2006 Physics GA 1: Written examination 1

GENERAL COMMENTS

The number of students who sat for the 2006 Physics examination 1 was 6712. With a mean score of 50 per cent, students generally found the paper to be more challenging than last year. There were no students who achieved the maximum score of 90. The majority of schools predictably chose to continue with Detailed Study 2.

A few areas of weakness that were noted included:

- universal gravitation – 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 10
- transistor amplifiers
- motion (particularly Questions 7, 8, 12 and 14).

When preparing for the examination, students should be aware of the following information.

- Students should only attempt **one** detailed study. A small number of students this year attempted two or three.
- Students must be more careful with their handwriting – if the assessor cannot decipher what is written, no marks can be awarded. This applies particularly to multiple-choice questions where one answer is written over another and it is unclear which alternative the student has chosen.
- Written explanations must address the question asked. Students who simply copy generic answers from their note sheets will not gain full marks.
- Students should show their working. Credit can be given for working even if the answer is incorrect.
- Students must follow the instructions given in questions. Some questions specifically state that working is to be shown. If this is not done, no marks can be awarded.
- Students must ensure that they read scale on axes carefully.
- Multiple-choice questions generally have only one answer. However, if the statement 'one or more answers' appears, there may be one answer or there may be more than one answer.
- Students must know how to handle prefixes; for example, M = 10^6.

SPECIFIC INFORMATION

Section A – Core

Area of study 1 – Motion in one and two dimensions

Questions 1–3

Marks	0	1	2	3	4	5	6	7	Average
%	21	2	11	5	9	14	4	33	4.2

Question 1
260 N

Since the speed was constant, the net force must have been zero. Thus, the driving force forward balanced the opposing forces and equalled 260 N. A few students incorrectly split the driving force between the front and rear wheels of the bicycle.

Question 2
The net force on the trailer was zero, thus the tension in the tow bar was 70 N.

Question 3
9 m

Most students attempted this question by using $F = ma$ to obtain the deceleration of 2 m s^{-1} and then applying a constant acceleration equation to get a distance of 9 m. An alternative method was to realise that the change in kinetic energy was equal to the work done. A common error was to assume that the deceleration would be 9.8 or 10 m s^{-2}.

Questions 4–7

Marks	0	1	2	3	4	5	6	7	8	Average
%	11	2	14	5	20	7	16	7	19	**4.6**

Question 4
Vivian's weight (W) was balanced by the force F. Thus, F = 60 × 10 = 600.

Question 5

C provided the force needed to maintain Vivian's circular motion. $C = \frac{mv^2}{R} = 968$ N.

The most common error was to substitute the diameter instead of the radius.

Question 6
A propulsive force of 22 N up and a weight force of 5 N down were acting on the rocket. Therefore, the resultant force was 17 N.

A common error was to add the two forces instead of subtracting them.

Question 7
38.25 m

Realising that the net force acting on the rocket during the 1.5 sec was constant, the most common correct approach was to first determine the acceleration (34 m s^{-2}) and then use one of the constant acceleration formulae to obtain a distance of 38.25 m. A common mistake was to assume that the acceleration was 10 m s^{-2}.

Question 8

Marks	0	1	2	3	4	Average
%	48	19	7	9	17	**1.3**

- speed: 67.7 m s^{-1}
- angle: 12.8°

Most students approached this question by attempting to find the horizontal (66 m s^{-1}) and vertical (15 m s^{-1}) components of the velocity. By using Pythagoras and a trigonometric relation, they then were able to determine the velocity as 67.7 m s^{-1} at an angle of 12.8° to the horizontal.

It was common for students to mistakenly calculate one or other (or both) of the components as it hit the ground. This question was not well answered.

Question 9

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

As well as viewing the vertical motion of the ball, Mary would also see it moving backward relative to her. The correct answer was therefore E.

Questions 10–14

Marks	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Average
%	16	4	12	10	5	9	7	5	8	6	3	7	3	2	2	**5.2**

Question 10
The momentum before docking was 6000 × 5 and after docking was (6000 + M)0.098. Therefore, the mass of the space station was 3.0×10^5 kg.

A common error was to neglect the momentum of the shuttle after docking. This gave an answer of 3.06×10^5, which students rounded off. In this case, only one mark was awarded for the idea of conservation of momentum.

Question 11
1470 N

The simplest approach was to use *impulse* = *change in momentum* and apply it to the space station. Thus, $F \times 20 = 3 \times 10^5 \times 0.098$. This gave F = 1470 N. Some students applied the same principle to the shuttle. Others first calculated the acceleration of the station or the shuttle and then used it in Newton's second law to obtain the force.

