2005 Physics GA 1: Written examination 1

GENERAL COMMENTS

The number of students who sat for the 2005 Physics examination 1 was 6901. With a mean score of 58%, students generally seemed to find the paper to be quite accessible. Those who had thoroughly prepared themselves were well rewarded for their efforts. There were 20 students who achieved the maximum score of 90. The majority of schools predictably chose to limit the changes to their course by selecting Detailed Study 2.

Students and teachers should be aware of the following points in relation to the 2005 examination 1 paper and for future reference.

- Students should only answer questions from one of the detailed studies; however, a considerable number of students attempted two or three detailed studies.
- Students need to be more careful with their writing – if the assessor could not decipher what was written, no marks were awarded. This applied particularly to multiple-choice questions where one answer was written over another.
- Written explanations must address the question. Students who simply copied generic answers from their note sheets did not gain full marks.
- In questions that required an explanation, one mark was generally awarded for each point made. Therefore, students could not expect to obtain full marks for giving a single phrase in response to a two mark question. Although the answer may have contained the key point, some expansion was expected for the second mark.
- Students should be encouraged to show their working. Credit can be given for working even if the answer is incorrect.
- Some students still had trouble with unit conversions; for example, A to mA.
- Students must follow the instructions given in questions. A number of questions specifically stated that working was to be shown. If this was not done, no marks were awarded.
- Perennial errors in responses on universal gravitation included: students forgetting to raise numbers to the required power (for example, R^3 and T^2); and an inability to manipulate large numbers and powers of ten.
- While students were generally able to cope with the DC bias conditions for the transistor amplifier, AC signal voltages seemed to cause confusion.
- Answers should be simplified to a decimal, not left as $10\sqrt{10}$ or 10.6/240.

SPECIFIC INFORMATION

Section A - Core

Area of Study 1 – Motion in one and two dimensions

Questions 1–4

Marks	0	1	2	3	4	5	6	7	8	9	Average
%	16	3	10	3	9	6	21	4	3	24	5.1

Question 1

The energy stored, 100 J, was obtained from the area under the graph.

Some students used $\frac{1}{2}kx^2$ and calculated the force constant from the gradient of the line.

Question 2

By using the energy stored from the previous question and equating it to kinetic energy, students were able to calculate the speed as 31.6 m s^{-1}.

Question 3

From the initial speed of the rocket calculated in Question 2, a constant acceleration formula was used to determine that the height reached was 50 m. Alternatively, some students equated the kinetic energy at ground level to the gravitational potential energy at the top of the path.

Question 4
The net force acting on the rocket was the gravitational force minus the retarding force (from the graph), i.e. 2 – 1.8 = 0.2 N. By using this in the equation for Newton's second law, the acceleration was found to be 1 m s^{-2}.

This question was not well answered. Many students simply substituted the retarding force into the equation without determining the net force.

Questions 5–6

Marks	0	1	2	3	4	5	Average
%	23	1	29	11	1	34	**2.8**

Question 5
The force was directed towards the centre of the circle. This question was well done.

Question 6
Students who realised that the maximum central force that could be provided by the rails would be the same in the two situations could equate the centripetal force at 60 to that at 120. This gave a radius of 800 m.

This question required a deeper level of thinking. Many students mistakenly seemed to believe that the radius was proportional to the speed instead of to the square of the speed. Students who converted the speeds from km h^{-1} to m s^{-1} often rounded off too early and obtained answers either side of 800.

Question 7

Marks	0	1	2	Average
%	67	0	33	**0.7**

By combining the central force with the braking force, the net force was determined to be in the direction B.

Those who gave C as their answer only considered the braking force, instead of the **net force** as emphasised in the question. About a quarter of the students selected option A, the central force, apparently without considering the braking force.

Questions 8–10

Marks	0	1	2	3	4	5	6	7	8	Average
%	9	8	4	8	10	9	9	23	20	**5.2**

Question 8
By equating the momentum before and after the collision, the speed of the truck immediately before the collision was found to be 9.3 m s^{-1}.

This question was generally well answered. The main difficulty was in sequencing the masses correctly.

Question 9
To obtain full marks, students had to address two points. One was that momentum is always conserved in a closed system, and the second was that elastic/inelastic refers to the conservation of kinetic energy. Many students did not refer to kinetic energy at all.

Question 10
Students were required to calculate the kinetic energy before (1.3×10^5 J) and after (9.8×10^4 J) and therefore deduce that the collision was inelastic.

The question was well done, although some students did not show any calculations and others calculated momentum instead of kinetic energy.

Question 11–13

Marks	0	1	2	3	4	5	6	7	8	9	Average
%	30	4	7	9	3	5	10	4	14	14	**4.3**

Question 11
The horizontal component of the ball's velocity when it left the racket was 30 m s^{-1} (the same as at the top of its path).

