^2$

$= 3.96 \times 10^{17}$ N (2 marks)

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12. $F = m v^2 / r = G M m / r^2$ and $v = s / t = 2 \pi r / T$

$m / r \{ 4 \pi^2 r^2 / T^2 \} = G M m / r^2$

$T^2 = r^2 / G M m \times 4 \pi^2 r^2 \times m / r = 4 \pi^2 r^3 / (G M)$ (2 marks)

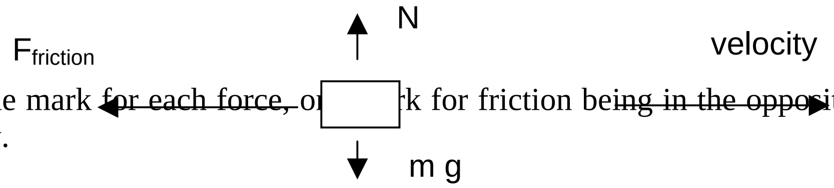
Mass (Jupiter) = $320 \times$ mass (Earth)

$T = \sqrt{[4 \pi^2 (4.22 \times 10^{8})^3 / (6.67 \times 10^{-11} \times 320 \times 5.98 \times 10^{24})]}$

$= 1.52 \times 10^{5}$ s

$=$ 42.3 hours (2 marks)

13.



Give one mark for each force, one mark for friction being in the opposite direction to velocity.

Give maximum of 2 marks for cases where there is a force in the direction of the velocity. Full marks are not to be awarded if there are any other forces shown.

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14. Statement is FALSE (1 mark)

☞ Magnetic fields are associated with moving charges (3 marks)

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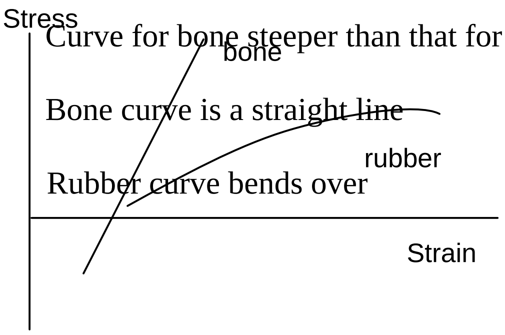
15. Curve for bone steeper than that for rubber (2 marks)

Bone curve is a straight line (1 mark)

Rubber curve bends over (1 mark)



SECTION B

1. a) i) $KE = \frac{1}{2} m v^2 \Rightarrow v = \sqrt{(2E/m)}$

$r = mv/(qB) = m \sqrt{(2E/m)}/(qB)$ (2 marks)

$r = \sqrt{(2 \times 1.67 \times 10^{-28} \times 2.3 \times 10^{6} \times 1.6 \times 10^{-19})}/(1.6 \times 10^{-19} \times 0.35)$

$= 198$ mm (1 mark)

ii) radius would increase

- From $r = mv/(qB)$, r increases as v (energy) increases (1 mark)

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b) i) $E = hf = hc/\lambda$ (1 mark)

$\lambda = hc/E = 6.626 \times 10^{-34} \times 3 \times 10^{8} \div (2.3 \times 10^{6} \times 1.6 \times 10^{-19})$

$= 5.40 \times 10^{-13}$ m (2 marks)

ii) X-rays (1 mark)
(It would be acceptable to have gamma rays.)

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c) i)
- Atmosphere absorbs photons (OR, slows down particles) (2 marks)
- Process absorbs energy (3 marks)

Process should involve some mechanism such as the ionization of atoms.

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ii)
- Gamma rays have high energy (2 marks)
- Gamma rays ionize atoms and thereby ruin molecules (3 marks)

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iii)
- X-rays penetrate metals (2 marks)
- Absorption of X-rays depends on density (3 marks)

2. a) $IL = 10 \log [I / I_0] = 10 \log 10^2 / 10^{-12}$

$= 140$ dB (2 marks)

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b) Inverse square law $I_1/I_2 = d_1^2 / d_2^2$ (2 marks)

For 60 dB $60 = 10 \log I_2 / 10^{-12}$

$I_2 = 10^{-6}$ W m^{-2} (2 marks)

