Curriculum Council

EXAMINERS' REPORT ON 2001 TERTIARY ENTRANCE EXAMINATION

SUBJECT: PHYSICS

STATISTICS

Year	Number Who Sat	Non-Examination Candidates	Did Not Sit
2001	3131	55	162
2000	3237	70	204
1999	3307	62	156

The Examiners' Report is written by the Chief Examiner (or another Examiner on their behalf) to comment on matters relating to the Tertiary Entrance Examination in their 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/ABSTRACT

The format used for the paper in previous years was retained. Comment was made that the paper required a greater amount of interpretation, but there was no conscious effort to do this. The examiners considered the paper was about the same level of difficulty as for last year, but the average mark of 58% was almost 5% less. Marks were well spread from 2% to 95%.

Many of the candidates demonstrated a quite reasonable level of achievement in understanding the principles of physics. The major areas of weakness have not changed. Candidates in general do not have good graphical interpretation skills. Further, there is a reluctance to draw diagrams, and many of the diagrams that are drawn are unclear.

Although comment was made that the paper had a greater emphasis on the explanation of key concepts, there was no conscious effort to do this. Further, comment was made that the performance of candidates in Sections A and B was inconsistent with that in Section C. The statistics on this perception are not clear, but it is a point that could be reviewed by the Syllabus Committee.

GENERAL COMMENTS

The structure of the examination has not changed for some time. It consists of three sections, short answers, problem solving, and comprehension. Questions are framed so that candidates can demonstrate their understanding of physics, and apply their understanding to the solving of problems. It is considered an important part of the problem solving exercise that candidates have an appreciation of the magnitudes of quantities. This is one of the reasons for the inclusion of questions involving estimates, where candidates are required to supply appropriate numerical data.

The examiners make every attempt to keep the difficulty of the paper the same from year to year, but this is not an easy thing to accomplish. This year, the average mark for the paper was 58%, about 5% less than for last year. The examiners never cease to be surprised by how well candidates cope with questions considered reasonably difficult.

Of course, answers to questions considered easier can range from the not quite correct to wild misconceptions. Basically, the examiners have learnt that it is almost impossible to anticipate candidate response. Section A Question 1 is a case in point, the average mark being just 2.14.

There were two questions that gave candidates the opportunity to choose alternatives from the context they studied. The amount of choice was slightly less than in past years, but this was not done deliberately. As usual, there was no way of telling whether or not candidates actually used examples from the context they studied.

Candidates have consistently had difficulty in the interpretation of straight line graphs. The question on graphical analysis this year may have been answered a little better than usual. However, many candidates do not even draw a line of best fit, let alone calculate the slope, which is the technique they are expected to adopt. Some just read the coordinates of a single point and use this to determine the slope. This will only give a reasonable answer if the graph passes through the origin, which cannot be assumed.

A number of questions asked candidates to use diagrams in their explanation. It seems that candidates draw diagrams with the utmost reluctance. Frequently, diagrams are very vague. Candidates should be aware that diagrams are a very useful adjunct to making explanations, and this is a skill well worth practicing. They should be made well aware that drawing diagrams is very useful, whether or not diagrams are requested.

The issue of significant figures arose again this year. The panel emphasizes once again that, at this level of understanding, the matter of significant figures is considered a very minor issue. The panel reiterates its recommendation that all answers are quoted to three significant figures. There is no penalty if this is done for questions involving estimates.

In general, candidates correctly interpreted the questions. There was only one question with possible ambiguity. Section B Question 7 stated that, at the North Pole, the magnetic field is vertical, and then asked if it was downwards or upwards here. A number of candidates interpreted *here* as asking about the magnetic field in Perth. This was unintentional, but it does demonstrate how difficult it is to achieve absolute clarity.

The average mark showed that candidates were capable of giving answers to all questions asked, indicating the paper was a fair test.

Changes were made in response to comments made by the independent reviewer, Shelley Yeo, and her input was very much appreciated. Other useful comments were received from the final checker, Jeff Cahill.