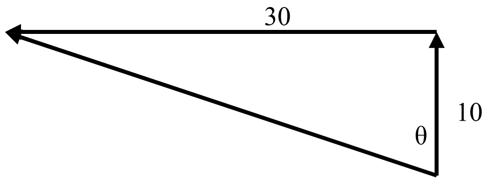
So its speed relative to the deck was $\frac{30}{\cos 8}$ = 30.3 m s^{-1}.

There were two main problems for students in answering this question. Some students assumed that the launch speed was 30 and obtained the horizontal component of this. Others had the diagram correct, worked out that $V\cos 8 = 30$ but then could not complete the mathematics to determine *V*.

Question 12
First the vertical component of the initial velocity needed to be determined (4.22 m s^{-1}), then a constant acceleration formula could be used to find that the height increase was 0.89 m. To this, students needed to add 3 m for the height above the deck when it left the racket, giving an answer of 3.89 m.

The main difficulty experienced by students involved finding the vertical component of the initial velocity.

Question 13
13a



There were two components to the ball's velocity: the forward velocity of the boat (10 m s^{-1}) and the sideways velocity (30 m s^{-1}). Use of Pythagoras' theorem showed the answer to be 31.6 m s^{-1}.

13b
The use of simple trigonometry gave the correct answer of $\theta = 71.6^{o}$.

One common error was to give the complementary angle 18.4^{o}. Another common, incorrect answer was 90^{o}.

Question 14

Marks	0	1	2	Average
%	62	0	38	**0.8**

The only option which did not describe the term *g* was option B: '*g* is the force that a mass *m* feels at the surface of Earth'. Students' responses were evenly spread over the distractors.

Questions 15–16

Marks	0	1	2	3	4	5	Average
%	13	4	18	12	10	42	**3.4**

Question 15
This question was quite well done. The simplest method was to use $F = mg$ where $g = 10$. So,

$F = 3.0 \times 10^{-26} \times 10 = 3.0 \times 10^{-25}$. Many students used $F = \frac{GMm}{R^2}$ and obtained the mass and radius of the Earth from the data sheet.

Question 16
By equating the formulae for centripetal and gravitational force and transposing, the answer of

$M_E = \frac{4\pi^2 R^3}{GT^2}$ = 5.83 x 10^{24} could be found. Another method involved using the gravitational field strength at the Earth's surface, $g = \frac{GM_E}{R^2}$ and substituting values from the data sheet.

Common errors included an inability to manipulate large numbers and powers of ten, forgetting to raise numbers to the required power (for example, R^3) and adding the radius of the Earth to the orbital radius. This question required working to be shown. Students who simply copied the mass of the Earth from the data sheet were not awarded any marks.

Area of Study 2 – Electronics and photonics

Question 1

Marks	0	1	2	Average
%	10	6	85	**1.8**

A direct application of Ohm's Law gave a voltage of 4.0 V.

This question was very well done. However, some students overlooked the fact that the current was given in mA and needed to be converted. Others realised that mA needed to be converted, but were unable to do so.

Question 2

Marks	0	1	2	Average
%	23	0	77	**1.6**

Most students selected the correct answer of A: 'the potential at point A is higher than point B'.

Questions 3–4

Marks	0	1	2	3	4	5	Average
%	19	8	6	15	24	27	**3.1**

Question 3

The formula $P = VI$ needed to be used to show that the energy dissipated in one second was 0.16 Joule. About one quarter of the students mistakenly gave the unit as Watt.

Question 4

By first determining the effective resistances of the combinations, students were able to use the voltage divider relationship to determine V_{OUT} = 15 V.

A number of students had difficulty combining resistors in parallel.

Question 5

Marks	0	1	2	Average
%	23	0	77	**1.6**

The correct answer, D: 'the current in resistor A is identical to the current in resistor D', was selected by most students.

Questions 6–10

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
%	7	4	6	5	6	7	7	6	6	6	7	9	6	7	11	**7.8**

Question 6

Students first had to determine that the voltage across the collector resistor R_C was 10 V. This was then subtracted from the supply voltage V_{CC} to give the answer 20 V.

Since the actual answer was provided in the question, it was essential that students showed the details of their derivation.

Question 7

By using the current gain of 200, the increase in the current through R_C was 200 x 5 x 10^{-6} = 0.001 A. So the change in the voltage across R_C was then determined by Ohm's Law to be 0.001 x 500 = 0.5 V. Therefore the voltage gain was

$$\frac{0.5}{10 \times 10^{-3}} = 50$$

Students found this to be a reasonably difficult question. Some who were able to perform the first two steps found it difficult to distinguish the signal voltage from the DC bias voltages.