Question 12
The total work done dragging Sam up the incline was 22 720 J. Some of this went into increasing his gravitational potential energy (13 720 J). The remainder was the work done against friction up the incline (9000 J). This equalled 300 × L, so L = 30 m.

Students who did not show a relevant and logical sequence of calculation were not awarded any marks.

Question 13
Using $U = mgh$, $13720 = 70 \times 10 \times h$. Thus, h was 19.6 m.

This was a reasonably straightforward question.

Question 14
394 n m^{-1}

Sam's loss of gravitational potential energy equated to the gain in the potential energy of the bungee cord, $mgh = \frac{1}{2}kx^2$.

Thus, $70 \times 10 \times 18 = \frac{1}{2}k8^2$, leading to k = 394 n m^{-1}.

Common misconceptions included using a value other than 18 m for the change in height, using either 22 720 J or 13 720 J for the change in gravitational potential energy and attempting to evaluate k from $F = kx$. This final method assumed that, at the bottom, the gravitational force on Sam was equal to the force in the cord.

Question 15

Marks	0	1	2	Average
%	37	0	63	**1.3**

C

Acceleration due to gravity is the same as the gravitational field, since $g = G\frac{M}{R^2}$. As the mass was $\frac{1}{10}$ that of the Earth and the radius was a half, the gravitational field would be 0.4 that of the Earth. Therefore, the answer was C.

Question 16

Marks	0	1	2	3	Average
%	44	13	12	30	**1.3**

1.58×10^5 s

The force needed to keep the probe in orbit was $\frac{4\pi^2 Rm}{T^2}$. This was provided by gravity $G\frac{Mm}{R^2}$. Transposing this relationship and substituting the relevant values gave $T = 1.58 \times 10^5$ s.

Some common errors included using a value of g (usually 4) from the previous question and forgetting to cube R.

Area of study 2 – Electronics and photonics

Question 1

Marks	0	1	2	3	Average
%	21	39	22	18	**1.4**

- point 1: 20 V
- point 2: 4 V
- point 3: 12 V

While many students obtained 20 V as the first point, they had difficulty in calculating voltages for points 2 and 3. The first answer was simply the supply voltage. The second was determined by treating R_1 and R_2 as a simple voltage divider. To obtain the third answer, students were first required to calculate the voltage across R_C, then subtract it from the supply voltage.

Questions 2–4

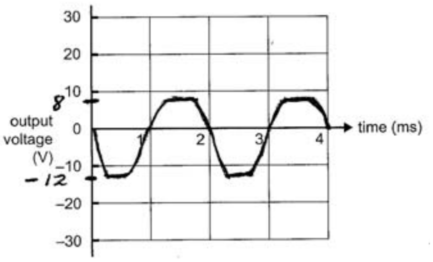
Marks	0	1	2	3	4	5	6	7	8	9	10	Average
%	10	13	14	14	14	8	10	11	6	2	0	**3.8**

Question 2
10 mA

Considering just the AC components, the output voltage $\Delta v_{OUT} = 200 \times 50 \times 10^{-3} = 10\text{V}$. Now $\Delta v_{OUT} = \Delta v_{RC} = 10 = \Delta i_c \times 1000$. So $\Delta i_c = 0.01 \text{ A} = 10 \text{ mA}$.

If working was not shown for this question, no marks were awarded.

Question 3



The output varied about zero, was inverted, had the same frequency as the original and was clipped at +8 and –12 V.

Students found this to be a very challenging question, and few showed any recognition of clipping. The further complexity of dealing with an output varying around an operating point, not in the middle of the linear range, proved to be difficult for most students.

Question 4
The purpose of the decouplers in a circuit is to ensure that the correct bias conditions are maintained, by preventing the flow of DC into or out of the amplifier. A capacitor achieves this by preventing the flow of DC but allowing AC signals to pass through.

While many students were aware of the operation of a capacitor, most did not address why this was necessary in the amplifier circuit.

Questions 5–7

Marks	0	1	2	3	4	5	6	Average
%	2	17	7	8	16	8	42	**4.2**

Question 5
43 mA

From the graph, the potential difference across the diode was 0.7 V. Therefore, the potential difference across the resistor had to be 4.3 V. Hence, by applying Ohm's Law, the current was 43 mA.

Question 6
A temperature of 30°C equated to a resistance of $100\,\Omega$.