COMMENTS ON SPECIFIC QUESTIONS

Section A

1. *Attempted 3081* *Average 2.19 (55%)*
   The panel expected that candidates would not find this difficult. However, the average mark shows this was not the case. Surprisingly, a considerable number correctly mentioned changing flux and then proceeded to assert the output was DC. There was a reasonably high correlation of the question mark with the paper total.

2. *Attempted 3118* *Average 2.02 (50%)*
   This proved more difficulty than anticipated, mainly because the human body is flexible and internal action is used to maintain balance. This has distracted the candidates. It would be interesting to see what the response would be if the question were asked about a statue on one leg.

3. *Attempted 3006* *Average 2.26 (56%)*
   The candidates were able to demonstrate they understood how beats are formed, but their expression was poor. Diagrams would have helped. Many seemed to have difficulty providing an example, some apparently putting this in as an afterthought.

4. *Attempted 3057* *Average 1.59 (40%)*
   A considerable number of candidates drew in graphs of the correct shape, but neglected to do it on the same scale. On this scale, the breaking point of bone does not appear on the graph.

5. *Attempted 3069* *Average 2.60 (65%)*
   This was another question that provided far more difficulty than anticipated. Most appreciated that the important feature was the counterweight. However, a significant number stated the supporting wires were important.

6. *Attempted 3079* *Average 3.21 (80%)*
It was interesting that many answered the question using the example of 20 violins, even though the question stated more than 20 violins.

7. *Attempted 3079* *Average 2.97 (74%)*
The examiners were pleased that most candidates realized that the space station is affected by gravity. However, a considerable number did not say (or realize) that the gravitational force provides centripetal acceleration.

8. *Attempted 3046* *Average 3.25 (81%)*
Most candidates were able to show they appreciated the relationship between magnetic field and magnetic flux.

9. *Attempted 3009* *Average 3.43 (86%)*
Again, candidates were well able to answer this question. A number did not realize the frequency of their favourite radio station was in MHz.

10. *Attempted 3061* *Average 2.32 (58%)*
Many of the diagrams of wave fronts were poor, and frequently, a ray diagram only was provided.

11. *Attempted 3067* *Average 2.71 (68%)*
Some candidates came up with rather large eagles! The major error was the omission of the mg factor, and in a proportion of cases this had the wrong sign.

12. *Attempted 3055* *Average 1.70 (43%)*
Poorly drawn diagrams often made it difficult for markers to interpret the answers. Many answers included forces that were not forces exerted on the athlete.

13. *Attempted 2996* *Average 2.91 (73%)*
Generally answered well, but some responses were not clear since the vector drawn was very small or non-existent.

14. *Attempted 3062* *Average 2.76 (69%)*
Most candidates know that it is current that is important in the transmission of electric power, but a number were unable to explain why.

15. *Attempted 2749* *Average 0.89 (22%)*
The average mark shows that this question gave great difficulty. Many candidates ignored the statement in the question, "*If the earth were perfectly spherical*…..", and proceeded to say the equatorial radius was greater than the polar radius.

Section B

1. *Attempted 3102* *Average 56%* *(whole question)*
Attempted 928 *Average 57%* *(part cA)*
Attempted 1064 *Average 52%* *(part cB)*
Attempted 1044 *Average 55%* *(part cC)*
The wording to the first part of this question was unambiguous, but it did require interpretation. Many answers used the transition between the two closely spaced energy levels as the source of the sodium yellow lines. One wonders how candidates think that this can produce two lines.
Although the alternative questions obtained reasonable marks, the answers were not impressive. Many answers gave an example, but the physical principle, which was specifically asked for, was omitted.

2. *Attempted 3121* *Average 71%*
The diagram was almost always correctly drawn. Many answers to the trajectory problem were quite well done, but there were still many who did not resolve vectors or resolved them incorrectly. A surprising number confused velocity and acceleration vectors. A significant number of candidates believe the ball has zero acceleration at the top of its trajectory. Although quite untrue, this is a very common misconception.