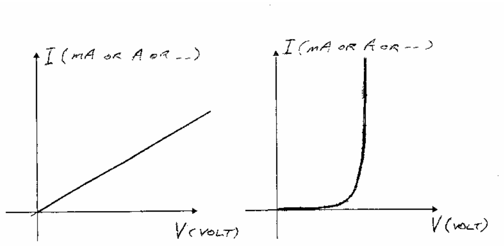
Question 8
The LED converts electrical energy to light and the photodiode converts light to electrical energy.

While students generally received the marks for the question, many misunderstood the intended scope and seemed to copy everything they had on the components from their A4 notes sheet.

Question 9
The photodiode and resistor were in series so the current in each would be the same. The application of Ohm's Law was required to calculate $V_{OUT} = 5 \times 10^{-4}$ V.

Quite a few students did not realise that μ represents 10^{-6}. Other than this, the question was well handled.

Question 10



The graphs expected are shown. Students scored well on this question, although some of the graphs for the LED could have been sketched more carefully.

Section B – Detailed studies
Detailed Study 1 – Einstein's relativity

Questions 1–2

Marks	0	1	2	3	4	5	6	Average
%	21	3	11	24	5	9	27	**3.3**

Question 1
Nearly all students scored full marks for this question. The answers were S, D and D.

Question 2
Hilary was correct, as the speed of light is invariant in inertial frames of reference.

Question 3

Marks	0	1	2	Average
%	46	0	54	**1.1**

The correct answer of B: '$L < L_0$, $W < W_0$, $H < H_0$' was selected by just over half of the students.

This 'length contraction' question was not quite as easy for students as might have been anticipated. As expected, the most common incorrect response was C.

Questions 4–9

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
%	38	4	4	3	3	4	4	3	4	5	6	5	7	4	2	4	**5.4**

Question 4
Marks were awarded for statements such as:
- the speed of light is the same in both directions
- no motion relative to the ether
- no evidence to support the existence of the ether
- light does not need a medium
- there is no absolute frame of reference.

It was common for students to mention two of the points listed.

Question 5
The time was 3.05×10^{-13} s.

While students were aware of which equation to apply, some were uncertain about which time applied to which frame of reference and therefore multiplied by 20 instead of dividing.

Question 6
The distance (as measured by the scientists) could be calculated by multiplying the speed (as measured by the scientists) by the time (as measured by the scientists). This gave 1.83×10^{-3} m.

Question 7
The distance was that which was measured in the laboratory reference frame divided by 20, which gave 9.15×10^{-5} m.

Difficulties arose in deciding which was the proper frame of reference in terms of the formula.

Question 8
Students were required to show a substitution in the equation $E = mc^2$. Since the answer was provided in the question, students were required to show the substitution in detail.

Question 9
Since the mass is 22 times the original, the Lorentz factor is 22.

Question 10

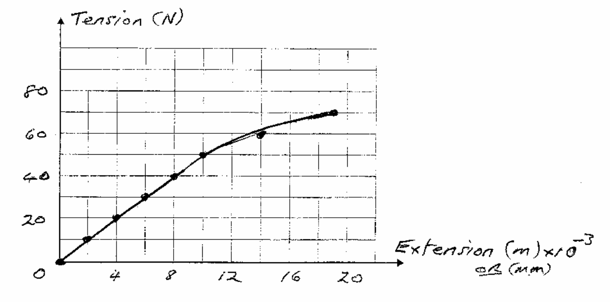
Marks	0	1	2	Average
%	70	0	30	**0.6**

The answer, B: '1.72×10^{-12} J', could be obtained by multiplying the rest mass energy by 21.

Detailed Study 2 – Investigating materials and their use in structures

Question 1

Marks	0	1	2	Average
%	24	39	37	**1.2**



This question was reasonably well done. Common errors included plotting mass and total length, and plotting tension but using kg as the unit. Some students plotted a stress-strain graph.

Question 2

Marks	0	1	2	Average
%	49	0	51	**1.1**

From the area under the graph, the potential energy could be found to be option B: 0.16 J.

The most common incorrect response was 0.016 J, where students had confused the scales on the axes.

Questions 3–4

Marks	0	1	2	3	4	Average
%	19	14	18	16	34	**2.4**

Question 3
The stress was 2 x 10^9 Pa.

Students were required to provide the value and the unit. Alternative units were acceptable; for example, N m^{-2}, MPa, GPa, etc.

Question 4
The value of Young's modulus was 1.25 x 10^{11}.

To obtain this answer, it was necessary to determine the strain. Common errors were to use the total length instead of the extension, or to divide the stress obtained from one point on the graph by the strain from another point.

Question 5

Marks	0	1	2	Average
%	46	0	54	**1.1**

The elastic limit would be near the end of the linear section of the graph where the tension is 500 N. When this was divided by the cross sectional area it gave the answer 2.5 x 10^9 N m^{-2} (option B).

