EXAMINERS' REPORT ON 2005 TERTIARY ENTRANCE EXAMINATION

SUBJECT: PHYSICS

STATISTICS

Year	Number Who Sat	Non-Examination Candidates	Did Not Sit
2005	3021	29	170
2004	2975	33	208
2003	3154	45	209

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 4 and Questions C 1 & 2.

The format of the paper was the same as last year except that the only question containing a choice component was Question A 13 which allowed candidates to choose 1 of 2 diagrams to explain understanding of tensile and compressive strengths. The majority of the students appeared to complete the paper in the time allowed. The 2005 mean raw exam score of 52.2 was considerably less than that in 2004 (60.6), and the standard deviation of 17.2 was slightly bigger than that of 2004 (15.6). This suggests a harder paper than last year but the spread of marks was similar, ranging from 0 to 96%.

Significant figures were again an issue with many students using an inappropriate number. Students are penalised on this in all questions that require an estimate.

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. The major criticisms were:

1. that there was not enough space left below some questions to adequately cater for the different sizes of writing styles.
2. that there was no extra paper in the booklet if students needed more space or had to redo a question.
3. that the graph paper should have been in the examination paper.

The design of the paper this year was consistent with the format used in 2004. The 2004 paper was considered a little too easy and it was intended that the level of difficulty be increased for this paper. This was achieved but some questions proved more difficult than expected. Conceptual problems were encountered in: power losses in circuits, constructive and destructive interference of waves from two sources, simple equilibrium calculations and applications of Lenz's law. The other major area for concern was the poor use of diagrams. These are often essential in order to clarify understanding or provide correct working. Students should also avoid repeating information that is given in the question.

Particular features of the paper included the following:

1. There was a deliberate attempt to vary the question types and thus the way in which information was presented to students and also in the way students were required to answer the question. A brief description of the types of question formats for Part A is given in the breakdown of paper section.

2. Part A contained three items in which a multiple choice question was used, but for which the student was also asked to explain their choice of answer.

3. As in 2004, there was no choice of alternate-context questions, but instead question 13 in Part A offered a choice of two contexts through description and diagrams. The principle examined was the same for both. By setting it out this way, students would not be tempted to try to answer both alternatives.

4. In parts B and C, most questions had an initial short, low value part-question to assist all students to make a start each time or to focus their attention on the stimulus material provided to reduce the likelihood of them misinterpreting the question.

5. There was a deliberate attempt to include questions or part-questions that specifically tested students' conceptual physics understanding.

6. As in 2004, a question on experimental design and the analysis of data was included in Part C rather than Part B or Part A. This question also accommodated students who preferred to formulate a solution using manual graphing as well as those who preferred to use a graphics calculator. This question provided a numerical value that students might use in part (d) should they have been unable to complete the earlier parts of the question.

7. One part-question specifically asked students to explain the number of significant figures that an answer should have. This was an attempt to alleviate the need for close scrutiny of the number of significant figures in each numerical answer.

Breakdown of Paper

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

1. The approximate mark allocation for different answer types is given below. The figures are percentages.

	Part A	Part B	Part C	Total
Numerical answers	15	29.5	8	52.5
Written answers	10	14	10.5	34.5
Graphical or diagrammatic	1	6.5	1.5	9
Multiple choice answers	4	--		4
	30	50	20	100

2. On setting the paper, the breakdown by area of study in comparison with the syllabus requirements is given below. Figures for the 2004 paper are also provided. The figures are percentages.

Topic	**Syllabus requirement**	**2005 paper**	**2004 paper**
Sound Waves	15-20	18.5	15
Electric power	20-30	21	30
Movement	20-30	20	23
Structures and Materials	15-25	21	20
Atomic Physics	10-20	19.5	12

3. Breakdown by parts of the paper was:

	Part A	Part B	Part C	Total
Sound Waves	2	6.5	10	18.5
Electric power	8	13		21
Movement	10	10		20
Structures and Materials	8	13		21
Atomic Physics	2	7.5	10	19.5

The following illustrates the range of ways in which students were required to provide answers:
Part A:

1. Estimate distance from a photograph of a person and calculate an answer.
2. Translate information from description and a diagram to a vector diagram and perform a calculation.
3. Calculate an answer for which a 'formula' was not readily available.
4. Interpret a diagram and choose an answer from a series of vectors. Tested conceptual understanding.
5. Calculate a relatively simple answer based on interpreting a fairly complex real-world context diagram.
6. A calculation based on proportional reasoning.
7. Interpret a diagram, choose a multiple choice answer and explain the choice.
8. Complete a diagram and perform a calculation.
9. Transfer information from written form to a diagram and calculate an answer. Simple mathematics. One piece of information was not needed.
10. Contextual written question requiring relatively straight-forward written response.
11. Interpret written information and diagram and formulate a written response.
12. Interpret a diagram, choose a multiple choice answer and explain the choice.
13. Information given in two contexts—both in written and diagrammatic form. Formulate a written response and label/refer to diagram.
14. Interpret a diagram, choose a multiple choice answer and explain the choice.
15. Interpret two diagrams and provide a mixed calculation/written response. Complex situation but relatively simple answer required.