Question 7
$800\,\Omega$

The first step was to determine that at a temperature of 10°C the resistance of the thermistor was $400\,\Omega$. By then applying the voltage divider relationship, the variable resistor was $800\,\Omega$.

The most common difficulty students had with this question was correctly substituting into the voltage divider formula. Many were confused about what R_1 and R_2 represented.

Questions 8–9

Marks	0	1	2	3	4	5	6	Average
%	25	12	30	9	18	3	4	2.1

Question 8
In the context of this question, modulation referred to variation of the light intensity. Demodulation meant that the variation in the light intensity created an electrical signal.

Quite a few answers dealt with the general concept of carrier waves being modulated by a signal wave. Many students used the term modulated when defining modulation – students should avoid using a term in its own definition.

Question 9
The LED was the best option for P and the LDR was the best for Q.

Section B – Detailed studies

Detailed study 1 – Einstein's relativity

Questions 1–2

Marks	0	1	2	3	4	5	Average
%	27	10	12	16	19	16	2.5

Question 1
In a moving medium (ether) the speed of waves would differ depending on the direction of travel. The ether is a moving medium relative to the Earth. By showing that the speed of light was the same both parallel to and perpendicular to the flow of the ether, it indicated that there was no evidence for the existence of the ether.

A large number of students did not actually draw any conclusion about the existence of the ether.

Question 2
An inertial frame of reference is where the observer is at rest or moving at a constant velocity.

Question 3

Marks	0	1	2	Average
%	27	20	53	1.3

Most students were able to identify Kris' measurement as the proper length. This must be measured in the frame of reference in which the object is at rest.

Question 4

Marks	0	1	2	Average
%	41	0	59	1.2

The correct relationship was B.

Question 5

Marks	0	1	2	Average
%	41	3	57	1.2

- Lee: 310 m s^{-1}
- Sung: 370 m s^{-1}

This question was generally well done, although a few students had the speeds in the reverse order or had 340 m s^{-1} for both. Presumably they equated the behaviour of sound with that of light.

Question 6

Marks	0	1	2	Average
%	30	0	70	1.4

Most students selected the correct answer, A.

The most common incorrect response was D. Students who chose this option presumably applied the concepts of Galilean relativity, which were relevant to the previous question.

Questions 7–9

Marks	0	1	2	3	4	5	6	7	8	Average
%	40	5	6	6	4	13	5	4	18	3.3

Question 7

Substituting in the formula for γ gave an answer of 10.01, and multiplying this by the proper time gave the required 22 μs.

A significant number of students did not attempt this question. Others could not calculate γ or got the reciprocal 0.1.

Question 8

Having already calculated γ in the previous question, the height of the mountain relative to the muons was

$$\frac{2627}{10.01} = 262 \text{ m.}$$

The main errors in this question were caused by difficulties determining γ and then knowing whether to multiply or divide by it.

Question 9

The measured length had to be 99 per cent of the proper length. So,

$$0.99\ L_0 = \frac{L_0}{\gamma} \rightarrow 0.99 = \sqrt{\left(1 - \frac{v^2}{c^2}\right)} \rightarrow v = 4.2 \times 10^7 \text{ m s}^{-1}.$$

Some students did not attempt this question, while others used 101 per cent instead of 99 per cent. Students found this to be quite a challenging question.

Question 10

Marks	0	1	2	Average
%	51	0	49	1.0

About half of the students selected the correct answer, B.

Question 11

Marks	0	1	2	Average
%	62	0	38	0.8

The correct answer, C, was chosen by about 38 per cent of students. The most common incorrect response was B.

Detailed study 2 – Investigating materials and their use in structures

Question 1

Marks	0	1	2	Average
%	14	0	86	1.8

B was correct, as the acrylic has no plastic region.

Question 2

Marks	0	1	2	Average
%	12	11	77	1.7

Polyethylene is tougher, as there is a greater area under the graph.

Questions 3–6

Marks	0	1	2	3	4	5	6	7	8	9	10	Average
%	12	14	7	9	8	10	8	10	7	4	10	4.6

Question 3

A stress of 20 MPa meant a strain of 2%: 2% of 5 is 0.1 m.

Many students did not read the scale on the strain axis and obtained a strain of 2 instead of 2 per cent.

Question 4

Young's modulus for the acrylic was $\frac{60\times10^6}{0.02} = 3000$ MPa.

Common errors included calculating the value for the wrong material or once again misreading the strain axis.