3. *Attempted 3079* *Average 55%*
To quote one marker, "Instructions like *use the graph* open a Pandora's box when there are alternative ways to answer the question". This is quite true, even though the examiners would never even have contemplated any means other than drawing a straight line and finding its gradient. Again, it is necessary to guide candidates starting their studies in physics to use the best technique.

4. *Attempted 3057* *Average 55%* *(whole question)*
Attempted 2060 *Average 61%* *(part cA)*
Attempted 981 *Average 48%* *(part cB)*
The problem centred on moments, and there were significant errors in many of the calculations. It would help if candidates took the trouble to draw a good diagram. Many omitted to include the mass of the boat. The human and animal frames question proved to be a more difficult alternative. However, most candidates were able to recognize the essence of the situation even if they were not able to work through the full ramifications.

5. *Attempted 3055* *Average 62%*
Candidates handled this reasonably well although a surprising number forgot to square the radius even though they had written it as a squared quantity on the previous line. Others added the radius of Ceres' orbit and Ceres' radius, which is not correct if the radius of the orbit is taken between centres of mass. But this is a subtle error. Some of the responses were just guesses. Candidates frequently had difficulty in working out which data was to be used in the various parts of the question.

6. *Attempted 3023* *Average 65%*
Candidates do not find the topic of electromagnetic forces an easy one, but many handled this question reasonably well. A few had the positions of maximum and minimum torque in part c) reversed, this required interpretation of the diagram.

7. *Attempted 3029* *Average 49%*
Although many had the correct direction for the magnetic field in part a), explanations were poor. In part b), poorly phrased answers were much easier for the markers to follow if a diagram were drawn. This was probably the worst answered question in the paper in terms of clarity of explanation. Perhaps candidates were unable to properly visualise the situation. For part c), very few chose the correct option of A, most selecting C, stating that the current was always in the same direction. This is a more difficult topic, so perhaps there is reason for these errors.

Section C

1. *Attempted 3082* *Average 45%*
The majority of candidates answered part a) correctly, although many were unable to support this response from the material provided in the article. Part b) was poorly done, a major error being quoting Planck's constant as J s^{-1} and not J s. Part c) was quite difficult, but was not badly done (average 58%). Very few provided the best response of 180° for the scattering angle, but this is a subtle point. Most had some sort of idea about part e), but few recognized the connection between force and change in momentum, and diagrams were generally poor.

2. *Attempted 2964* *Average 59%*
Most answers to part a) were correct, although in most answers the reasons given were extremely brief and few referred to information from the article. Parts b) and c) were reasonably well done. Most responses to part d) showed the magnetic moments correctly aligned, and a very frequent error was to have these in the wrong direction compared to the motion of the magnet.

POINTS FOR CONSIDERATION BY THE SYLLABUS COMMITTEE

Some comments were made by candidates that they preferred questions on the syllabus rather than have a comprehension and interpretation section. It could be useful for the Syllabus Committee to review the function and weighting of this section of the paper. Another comment was made that, in answers where quite unreasonable numerical answers were obtained, marks should be deducted.

Ian Bailey
December 2001

2001 Examining Panel
Chief Examiner: Dr Ian Bailey
Deputy: Mr George Przywolnik
Third Member: Dr Geoff Swan

Chief Marker: Dr Ian Bailey

PHYSICS TEE 2001 MARKING GUIDE

NOTE: The purpose of this guide is to provide an outline for markers to use in awarding marks to student responses. It is important to appreciate that this is NOT a set of model answers but presents the principles of which students should demonstrate understanding. The guide as presented here is a draft version only. After discussion at the markers' meeting, modifications could be made.

Where the symbol Ψ appears in this guide, it indicates that the statement following is a key concept which should be presented in the answer.

SECTION A

1. Always alternating (1 mark)
   Ψ Transformers can only operate with changing flux. (3 marks)

2. Stable equilibrium (best answer) (1 mark)
   Ψ Requires small, but not zero, displacement to become unstable (tip over). (3 marks)

   Unstable equilibrium can be given 3 marks if reasoning is correct (students may consider very small close enough to zero).