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 2953 Mean 70%

This was a good easy start to the paper. The main errors here were the conversion of frequency into period and the inappropriate use of $v = f\lambda$ to solve the problem.

Q2 Attempted 2847 Mean 45%

This surprisingly proved to be one of the more difficult questions with many students not attempting it. Few students drew an adequate diagram and therefore did not use the correct measurements or the correct trigonometric identity. A large number found the complementary angle.

Q3 Attempted 2889 Mean 63%

This was generally well answered with students giving clear and concise answers. A significant number of students tried to divide the values given which indicates little understanding of units and dimensional analysis.

Q4 Attempted 3004 Mean 38%

This proved to be a difficult question as it tested the understanding of a fundamental concept. As there were no alternatives that were partially correct no part marks were awarded. The low number of correct responses indicates that students do not fully appreciate that any object that is moving in a circular arc must have a centripetal acceleration towards the centre of the circle.

Q5 Attempted 2970 Mean 75%

This was well answered with students applying the principle of moments correctly. Most errors occurred in not carrying out the algebra correctly.

Q6 Attempted 2970 Mean 83%

A very straightforward question which proved to be the easiest question in section A. Many students who calculated the acceleration on Mars could not convert this back to a weight correctly.

Q7 Attempted 3008 Mean 58%

Most students chose B but the majority failed to indicate that the horizontal motion was independent of the vertical motion. Despite being told that there was no friction acting, a number of students used friction to explain why the balls would not hit.

Q8 Attempted 2708 Mean 49%

This question was not done very well with many students failing to realise the main physics principle of constructive interference given by a path difference of $n\lambda$. Many students calculated the distance from S-2 to X but little else. The number of students attempting this question was the lowest for the whole paper.

Q9 Attempted 2781 Mean 25%

Students answered this question very poorly. The information given was not used correctly and there seemed little understanding of circuit theory in a practical situation.

Q10 Attempted 2987 Mean 64%

This was answered well with the main error being that students did not give enough justification on where and how the transformer would overheat.

Q11 Attempted 2939 Mean 59%

This was a very good discriminator with a high correlation to the total. Good students identified that a changing magnetic flux was needed to generate an emf.

Q12 Attempted 2978 Mean 29%

This proved to be the second hardest question on the paper. Many students correctly identified answer B but had the wrong idea as to why it was attracted. Even those students who understood that eddy currents would be generated often could not give a complete description as to why the disk moved. This was intended to be a harder conceptual question.

Q13 Attempted 2762 Mean 53%

Student answers lacked clarity and many did not state what features illustrated the relative tensile and compressive strengths. Many repeated information given in the introductory paragraph. Students who chose the human skeleton gave noticeably poorer answers. This illustrates the potential measurement difficulties with choice questions which attempt to measure the same theoretical concepts in different contexts. This was another excellent discriminator.

Q14 Attempted 2984 Mean 47%

This was a simple but discriminating question. Few students got the correct diagram but many were able to give quite good explanations for why it would continue to orbit the Earth. The better students realised that it would remain in a geosynchronous orbit.

Q15 Attempted 2850 Mean 45%

Many students misinterpreted the diagram, with some thinking the bottom walkway supported the top. Few realised that pin Y now has double the force. A large number went for a more descriptive answer involving rotation and moments without adequately justifying their answers.

SECTION B: *Problem Solving*

Q1 Attempted 2970 Mean 51%

This was intended to be a fairly straightforward question but was in fact the third hardest of the Section B questions. The major problem here was that students do not know the difference between sound intensity (Wm^{-2}) and sound intensity level (dB). The problems some students have with logarithms were also exposed here. Many students knew that beats would occur in part (d) but did not discuss interference and phase differences for a complete answer.

Q2 Attempted 2988 Mean 55%

Generally part (a) of this question was handled well. Students showed an excellent grasp of moments, with the only errors encountered being associated with distances on the diagram. Part (b) on the other hand was poorly done. Many students did not realise that the tension in the cord was the same as the weight. Vector diagrams were poor or non-existent. Part (c) was done reasonably well but many students did calculations for each cord rather than looking at the value that is required to satisfy the conditions given. Students need to work on the clarity and setting out of their arguments. Incorrect conversion of units and incorrect calculation of areas caused many students to draw the wrong conclusions.

Q3 Attempted 2988 Mean 59%

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 (b) were not very lucid, although a considerable number knew that hydrogen only had 4 visible lines. Not many students used the emission line of 659 nm to eliminate (b) or lower transitions not possible to eliminate (a). Part (c) was generally well done.