From the inverse square law

$d_2^2 = \{ I_2 / I_1 \} d_1^2 = 10^8$ m^2

$d_2 = 10$ km (2 marks)

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c) $IL = 10 \log 6 \ I_2 / 10^{-12}$

$= 10 \log I_2 / 10^{-12} + 10 \log 6$

$= 60 + 7.8$ (2 marks)

$= 67.8$ dB (1 mark)

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d) Forced oscillations (1 mark)

Description of process should demonstrate understanding that the sound waves exert a periodic force on the bell

(3 marks)

The bell rings at its resonant frequency (1 mark)

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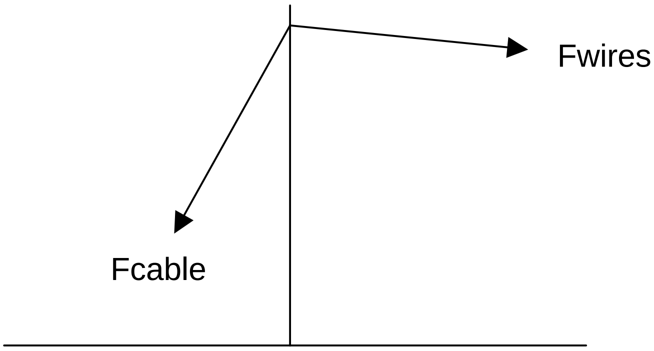
3. a)



(2 marks)

- Component of force exerted by the cable in the horizontal direction opposes the force exerted by the wires

(2 marks)

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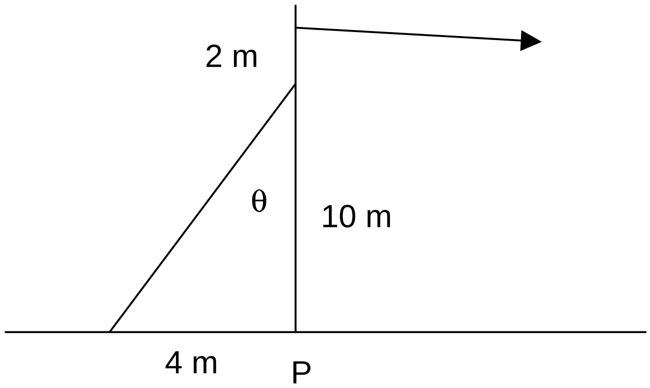
b)



(2 marks)

Sum of moments about P is zero

$T_{cable} \sin\theta \times 10 = T_{wires} \sin 87 \times 12$ (2 marks)

$T_{cable} = T_{wires} \sin 87 / \sin\theta \times 12 / 10$ (1 mark)

$\sin\theta = 4 / \sqrt{116}$

$T_{cable} = 4840$ N (1 mark)

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c) $Y = F\ell / \Delta\ell A$ (1 mark)

Estimate : Y for wood 0.1×10^{11} Pa

r for pole 250 mm

$\Delta\ell = F\ell / (AY) = T_{cable} \cos\theta \times 10 / (\pi \times 0.25^2 \times 0.1 \times 10^{11})$

(2 marks)

$\cos\theta = 10 / \sqrt{116}$

$\Delta\ell = 23\ \mu m$ (1 mark)

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4. a) Rod provides centripetal force to keep the balls rotating in a circle. (2 marks)

When centripetal force exceeds breaking force, rod fractures (2 marks)

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b) For one ball

$F = m v^2 / r$ (1 mark)

Breaking stress $= F/A = m v^2/ (A r) = 4.9 \times 10^8$ (for copper) (1 mark)

$v^2 = \{ 4.8 \times 10^8 \times \pi \times (6.8 \times 10^{-3})^2 \times 0.16 \} / 0.18$

$v = 251 \text{ m s}^{-1}$ (1 mark)

Time for one rotation is found from

$v = 2 \pi r / T \Rightarrow T = 2 \pi r / v$

frequency $= 1/T = v / \{2 \pi r\} = 251 / \{ 2 \times \pi \times 0.16 \}$ (2 marks)

$=$ 250 revolutions per second (1 mark)

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c) i) Centre of mass should be in the middle of the rod (2 marks)

ii) Centripetal force on the ball requires a torque to be exerted by the shaft (2 marks)