3. Ψ Answer should include
   - two waves of differing frequency (1 mark)
   - waves interfere to produce beats (2 marks)
   - appropriate example from context (1 mark)

   Give appropriate credit for diagrams.

4. Graph should be drawn with the appropriate scale (3 marks)
   Line should continue over whole width of graph. (1 mark)

5. Ψ The counterweight is the important feature. (1 mark)
   Ψ Load exerts large torque when arm is long (2 marks)
   Ψ Large counterweight opposes this torque. (1 mark)

6. Estimate 12 - 50 violins (1 mark)
   Correct calculation (3 marks)

7. Station **is** affected by gravity (1 mark)
   Ψ Gravitational force provides centripetal acceleration to keep the station in its orbit. (3 marks)

8. Magnetic flux is $\Phi = B A$ (1 mark)

$A = \pi r^2$ (1 mark)

Estimate $r = 0.2$ m (range 150 - 500 mm)

$\Phi = 50 \times 10^{-6} \times \pi \times 0.04 = \mathbf{6 \times 10^{-6}}$ **Wb**

(2 marks)

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9. Estimate frequency of 98.5 Mc (for example) (1 mark)

Photon energy $E = h f$ (1 mark)

$E = 6.626 \times 10^{-34} \times 98.5 \times 10^{6} = \mathbf{6.5 \times 10^{-26}}$ **J**

(or $\mathbf{4 \times 10^{-7}}$ **eV**) (2 marks)

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10. Diagram should show

- wave fronts (1 mark)
- wave fronts angling at the boundary (1 mark)

Essential property of the media is the speed of sound (2 marks)

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11. The upward acceleration of the eagle is $a = F/m$ where F is the net upward force

(1 mark)

$F = F_w - m g$ (1 mark)

where F_w is the force on the eagle's wings.

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

Estimate mass of eagle as 5 kg

$F_w = 5 (24^2/85 + 9.8) = \mathbf{83\ N}$ (1 mark)

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12. 1 mark for each force

1 mark for all forces in the correct direction.

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13. Ψ Direction of travel must be such that it is tangential to the magnetic field.

(4 marks)

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14. Power is transmitted at high voltages (1 mark)

Ψ The power lost is $I^2 R$ (2 marks)

Ψ Using higher voltages means that currents are lower, causing less power loss.

(1 mark)

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15. Ψ Part of the total gravitational force provides centripetal acceleration.

(4 marks)

SECTION B

1. a) i) Minimum energy = **5.3 eV** (1 mark)

ii) Ψ Arrow represents electron falling to a lower energy level (2 marks)
Result is the emission of a photon. (1 mark)

b) i) Ψ Two energy levels are very close together (1 mark)

Ψ Electron transitions from these energy levels to the ground state produce almost equal wavelengths.

$\lambda = hc/E = 6.626 \times 10^{-34} \times 3 \times 10^{8} \div (2.103 \times 1.6 \times 10^{-19}) = \mathbf{591\ nm}$ (2 marks)

ii) Any transition with a lower energy level difference (1 mark)
Ψ Lower energies correspond to longer wavelengths. (1 mark)

c) i) Ψ There are lines in the spectrum. (1 mark)
Ψ These lines can be used to identify specific elements (1 mark)
ii) Ψ Benefit must include the main physical principle. (3 marks)

d) i) Ψ The laser contains a specific element (1 mark)
Ψ Each element emits its own characteristic wavelengths. (1 marks)
ii) Ψ Benefit must include the main physical principle. (3 marks)

e) i) Ψ Coloured lights contain a specific element (1 mark)
Ψ Elements emit line spectra (1 mark)
ii) Ψ Benefit must include the main physical principle. (3 marks)