Q4 Attempted 2860 Mean 47%

This question appeared very straightforward but few students showed working and simply wrote down a ratio which was incorrect. Too many students chose a length of 16cm when it must be less than this to the centre. A number of students also failed to state assumptions, although this was specifically asked for. Most students understood that the torque remained constant.

Q5 Attempted 2977 Mean 50%

Electromagnetic principles usually cause students some difficulty and this was evident in this question. Many students missed the most important factor in Part (a), which was that brushes provide an electrical connection with the external circuit and allow free rotation by minimising friction. Some students again talked about current going into the coils. Diagrams in Part (b) were generally done well for AC but not DC outputs. Most students used Faraday's law but did not realise that the average emf is calculated over a ¼ of a turn.

Q6 Attempted 2988 Mean 66%

Students demonstrated a good understanding of projectile motion and did Parts (c) and (d) extremely well. Few students understood that the underlying principle in Part (b) was the balancing of torques. A surprising number of students did not associate the weight, W, with the Earth as the other object.

Q7 Attempted 2880 Mean 55%

Part (a) was well done, although some students wanted to simply state the value for the Moon's mass from the data sheet. In hindsight, it would probably have been better to use a system where values were not given but students should get into the habit of showing their working. Part (b) was supposed to be more difficult and this proved to be the case. Although many students wrote down an appropriate equation, solving the equation correctly proved a stumbling block for many students.

Q8 Attempted 2931 Mean 57%

Unfortunately many students had trouble with interpreting the current direction in the diagram. Most students calculated a force, with the main error being that only one coil was used not N coils. Part (c) was partially correct for most students, with the main error being the failure to multiply the force by two for both sides. A surprising number of students still get the maximum and minimum positions confused. Part (d) was answered well, although many spoke of increasing the voltage or current, which is not a modification to the motor. Students who used the diagrams in Part (e) invariably gave very good answers. A lot of students explained how the split ring commutator worked, which did not really answer the question.

SECTION C: *Comprehension and Interpretation*

Q1 Attempted 2965 Mean 47%

Part (a) was poorly done with students often repeating what was stated in the question without correctly explaining the origin of the peaks. Few students did an appropriate calculation for determining the voltage in Part (a)(ii), with many simply choosing 50kV and then giving some vague justification. In Part (b), over 90% of the students chose to use their graphics calculator. Interpreting the equation was not done well, with many students entering the values the wrong way round or not putting in appropriate symbols. Some work is needed here on the correct use of graphics calculators. Part (c) was also poorly done with less than 30% of students identifying the correct number of significant figures and even fewer students being able to justify their answer. It is evident from this and other questions involving estimations that the fundamental concept of significant figures is not well understood by students. Even students who quoted 2 sig figs as their answer often gave many when writing down data values or their gradient value. Only the very top students gave a unit for their gradient (less than 2%). Despite being given a value for the gradient many students tried to simply enter numbers into the formula to determine Plank's Constant.

Q2 Attempted 2968 Mean 49%

This was a very difficult comprehension piece, but many students did well in interpreting the information given. The concept of resonance was generally well understood. Values from the graph were often not accurately estimated, which may be due to students rushing. The main problem with the student responses to Parts (b) and (c) was that not enough detail was given, with students often repeating their answers. Part (d) proved difficult as the response to (i) relied on even harmonics, whereas the vocal tract acted as a closed pipe which resonates at odd harmonics. Many students carried out calculations for closed pipes correctly but did not interpret the term ‘range’ correctly.

POINTS FOR CONSIDERATION BY THE SYLLABUS COMMITTEE

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

- Students continue to have trouble distinguishing between average and maximum values for generated emfs, in particular the significance of rms values. Given the common occurrence of this term some thought should be given to including this in the syllabus.

- The issue of **significant figures** continues to be a problem. Students do not appreciate the importance of significant figures and the information they convey about the accuracy of the data or the final value calculated. Given the importance of this to experimental work, some effort needs to be made to covey the importance of significant figures to students.

W. R. Biffin
December 2005

2005 Examining Panel
Chief Examiner: Dr Shelley Yeo
Deputy: Dr Dmitry Fursa
Third Member: Mr Jeff Cahill

Chief Marker: Bill Biffin

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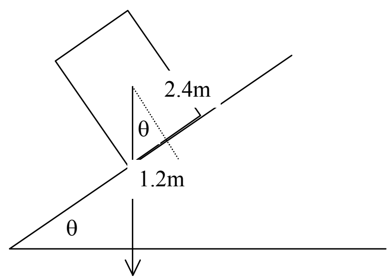
PHYSICS 2005 MARKING GUIDE

SECTION A: Short Answers (60 Marks)

1. Estimate r = 1.0 m (acceptable range = 0.8-1.2?) [1 mark]

$T = \frac{1}{f} = \frac{1}{2} = 0.5\text{s}$ $\quad v = \frac{2\pi r}{T} = \frac{2\pi .1.0}{0.5} \approx 13\,\text{ms}^{-1}$ **(range 10-16)** [3 marks]

2.