The force exerted by the shaft is constantly changing direction (2 marks)

{Give generous credit for diagrams.}

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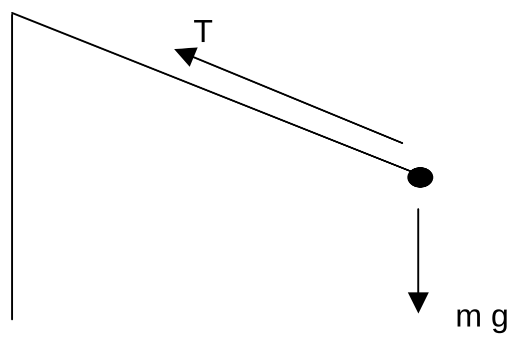
d) The tension in the string must provide a component to balance the gravitational force on the ball (4 marks)



(In the diagram, the two forces give a net force which is the centripetal force)

{Give generous credit for diagrams.}

5. a)

Correct shape of field (3 marks)

Correct directions for fields (1 mark)

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b) **A** is the best choice (1 mark)

Mid- point between the peaks is the spot (1 mark)

☞ maximum change in flux occurs as poles pass through the coil (1 mark)

emf has opposite sign for opposite poles. (1 mark)

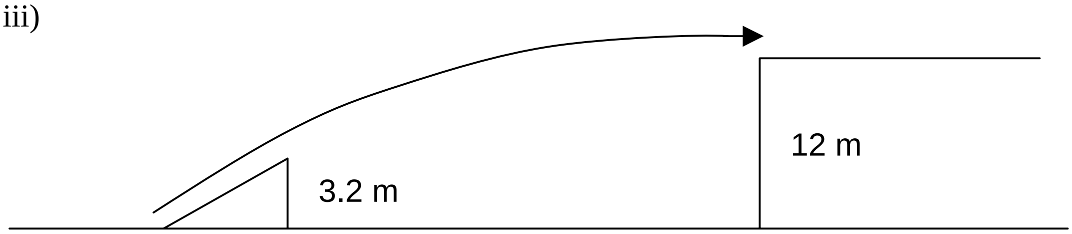
6. a) i) $x = (v_0 \cos\theta)\, t$ (or $x = v_H t$) (1 mark)

variables statement (1 mark)

ii) $y = u_H t + ½ g t^2$

$= v_0 \sin\theta\ t + ½ g t^2$ (1 mark)

iii)



$$x = (v_0 \cos\theta)\, t$$

$$t = x / (v_0 \cos\theta)$$

$$y = v_0 \sin\theta \{ x / (v_0 \cos\theta)\} + ½ g \{ x^2 / (v_0^2 \cos^2\theta) \}$$

(1 mark)

Multiply by $v_0^2 \cos^2\theta$

$$y v_0^2 \cos^2\theta = v_0^2\ x \cos\theta \sin\theta + ½ g x^2$$

$$v_0^2 = \{ ½ \times -9.8 \times 400 \} / \{ 8.8 \cos^2\theta - 20 \cos\theta \sin\theta \}$$ (2 marks)

$$v_0 = 17.8 \text{ m s}^{-1}$$ (1 mark)

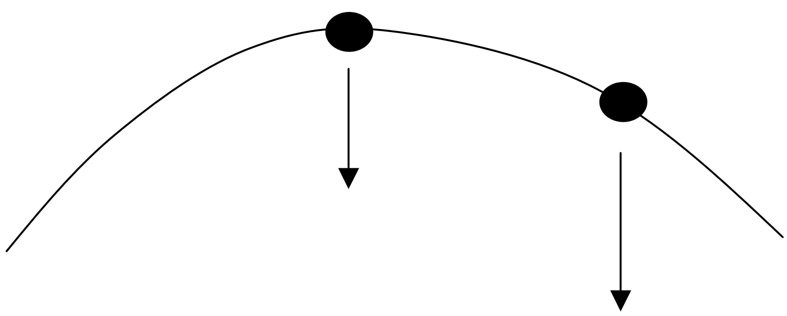
b) 17.8 m s^{-1} is 64 kph (1 mark)

This is quite achievable by modern motorbikes (1 mark)

c) Example (1 mark)