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2. a) i) Diagram should show a parabolic path (1 mark)

ii) With air resistance, ball hits ground earlier (1 mark)
Ψ Air resistance reduces the ball's velocity. (2 marks)

iii) At no time is the acceleration zero (1 mark)
Ψ The gravitational force provides a constant vertical acceleration (1 mark)

b) i) Considering the vertical direction (1 mark)

$$v^2 = u^2 + 2as = (55 \sin 1.5)^2 + 2(-9.8)(-0.35)$$
$$v = -2.988 \text{ m s}^{-1}$$
(2 marks)

$$t = \frac{v-u}{a} = \frac{-2.988 - 55 \sin 1.5}{9.8} = 0.452 \text{ s}$$
(2 marks)

ii) Horizontal distance travelled is

$s = vt = 55 \cos 1.5 \times 0.452$ (2 marks)
$s = \mathbf{24.8\ m}$ (1 mark)

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3. a) i) Ψ This makes the graph a straight line (2 marks)

ii) $$\mu = \frac{T}{v^2} = \frac{\text{force}}{\text{velocity}^2} = \frac{MLT^{-2}}{L^2T^{-2}} = ML^{-1}$$

So the units of μ are kg m^{-1} (2 marks)

b) Slope = (45000 - 15000) ÷ (210 - 75) (2 marks)
Since v^2 = (1/μ) T (1 mark)
Slope = 1/μ = 3000/135 (1 mark)
From which μ = **4.50 g m^{-1}** (1 mark)

c) The wave velocity is $v = \sqrt{\frac{T}{\mu}} = \sqrt{\frac{125}{4.5 \times 10^{-3}}}$ (1 mark)
The wavelength is 2 × 0.76 so we can find the frequency (1 mark)
f = v/λ = **110 cps** (2 marks)

d) Diagram should show 3 loops (2 marks)
ii) Ψ String vibrate transversely to its length (1 mark)
Ψ Sound waves travel transversely to the string (1 mark)
Ψ This is the same as the direction of the vibrations (in air) (1 mark)

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4. a) Direction of the force is upward (1 marks)
Ψ Torque produced by the force of gravity on the boat is anticlockwise. (1 mark)
Torque exerted by hitch must balance this (2 marks)
There are no horizontal forces

b) (1 mark)
(1 mark for direction)
Clockwise torque = anticlockwise torque (1 mark)
Taking moments about the axle (1 mark)
$F_{hitch} \times 2.3 + F_{motor} \times 1.2 = F_{boat} \times 0.5$ (1 mark)

$$F_{hitch} = \frac{650 \times 9.8 \times 0.5 - 72 \times 9.8 \times 1.2}{2.3}$$

= **1017 N upwards** (1 mark)

c) Ψ Force exerted by person is some distance from the pivot (2 marks)
Force exerted by the boat is much closer to the pivot (1 mark)
Smaller force is required to exert the same torque (1 mark)

d) Ψ On the bar, the arms have to support the entire body (2 marks)
Doing pushups, the feet provide some of the force to support the body (2 marks)

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5. a) $g = \frac{GM}{r^2} = \frac{6.67\times10^{-11}\times1.11\times10^{21}}{(386\times10^3)^2}$ (3 marks)

$= \mathbf{0.497\ m\ s^{-2}}$ (1 mark)

b) $\text{acceleration} = \frac{F}{m} = \frac{GM}{r^2}$ (2 marks)

$= \frac{6.67\times10^{-4}\times1.99\times10^{30}}{(414\times10^9)^2}$ (1 mark)

$= \mathbf{7.74 \times 10^{-4}\ m\ s^{-2}}$ (1 mark)

c) $a = v^2/r$ so $v = \sqrt{(a\,r)}$ (2 marks)

$= \sqrt{[7.74\times10^{-4}\times414\times10^9]}$ (1 mark)

$= \mathbf{1.79 \times 10^4\ m\ s^{-1}}$ (1 mark)

d) Estimate wire radius = 1/20 mm = 0.05 mm (1 mark)

From $Y = F\,l\ /\ (A\,\Delta l)$ (1 mark)