$\tan\theta = \frac{1.2}{2.4}$ [2 marks]

$\theta = 27^0$ [1 mark]

diagram [1 mark]

3. $\text{number of pulses} = f \times t$ [2 marks]

$= f \times t = 3.3\text{x}10^9 \times 0.1\text{x}10^{-6} = 330$ [2 marks]

4. Answer = A [4 marks]

5. System is in equilibrium → **apply principle of moments** [2 marks]
mass C+D = 30g
mass C+D+B = 120g
mass A = 40g [2 marks]

6.

$$F = \frac{Gm_1 m_2}{r^2}$$

$$\frac{F_{Earth}}{F_{Mars}} = \frac{Gm_{AT} m_{Earth}}{Gm_{AT} m_{Mars}} \times \frac{r_{Mars}{}^2}{r_{Earth}{}^2}$$ [4 marks]

$$\frac{780}{F_{Mars}} = \frac{1}{0.107} \times \left(\frac{0.529}{1}\right)^2$$

$$F_{Mars} = 298\,\text{N}$$

7. Answer = B [2 marks]
Reason: Both have same horizontal velocity therefore cover same horizontal distance in same time. **Horizontal motion is independent of vertical motion.** [2 marks]

8. Loud sound means constructive interference at X, therefore waves in phase, therefore path difference = nλ [1 mark]
Distance from S-2 to X = $\sqrt{(6^2+8^2)}$ = 10m [1 mark]
nλ = 10 – 6 = 4m
λ_1 = 4m $\quad \lambda_2$ = 2m [2 marks]

9. Voltage drop over wires = IR = 4.0 x 0.50 = 2.0V [1 mark]
Voltage drop across lamp 2 = 12 – 2.0 = 10V [1 mark]
P = VI = 10 x 4 = 40W (other methods can be used) [2 marks]

10(a) A transformer increases or decreases AC voltage. [2 marks]

10(b) Alternating current causes heating in the transformer core due to eddy currents. [2 marks]
Possible alternatives:
If it is a step-down transformer (most likely) and current is increased, there may be resistive heating.
External heat (from stove) may damage wires leading to a short-circuit which would generate heat.
Others include: Poor ventilation/ poor connections with appropriate explanations

11(a) The increasing current in the primary coils causes magnetic flux to move across the secondary coil inducing a current and hence the needle deflects. [2 marks]

11(b) While current is constant, there is no relative motion between flux lines and coil so no current flows. [2 marks]

12. Answer = B [1 mark]

Reason: Lenz's Law: changing magnetic field induces eddy currents which create a magnetic field with opposite pole in the disc—resulting in attraction between the disk and the pole. This causes the disk to follow the pole. [3 marks]

13. In both, the weight is supported on vertical columns, which are under compression only, and have high compressive strength. [2 marks]
In both, the columns are close together because the supporting structure between columns is under tension (and perhaps shear stress in the pelvis). The dependence of the structure on those components under tension is thus minimised. [2 marks]

14. Answer = A [1 mark]

Reason: Because it is in orbit, it will remain in orbit and therefore adjacent to the Castle (above the same point on the Earth's surface).
If in geosynchronous orbit, it revolves around the equator, not the poles (eliminating C). It is in orbit well beyond any effects of atmospheric friction, so it will stay in orbit (eliminating B and D). [3 marks]

15(a) Force on pin A is due to weight of upper walkway section only
F = half weight of walkway section = mg/2 = 2000 x 9.8 / 2 = 9800N (down) [2 marks]

15(b) Pin Y must now support BOTH upper and lower walkway sections
i.e. it must support 19600N. Hence it will be less safe (unless pin Y is much stronger than pin A). [2 marks]

SECTION B: Problem Solving (100 Marks)

Question 1 [**13 marks**]

1(a) $P = \dfrac{E}{t} = \dfrac{2 \times 1.5\text{x}10^6}{5} = 6.0\text{x}10^5\ \text{W}$ [2 marks]

1(b) $A = 4\pi r^2$ $I = \dfrac{P}{A} = \dfrac{6\text{x}10^5}{4\pi(50.0)^2} = 19.1\text{Wm}^{-2}$ [2 marks]

$\text{dB} = 10\ \log\left(\dfrac{19.1}{1\text{x}10^{-12}}\right) = 133\ \text{dB}$ (or 130 dB) [2 marks]

1(c i) $I = \dfrac{P}{A} = \dfrac{6\text{x}10^5}{4\pi(3000)^2} = 5.31\text{x}10^{-3}\ \text{Wm}^{-2}$