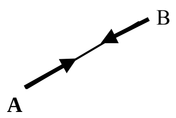
Just over half of the students answered this question correctly.

Questions 6–7

Marks	0	1	2	3	4	Average
%	23	11	45	6	16	**1.9**

Question 6
The material was ductile because it had a significant plastic region. Students did well on this question.

Question 7



The answer required arrows from points A and B that were directed toward the centre of the cable. This question was not well answered.

Question 8

Marks	0	1	2	Average
%	10	0	90	**1.8**

Underneath, the deck was stretched and therefore in tension. On the upper surface, it was in compression. Most students selected the correct answer of A.

Questions 9–11

Marks	0	1	2	3	4	5	6	7	Average
%	22	7	16	7	7	10	7	23	**3.6**

Question 9
Concrete provided the compressive strength, and steel provided the tensile strength.

Students generally found this to be a straightforward question.

Question 10
The torque about point A due to the weight of the platform was $\tau = F \times d = 200 \times 10 \times 0.5 = 1000$

Question 11
The torque about A due to the weight of the platform would be balanced by the torque due to Alf's weight. So, 1000 = 100 x 10 x X. Therefore X = 1.0 m.

This was very poorly answered.

Question 12

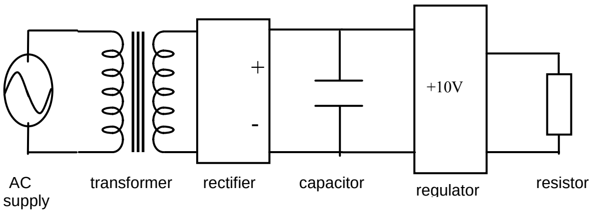
Marks	0	1	2	Average
%	28	0	72	1.5

Varying the height of the pedestal would have no effect, so the answer was B. Most students had little difficulty with this question.

Detailed Study 3 – Further electronics

Question 1

Marks	0	1	2	3	4	Average
%	36	8	7	24	25	2.0



The diagram illustrates the answer. The most common error was to insert a resistor between the rectifier and capacitor or between the capacitor and regulator, which may have been caused by a failure to distinguish between the regulator unit and a Zener diode. Another common error was for students to draw a type of series circuit with components connected at various points along the circuit. This displayed little evidence of the practical work involved in constructing a regulated power supply.

Question 2

Marks	0	1	2	Average
%	56	0	44	0.9

Multiplying the RMS value by $2\sqrt{2}$ gave option B: 480 V as the answer.

About half of the students answered this question correctly.

Question 3

Marks	0	1	2	Average
%	59	12	29	0.7

The ratio of the number of turns was the same as the ratio of the voltages; that is, $\frac{10.6}{240} = 0.0442$.

This was quite well done, although students are encouraged to evaluate the ratios to a decimal answer.

Questions 4–5

Marks	0	1	2	3	4	Average
%	17	0	26	0	57	2.8

Question 4
Option C was the correct choice for the bridge rectifier. Most students gave the correct answer.

Question 5
The time constant = RC had to be at least 50 ms. Since R = 1.0 kΩ, the capacitor had to be at least 50×10^{-6} = 50 µF. Therefore, option D: 60 µF, was the best option.

This question was well done.

Questions 6–7

Marks	0	1	2	3	4	5	Average
%	38	12	14	14	13	10	**1.9**

Question 6
In reverse bias, the Zener diode maintained a constant output voltage independent of the current drawn. Students who simply stated that it regulated the voltage did not always show that they knew what regulated meant.

Question 7
As this was a three mark question, students should have realised that simply stating 'use a CRO' was insufficient for full marks. Points which could have been made included:

- AC – use a CRO to see variation
- AC – multimeter ineffective, it 'averages'
- DC – use a CRO or multimeter for pure DC
- ripple voltage needs a CRO.

Marks were also awarded for explaining where and why each device would be used at various points of the circuit.

Question 8

Marks	0	1	2	Average
%	65	0	35	**0.7**

The best answer was A: 'the output voltage across the load resistor is virtually unchanged'.

The reason for a regulated power supply is that it maintains a constant output voltage.

Questions 9–10

Marks	0	1	2	3	4	Average
%	28	9	19	18	26	**2.1**

Question 9
Increasing the load resistance has no effect on the output voltage (because it is a regulated supply), but will decrease the current through the load.

Both parts of this question were handled very well by students.

Question 10
Points which earned marks included:

- electrical components have resistance and so generate heat
- the heat sink removes the heat generated
- by increasing the area of the heat sink, more heat can be dissipated.

Most students gave adequate information for full marks. Stating that 'the heat sink ensured components maintained a correct operating temperature' was not awarded any marks because this information was written in the stem of the question.

Question 11

Marks	0	1	2	Average
%	49	0	51	**1.1**

Most students knew that using a half-wave rectifier would **increase** the ripple voltage at the input to the regulator.