Question 5

From the graph, the maximum stress for the acrylic was about $62\times10^6 = \frac{F}{A} = \frac{(m\times10)}{2\times10^{-4}} \rightarrow m = 1240$ kg.

A common error was to omit the gravitational field of 10.

Question 6

240 J

The work done was the area under the graph multiplied by the volume of the rod. Some students only calculated the area and neglected the volume, other students omitted the $\frac{1}{2}$ in the formula for the area of a triangle.

Question 7

Marks	0	1	2	Average
%	13	26	62	1.5

Steel has good tensile strength, which compensates for concrete's weakness in tension.

Some students appeared to have copied directly from their note sheets and did not always address the specific question. Many persisted with the false statement that 'steel is strong in tension and weak in compression'. Others provided a detailed description of the process of producing pre-stressed concrete, which was not relevant to the question.

Question 8

Marks	0	1	2	Average
%	29	0	71	1.5

Most students were aware that the correct answer was option C.

Question 9

Marks	0	1	2	Average
%	30	0	70	**1.4**

The correct answer was D. Students who answered incorrectly probably missed the implication of the centre of mass being outside the support B, and the torque produced by this.

Question 10

Marks	0	1	2	3	Average
%	42	21	7	29	**1.3**

Evaluating torques about support B, $F_A \times 8 = 500 \times 10 \times 1 \rightarrow F_A = 625$ N.

Most students knew to take torques, but many struggled with correctly allocating the distances.

Question 11

Marks	0	1	2	Average
%	45	0	55	**1.1**

Approximately 55 per cent of students selected the correct answer, option D.

Detailed study 3 – Further electronics

Questions 1–2

Marks	0	1	2	3	4	Average
%	21	2	21	5	51	**2.7**

Question 1

By applying the relationship $P = \frac{V^2}{R} = \frac{12^2}{240}$, the power dissipated was 0.6 W.

Question 2

A straightforward application of the transformer ratio gave the number of turns as 360.

Question 3

Marks	0	1	2	Average
%	56	0	44	**0.9**

Both option B and option C had the correct amplitude, but only B also had the correct period.

This question was a straightforward test of students' ability to interpret the display on an oscilloscope screen. Considering the requirement to design, construct and evaluate a power supply, it was expected that more students would answer this question correctly.

Question 4

Marks	0	1	2	Average
%	18	0	82	**1.7**

Most students chose the correct answer, option B.

Question 5

Marks	0	1	2	Average
%	27	0	73	**1.5**

Once again, most students selected the correct answer, option D. The most common incorrect response was A, which had the wrong period.

Questions 6–7

Marks	0	1	2	3	4	5	Average
%	37	12	14	11	15	10	**1.9**

Question 6
Since it is a regulated supply, increasing the input voltage would not affect the output. Therefore it would remain at 12 V.

Question 7
The output from the transformer would be reduced to an RMS voltage of 10.5 V, resulting in a peak voltage of 14.8 V. Accordingly, the regulator unit may or may not continue to provide an output of 12 V, depending on whether the input to the regulator remained above 12 V or not.

Students could obtain marks whichever way they argued, provided the relevant points were made.

Question 8

Marks	0	1	2	Average
%	22	0	78	**1.6**

This was another well answered question, with most students selecting the correct answer, A.

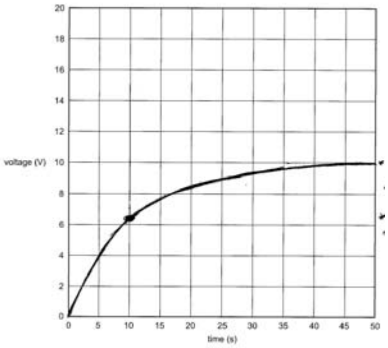
Questions 9–12

Marks	0	1	2	3	4	5	6	7	8	Average
%	14	4	10	13	14	7	9	8	20	**4.3**

Question 9
Since it is a regulated supply, the output voltage would remain constant, but the reduced resistance would mean an increase in the current.

Question 10
$\tau = \text{RC} = 2000 \times 10000 \times 10^{-6} = 20\text{ s}.$ Students simply needed to apply the formula for the time constant.

Question 11



The key points were that the general shape was correct, the trace asymptoted to 10 and the graph went through the point (10, 6.3).

Question 12
3.7 V

In one time constant (10 seconds), the voltage would drop 63 per cent. Thus, the reading after 10 seconds would be 3.7 V. Some students believed the drop would be 67 per cent.