$\text{dB} = 10\ \log\left(\dfrac{5.31\text{x}10^{-3}}{1\text{x}10^{-12}}\right) = 97.2\ \text{dB}$ [3 marks]

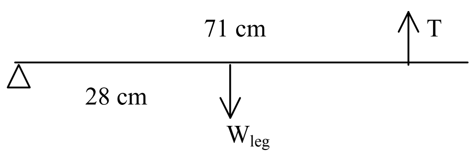
1(c ii) Further drop = 3.0 x 7.0 = 21dB, □ sound intensity level = 97.2 – 21 = 76 dB. [1 mark]

1(d) Passengers would hear the sound of the engines ‘throbbing’. i.e. beats. [1 mark]

Slightly different rates of rotation would give slightly different frequencies. This would result in alternating constructive and destructive interference at the ear of the listener as the waves come into and go out of phase. [2 marks]

Question 2 [**12 marks**]

2(a)



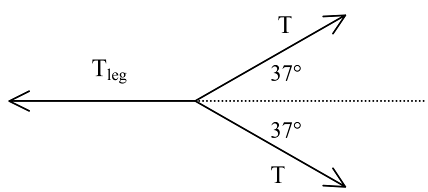
For equilibrium: $\Sigma cwm = \Sigma acwm$ [1 mark]

(about hip joint) $124 \text{ x } 28 = T \text{ x } 71$

$T = 48.9\text{N}$ [1 mark]

$m = 5.0\ \text{kg}$ [1 mark]

2(b)



For equilibrium: $\Sigma F = 0$

$\therefore \Sigma F_{left} = \Sigma F_{right}$ [1 mark]

$T_{leg} = 2\ T_{rope} \cos 37$

$= 2 \text{ x } 20 \text{ x } 9.8 \cos 37$ [1 mark]

$= 313\text{N}$ (=310N) [1 mark]

2(c) $\text{Minimum breaking stress} = \dfrac{F}{A} = \dfrac{1000}{\pi(2.5\text{x}10^{-3})^2} = 5\text{x}10^7\ \text{Pa}$ [2 marks]

Superope will break (breaking stress too low) ($A = 1.96\text{x}10^{-5}\ \text{m}^2$) [1 mark]

$\text{Young's Modulus} = \dfrac{F/A}{\Delta L/L}$

[2 marks]

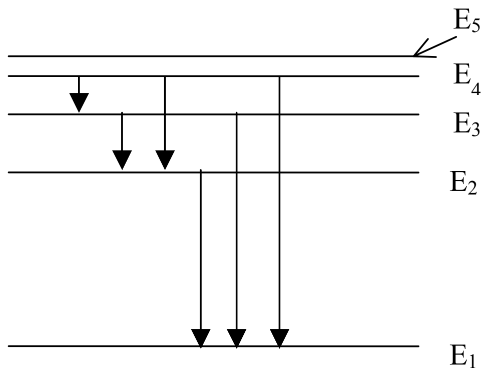
$\text{Minimum Young's Modulus} = \dfrac{400/\pi(2.5\text{x}10^{-3})^2}{1/100} = 2\text{x}10^9\ \text{Pa}$

Newire will stretch too much (Y too low)

Hence, only Magicord meets requirements. [1 mark]

Question 3 [**15 marks**]

3(a i)



Must show arrows

[2 marks]

3(a ii) ΔE=hc/λ

$$\Delta E_{3->1} = \frac{hc}{\lambda} = \frac{(6.63x10^{-34})(3x10^{8})}{102.6x10^{-9}} = 1.939x10^{-18}\,J$$ [1 mark]

$$\Delta E_{2->1} = \frac{hc}{\lambda} = \frac{(6.63x10^{-34})(3x10^{8})}{121.5x10^{-9}} = 1.637\,x10^{-18}\,J$$ [1 mark]

$$\Delta E_{3->2} = 1.939x10^{-18} - 1.637x10^{-18} = 0.302x10^{-18}\,J$$ [1 mark]

$$\lambda = \frac{hc}{\Delta E} = \frac{(6.63x10^{-34})(3x10^{8})}{0.302x10^{-18}} = 659nm$$ [1 mark]

3(b) Hydrogen spectrum is C (third spectrum) [1 mark]
It has an emission line in the red close to 659nm [1 mark]
OR It has four coloured lines only (others in green/blue and violet) [1 mark]
OR Emission lines get closer together

3(c i) Fluorescence [1 mark]

3(c ii) Atom excited by UV light. [1 mark]
Electrons drop to the ground state in a series of transitions. [1 mark]
At least one of these transitions emits coloured light. [1 mark]

3(c iii) Peak wavelength of emitted light is about 510 nm. [1 mark]
This corresponds to green light—see spectrum in 3(b) [1 mark]

Question 4 [**8 marks**]