$\Delta l = \frac{Fl}{AY} = \frac{1.5\times0.497\times1.5}{\pi\times(0.05\times10^{-3})^2\times1.16\times10^{11}}$ (1 mark)

$= \mathbf{1.23\ mm}$ (1 mark)

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6. a) $F = I\,l\,B$ (1 mark)

$= 5.6\times10^{-2}\times0.45$ (2 marks)

$= \mathbf{0.0252\ N}$ (1 mark)

b) torque $= r\times F\times$ (number of loops) $\times$ (2 sides) (2 marks)

$= \mathbf{28.6\ N\ m}$ (2 marks)

c) Torque is maximum for position 1 (2 marks)

Torque is minimum for position 3 (2 marks)

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7. a) Field is vertically downwards (1 mark)

- Ψ N pole is a (geographic) north seeking pole

  Thus geographic north is magnetic south (3 marks)

b) Maximum emf occurs at the bottom of the swing (1 mark)

- Ψ emf is a maximum when the velocity is perpendicular to the magnetic field lines

  (3 marks)

(2 marks can be allocated for a statement that the velocity is greatest at that point)

c) Graph A is most likely (1 mark)

- Ψ emf must be alternating (2 marks)
- Ψ line can't be straight since velocity varies

  (1 mark)

Taken together, these give a peak at the bottom of the swing, rapidly decreasing away from the bottommost point.

SECTION C

1. a) Particle property (1 mark)

Ψ possible reasons are momentum is a property of particles, or collisions are characteristic of particles. (2 marks)

b) particle : p = m v = kg m s^{-1} (1 mark)

photon : p = h/λ = J s/m = kg m^2 s^{-2} s m^{-1}

= **kg m s^{-1}** (3 marks)

c) i) X-ray photon has the larger momentum (1 mark)

Reason : It has a smaller wavelength (1 mark)

ii) $$E = \frac{hc}{\lambda} \quad \Rightarrow \quad \lambda = \frac{hc}{E}$$

$$p = \frac{h}{\lambda} = \frac{hE}{hc} = \frac{E}{c} = \frac{110\times10^{3}\times1.6\times10^{-19}}{3\times10^{8}}$$ (2 marks)

p = **5.87 × 10^{-23} kg m s^{-1}** (1 mark)

iii) Needs to be scattered through 180° (1 mark)

Ψ cos (180) = -1 so change in wavelength is greatest (1 mark)

d) $$\lambda' = \lambda + \frac{h}{mc}(1-\cos\theta) = \frac{hc}{E} + \frac{h}{mc}(1-\cos\theta)$$ (1 mark)

= **1.251 × 10^{-11} m** (2 marks)

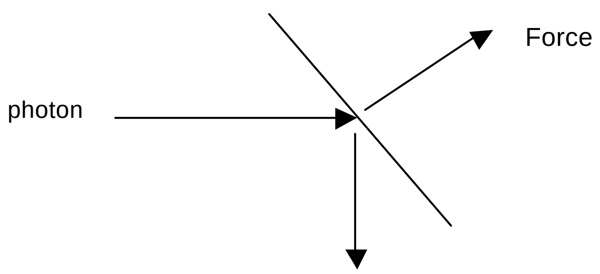
$$E' = \frac{hc}{\lambda'} = 1.59\times10^{-14}\,\text{J}$$ (1 mark)

= 99.2 keV (1 mark)

Hence energy of electron is **19.8 keV**

e) Ψ Photons have momentum (1 mark)

Ψ change in momentum (on reflection) creates a force (1 mark)



(2 marks)

2. a) Magnetic moment is a vector (1 mark)

   Ψ Magnetic moments have both size and direction (3 marks)

b) Would not expect a constant frequency (1 mark)

   Ψ Magnetic domains flip at random (2 marks)

   Thus there is not a constant time interval between events (1 mark)

c) Best described as noise (1 mark)

   Ψ Random events produce noise (3 marks)

d) Magnetic moments should all point in approximately the same direction (2 marks)

   Arrows should point in the opposite direction to the magnet's motion. (2 marks)