Diagram of projectile path showing effect of air resistance (1 mark)

Effect of air resistance (1 mark)



(2 marks)

(Force of air resistance could be shown. This must be clearly identificated as such)

Statement of two factors (1 mark)

7. a) i) Frequency = 83.3 Hz (1 mark)

ii) Power = $V^2 / R = 4.4^2 / 1.1$ (2 marks)

$= 17.6$ W (1 mark)

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b) emf = 4.4 V

But emf = $N \, \Delta\Phi / \Delta t$ (1 mark)

At 83.3 rps, half a revolution occurs in $1 / (2 \times 83.3)$ s

$\Delta \Phi = \text{emf} \; \Delta t / N = 4.4 \times 1 / (2 \times 83.3 \times 400)$ (1 mark)

$= 66 \; \mu\text{Wb}$ (1 mark)

$\Delta\Phi = 2 \; B A$

$B = \Delta\Phi \; / \; 2 A = 4.4 / \{ 2 \times 83.3 \; 400 \times 2 \times 140 \; 10^{-6} \}$ (1 mark)

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c) Diagram (2 marks)

- Commutator is a split ring which keeps current direction constant (2 marks)

SECTION C

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1. a) i) time $= 0.25 + 27/55 \times 1.75$ (1 mark)

distance $= v\,t = 346 \times 1.1$

$= 384$ m (1 mark)

But this is the distance travelled up and back. Thus

height $= 192$ m (1 mark)

ii) Total distance travelled $= 900$ m

time $= 900/340 = 2.65$ s (2 marks)

iii) Greater (1 mark)

velocity is inversely proportional to density (paragraph 6). (2 marks)

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b) From $IL = 10 \log \{ I / I_0 \}$

Decibel difference $= 10 \log \{ I_1 / I_2 \}$ (1 mark)

$= 85$ dB (1 mark)

$I_1 / I_2 = 10^{-8.5}$ (1 mark)

$= 3.16 \times 10^{-9}$ (1 mark)

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c) i) $B = v^2 \rho$ (paragraph 6)

Units of B are $(\text{m s}^{-1})^2 \; (\text{kg m}^{-3})$

$= \text{kg m}^{-1} \text{s}^{-2}$ (2 marks)

ii) Density of air is 1.2 kg m^{-3} (1 mark)

$B = v^2 \rho$

$= 346^2 \times 1.2$ (2 marks)

$= 1.4 \times 10^5 \;\text{kg m}^{-1} \text{s}^{-2}$ (1 mark)

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d) i) Line of best fit (1 mark)

NOTE : Line should NOT pass through point (5,5)

ii) slope $= [(28.5 - 8) \times 10^4] / [(25 - 5) \times 10^{-6}]$

$= 1.025 \times 10^{10}$ m^2 s^{-2} Pa^{-2} (2 marks)

iii) Since $v^2 = 8.45 \times 10^4 B \times 1/P$

slope $= 8.45 \times 10^4$ B (1 mark)

8.45×10^4 B $= 1.025 \times 10^{10}$ (2 marks)

B $= 1.025 \times 10^{10} / 8.45 \times 10^4$

$= 1.21 \times 10^5$ kg m^{-1} s^{-2} (1 mark)

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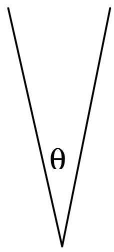
e) i) Diffraction (1 mark)

ii) Angular spread would decrease (1 mark)

angle is inversely proportional to aperture (paragraph 5) (1 mark)

iii) $\theta = 140 \lambda / a$



a = 2.5 m

$\lambda = c / f = 346 / 1650$

$\theta = 140 \times 346 / 1650 \times 1 / 2.5$ (2 marks)

Width of beam $= 350 \sin \theta$

$= 71$ m (1 mark)

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f) i) The pulse has a physical length (1 mark)

The length of the pulse depends on its duration (3 marks)

(Note that this is not the only acceptable explanation.)

ii) $s = v t = 346 \times 7.5 \times 10^{-3}$ (1 mark)

$= 2.60$ m (1 mark)

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g) Steel is denser than air (1 mark)

Hence it must have a much higher bulk modulus. (2 marks)