4(a) t = (with) tap turner h = tap handle (only)
Estimate using ruler: r_t = 10-15 cm r_h = 1-2 cm (depending on location of force on centre or end of tap turner) [2 marks]
Assuming same torque is required:

$$\tau_{with} = \tau_{without} \quad -- > \quad r_t F_t = r_h F_h$$

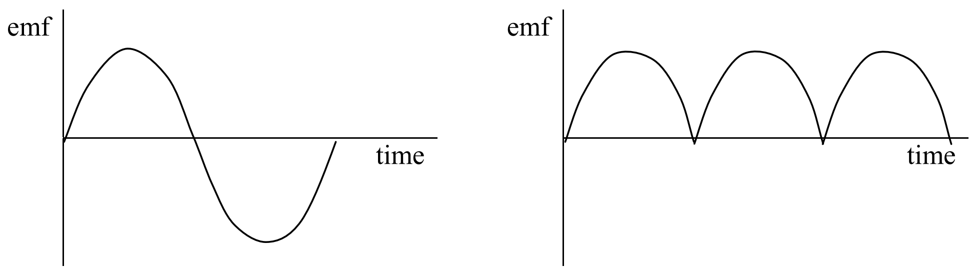
$$\therefore \quad \frac{F_t}{F_h} = \frac{r_h}{r_t} = \frac{1}{10} = 0.10$$ **(range 0.06-0.25)** [2 marks]

4(b) Assumptions: distances, turner fits neatly over prongs… [1 mark]
$\tau = r_t F_t = (10 \times 10^{-2}) \times 2 = 0.20$ Nm [1 mark]
$F_h = \tau / r_h = 0.20 / (1 \times 10^{-1}) = 20$ N.
Hence force on each prong = 20 ÷ 4 = 5 N (range 3 – 8 N) [2 marks]

Question 5 [**10 marks**]

5(a) Brushes provide an electrical connection between a rotating coil and the fixed external circuit. [2 marks]

5(b)



Generator P **Generator Q**

[2 marks]

5(c) Enables use of transformer to convert to high voltage for transmission, thereby reducing energy losses due to resistive heating. [2 marks]

5(d) Could be several acceptable answers depending on interpretation and use of "average output is 240V". Expected:

$$\text{emf} = -N\frac{\Delta\Phi}{t}$$

$$t = 300\left(\frac{0.20 \times 120\,\text{x}10^{-4}}{240}\right)\text{......for } 90^0 \text{ turn}$$

$$= 3.0\text{x}10^{-3}\,\text{s} \quad (\text{quarter turn}) = 0.12\,\text{s} \quad (\text{full turn})$$ [4 marks]

$$f = \frac{1}{t} = 83\,\text{Hz}$$

OR If peak voltage is calculated = 240 ÷ 0.7 = 343V

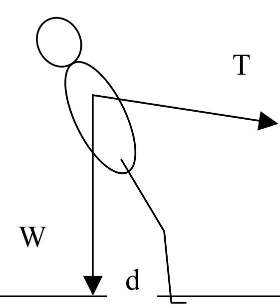
$$\text{emf} = \text{NlvB} = \text{Nl}\left(\frac{2\pi r}{T}\right)B = \text{NAB}\left(\frac{2\pi}{T}\right) = \text{NAB}(2\pi)f$$

$$f = \frac{\text{emf}}{\text{NAB}(2\pi)} = \frac{343}{300(0.012)(0.2)(2\pi)} = 76\text{Hz}$$

Question 6 [**14 marks**]

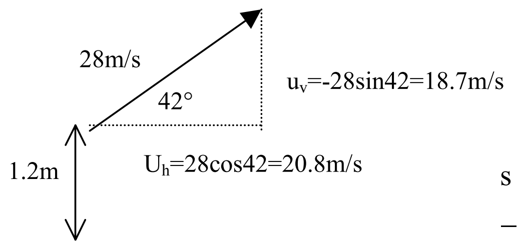
6(a) W: Earth
F_x: Wire
R: Ground (surface) [2 marks]

6(b) As the speed of the hammer is increased, the tension T in the wire increases. [1 mark]
This increases the CW moment. [1 mark]
To balance, the thrower leans back, increasing the distance of her weight W from the pivot (feet), creating a larger ACW moment. [1 mark]



6(c) $T = F = \dfrac{mv^2}{r} = \dfrac{6(28)^2}{1.4} = 3.4\text{x}10^4\,\text{N}$ [3 marks]

6(d)



[2 marks]

$$s = ut + 0.5at^2$$
$$-1.2 = -18.7(t) + 0.5(t)^2$$

[2 marks]

$$t = 3.89\text{s}$$
$$\text{range} = u_h t = 20.8(3.89) = 80.9\text{m}$$

[1 mark]

Partial working:
distance to top of trajectory = 17.9m
time to top of trajectory = 1.91s
time from top to bottom (1.2m below start) = 1.98s

Question 7	[**12 marks**]

7(a i) $v = \dfrac{2\pi r}{T} = \dfrac{2\pi(1.85\text{x}10^6)}{119(60)} = 1.63\,\text{x}10^3\,\text{ms}^{-1}$ [2 marks]

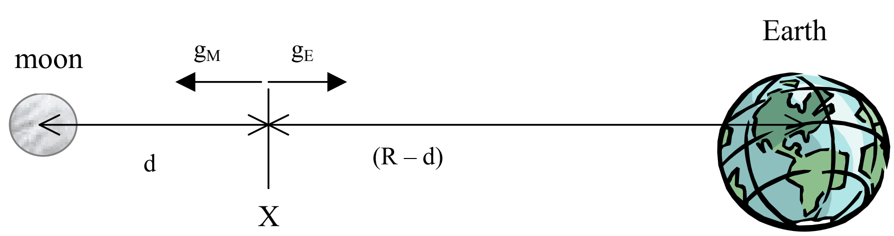
7(a ii)

$$\boldsymbol{F = \frac{mv^2}{r} = \frac{Gmm_m}{r^2}}$$

[4 marks]

$$\boldsymbol{m_m = \frac{v^2 r}{G} = \frac{(1.63\,x10^3)^2(1.85\,x10^6)}{6.67\,x10^{-11}} = 7.35\,x10^{22}\,kg}$$

7(b)



[2 marks]

$$g_E = g_m$$
$$\frac{Gm_E}{r^2} = \frac{Gm_M}{r^2}$$
$$\frac{m_E}{(R-d)^2} = \frac{m_M}{d^2}$$
$$\frac{m_E}{m_M} = \frac{(R-d)^2}{d^2}$$

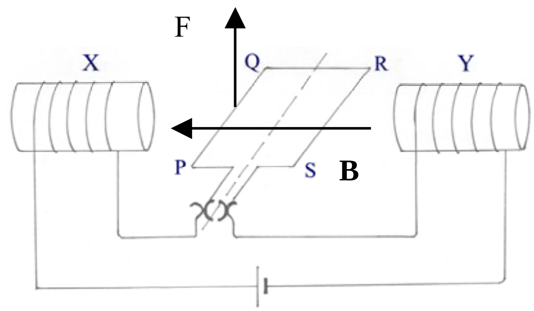
[2 marks]

$$\frac{5.98\text{x}10^{24}}{7.34\text{x}10^{22}} = \left(\frac{R-d}{d}\right)^2$$
$$\sqrt{81.4} = \frac{R-d}{d}$$
$$\frac{d}{R-d} = \frac{1}{9} \quad \therefore \frac{d}{R} = \frac{1}{10} = 10\%$$

[2 marks]

Question 8 [**16 marks**]

8(a i) [1 mark]



8(a ii) [2 marks]

8(a iii) clockwise [1 mark]

8(b) F = NilB = 150(0.75)(0.05)(0.095) = 0.53N (upwards) [3 marks]

8(c i) $\tau = 2rF = 2(0.02)(0.053) = 0.021$Nm [3 marks]

8(c ii) $\tau = 0$ [1 mark]

8(d) Any two of: more field coils, more turns on armature,
add iron core, use curved poles
increase length/area of armature [2 marks]

8(e) The field coils are in series with the armature coils so that when the current reverses in one, it reverses in the other. [1 mark]
Thus, when the direction of B changes, the direction of the force on each side of the coil stays the same. [1 mark]
This means that the coil will always rotate in the same direction.
(Diagrams should illustrate something relevant) [1 mark]

SECTION C: Comprehension and Interpretation (40 Marks)

Question 1 [20 marks]

1(a) [6 marks]

1(a i) X-rays are produced when high energy electrons are rapidly decelerated—as when striking the molybdenum target. [1 mark]

The peaks result when electrons are lost ('knocked out') from the lowest energy levels (shells) of a molybdenum atom. When electrons from higher levels drop into the vacant spaces, X-rays of a specific energy are produced. [2 marks]

Note: K_α results from electron transition from L shell to K shell

K_β results from electron transition from M shell to K shell

1(a ii) Max energy of incoming electrons corresponds to shortest wavelength

X-ray = 0.035nm (estimate) [1 mark]

$$W = Vq = hf = \frac{hc}{\lambda}$$

[1 mark]

$$\therefore \quad V = \frac{hc}{q\lambda} = \frac{6.63\text{x}10^{-34}(3\text{x}10^{8})}{1.60\text{x}10^{-19}(0.035\text{x}10^{-9})} = 3.6\text{x}10^{4}\,\text{V} = 36\text{kV}$$

[possible range that might be calculated = 35-41 kV] [1 mark]

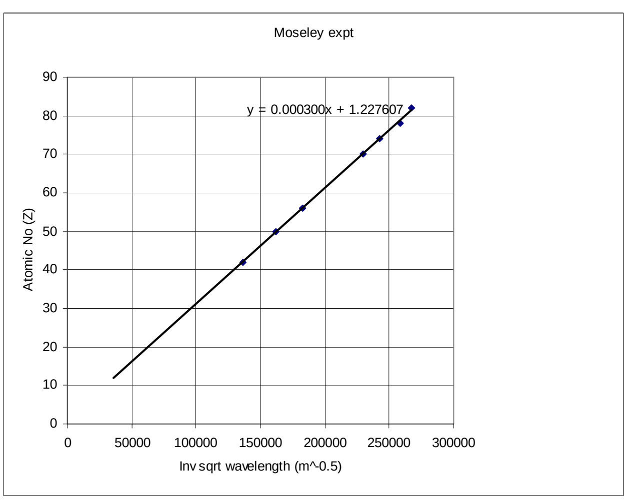
Hence answer = 35 kV

1(b) [6 marks]

1(b i) Completing the following table: [3 marks]

Element	Wavelength (m)	$\frac{1}{\sqrt{\lambda}}$ ($m^{-½}$)
Molybdenum	5.4×10^{-11}	1.4×10^{5}
Tin	3.8×10^{-11}	1.6×10^{5}
Barium	3.0×10^{-11}	1.8×10^{5}
Ytterbium	1.9×10^{-11}	2.3×10^{5}
Tungsten	1.7×10^{-11}	2.4×10^{5}
Platinum	1.5×10^{-11}	2.6×10^{5}
Lead	1.4×10^{-11}	2.7×10^{5}

1(b ii) Student who draw a graph: (axes = 1 mark, line = 2 marks) [3 marks]



2(b ii) Students using graphics calculator: [3 marks]

Line: $Z = \dfrac{3.0x10^{-4}}{\lambda} + 1.2$

1(c) [4 marks]

1(c i) $\boldsymbol{gradient = \dfrac{85 - 50}{2.80 - 1.64} = 3.0\,x10^{-4}\,m^{0.5}}$ [2 marks]

1(c ii) **two** significant figures, since both Z and λ are given to 2 SF (and gradient is the ratio of these two). [2 marks]

1(d) [4 marks]

1(d)

$\text{gradient} = 3.0x10^{-4} = 6.60x10^{8}\sqrt{hc}$ [2 marks]

$\therefore \quad hc = \left(\dfrac{3.0x10^{-4}}{6.60x10^{8}}\right)^2$

$h = \dfrac{2.1x10^{-25}}{3x10^{8}} = 6.9x10^{-34}\ \text{Js}$ [2 marks]

reasonable range = 6.4 – 7.3 ($x10^{-34}$)

If using $2.5x10^{-4}$, $h = 4.8x10^{-34}$Js

Question 2 [**20 marks**]

2(a) [2 marks]
2(a i) f_0 = fundamental frequency [1 mark]
2(a ii) R_2 = second resonant frequency [1 mark]

2(b) [5 marks]
2(b i) When the forcing (applied) frequency equals the natural vibrational frequency of an elastic medium, there is a rapid increase in the amplitude of vibration. In the case of sound, it will emit a louder sound. [2 marks]
2(b ii) When we change the shape of our vocal tract we change its natural vibrational frequency. The resonant frequency affects our ability to sing certain vowel sounds (resonant frequencies determine the distinction between vowel sounds). [2 marks]
Resonance increases the loudness of harmonics. [1 mark]

2(c) [7 marks]
2(c i) ~ 540 Hz (accept 530-550) and ~ 930 Hz (accept 920-940) [2 marks]

2(c ii) Vowel sounds are indistinguishable (unclear) when the note being sung (and vowel sound being produced) is higher than the resonant frequency of the vocal tract. [2 marks]

2(c iii) At this frequency (1000Hz), the resonant frequency is only about 850Hz. We cannot tell whether she is singing who'd or hoard because she can't make them sound different. She also cannot use resonance to increase the loudness of the sound. [3 marks]

2(d) [6 marks]
2(d i) 1020 Hz and 1530 Hz [2 marks]

2(d ii) $\boldsymbol{L = \frac{\lambda}{4} \quad \lambda = 0.60m \text{ to } 0.80m}$ [1 mark]

$$f = \frac{v}{\lambda} = \frac{346}{0.60} = 577\text{Hz} \quad = 580\text{Hz} \quad (570\text{Hz if } v = 340\text{m/s})$$

$$f = \frac{v}{\lambda} = \frac{346}{0.80} = 432\text{Hz} \quad = 430\text{Hz} \quad (420\text{Hz if } v = 340\text{m/s}))$$

[2 marks]

2(d iii) Opening the mouth decreases the effective length of the vocal tract so that it will resonate to higher frequencies. [1 mark]

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