2010 Physics GA 1: Written examination 1

GENERAL COMMENTS

The number of students who sat for the 2010 Physics examination 1 was 6989. With a mean score of 62 per cent, it was evident that students generally found the paper to be a little more challenging than last year. Six students achieved the maximum score of 90. The majority of students completed Detailed Study 2.

Particular areas of concern in this paper were:

- questions involving connected bodies
- circular motion on inclined planes
- more complex projectile questions
- momentum and kinetic energy in elastic and inelastic collisions
- obtaining the gain of an amplifier
- springs and energy conversions
- series and parallel circuits
- simple mathematical operations
- dealing with large numbers and powers of ten calculations.

This year all student papers were scanned and presented to assessors to mark online. Students must use blue or black pen in Section A. Other coloured pens or pencil may not show up when the paper is scanned.

Students should also be aware of the following general information.

- Students need to 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 in Section A 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 copy generic answers from their A4 sheets of pre-written notes will not gain full marks.
- Students should show their working. Credit can be given for working even if the final answer is incorrect.
- Students must follow the instructions given in questions. Some questions specifically require working to be shown; if this is not done, no marks are awarded.
- It is expected that formulas are copied correctly from the data sheet provided with the examination or from the student's A4 sheet of pre-written notes. If this is not done, zero marks will be awarded to that question.
- Attempting a question in a number of different ways will be awarded zero marks unless all methods are correct. Students must make clear which working is intended by crossing out the rest.

SPECIFIC INFORMATION

Section A – Core

For each question, an outline answer (or answers) is provided. In some cases the answer given is not the only answer that could have been awarded marks.

Area of Study 1 – Motion in one and two dimensions

Question 1

Marks	0	1	2	Average
%	13	5	82	1.7

Application of the centripetal force formula gave a speed of 28.3 m s^{-1}.

This question was generally well done, although some students treated it as if the car was doing a vertical loop.

Question 2

Marks	0	1	2	Average
%	13	2	85	1.8

16 m s^{-2}

To obtain the acceleration, students could either divide the net force by the mass or use the centripetal acceleration formula (v^2/R) to obtain the answer. Some students assumed that because the speed was constant the acceleration must be zero. Others simply gave the answer as 10 m s^{-2}.

Question 3

Marks	0	1	2	Average
%	42	48	10	**0.7**

The only force causing the blocks to accelerate was the gravity force acting on block 2. This gave a net force of 1 N. By applying Newton's second law, the acceleration was 1.0/0.50 = 2.0 m s^{-2}.

While many students identified the net force as 1.0 N, they then divided it by 0.40 kg instead of the total mass 0.50 kg. It was also common for students to simply write the acceleration as 10 m s^{-2}.

Question 4

Marks	0	1	2	Average
%	45	4	51	**1.1**

By substituting the acceleration determined in Question 3 into the constant acceleration formula $v^2 = u^2 + 2\,a\,x$, the speed after one metre was 2 m s^{-1}. From this, the kinetic energy was calculated to be 0.8 J.

A common mistake was to use an acceleration of 10 m s^{-2} in the constant acceleration equation. Another was to assume that the increase in kinetic energy of block 1 would be equal to the loss of gravitational potential energy of block 2.

Question 5

Marks	0	1	2	Average
%	53	3	43	**0.9**

The two forces required were the gravitational weight force and the normal reaction.

Many students incorrectly included the centripetal force, which was the resultant of the other two and not a separate force. Others also included components of either the normal force or the weight force. Some students did not attempt this question.

Question 6

Marks	0	1	2	3	Average
%	48	3	1	48	**1.5**

The required angle was 5.7^0.

There were a number of correct ways students answered this question. Some students had a standard formula involving tanθ on their A4 sheets. Others did vector diagrams with weight, normal and resultant centripetal force to form a right-angled triangle. From this they were able to obtain the relationship involving tanθ. However, many students who used this method of a vector triangle of forces determined the wrong angle or mixed up the sides of the triangle. The third correct method involved resolving the original forces vertically and horizontally and equating the horizontal component to the centripetal force.

Question 7

Marks	0	1	2	Average
%	16	4	80	**1.7**

The loss of gravitational potential energy was equal to the kinetic energy at point B. Equating these gave a speed of 20 m s^{-1}. Some students tried to turn it into a circular motion problem involving mv^2/R. Others incorrectly used the constant acceleration formula $v^2 = u^2 + 2\,a\,x$.

Question 8

Marks	0	1	2	Average
%	13	28	58	**1.5**

There were a number of ways this question could have been answered. One point involved the fact that Rebecca was correct, that the riders still had weight or that they were not experiencing true weightlessness. The second point involved explaining **why** they still had weight or were not truly weightless. It was common for students to incorrectly explain apparent weightlessness as when the normal reaction and weight forces are equal and cancel each other out. Others applied a shortcut formula $N = mg - mv^2/R$ but often got the signs wrong.

Question 9

Marks	0	1	2	Average
%	27	4	69	1.4

At point C the normal reaction force was zero, so $mv^2/R = mg$. By appropriate substitution the speed was 10 m s^{-1}.

Some students tried unsuccessfully to apply energy considerations. Others simply said the speed would be 10 m s^{-1} because g = 10 m s^{-2}.

Question 10

Marks	0	1	2	Average
%	34	5	61	1.3

The first step was to determine the time taken for the package to reach the ground by analysing the vertical motion. By using $x = u\,t + ½\,a\,t^2$, the time of flight was 6.32 s. This time was then multiplied by the horizontal velocity of 10 m s^{-1} to give a distance of 63 m.

Question 11

Marks	0	1	2	Average
%	40	17	44	1.1

As the package hit the ground it had both vertical and horizontal components of velocity. The horizontal component was 10 m s^{-1} and the vertical component of 63 m s^{-1} was obtained using $v = u + a\,t$. By then using Pythagoras' theorem, the speed was 64 m s^{-1}. Some students determined the vertical component of the velocity only. Some mixed up the vertical and horizontal components, substituting into $v^2 = u^2 + 2\,a\,x$ and getting $v^2 = 10^2 + 2x10x200$.

Question 12

Marks	0	1	2	Average
%	26	3	71	1.5

Substituting into the relationship I = F x t, the force was 212.5 N.

Question 13

Marks	0	1	2	Average
%	44	4	52	1.1

Since the mass is at rest when the spring is extended 0.40 m, the net force must be zero. Therefore the weight force on the mass equalled the force of the spring acting up on it, mg = kx. Hence k = 50 N m^{-1}.

Many students assumed that the decrease in gravitational potential energy equalled the increase in spring potential energy, neglecting the work which had been done against the block by the hand as it lowered it. Another common error was to equate the weight force on the block to the change in potential energy stored in the spring. Other students wrote Hooke's law as $F = –kx^2$. Some attempted to equate kinetic energy to the spring potential energy. It was surprising that many students substituted the value of the mass of the block as 0.2 kg instead of 2.0 kg. It was also common for students to give the value of k as –50 because they had mixed up signs in their equations.

Question 14

Marks	0	1	2	Average
%	43	45	13	0.7

The loss of gravitational potential energy from A to B was 8 J. The gain of spring potential energy was 4 J. Therefore, the difference in energy between the two positions was 4 J.

Many students determined the spring potential energy increased by 4 J, but did nothing else.

Question 15

Marks	0	1	2	Average
%	48	16	36	0.9

The answer was A. In elastic collisions the kinetic energy after the interaction equals that before the interaction. During the collision some of the kinetic energy was converted to spring potential energy and then back again.

Question 16

Marks	0	1	2	Average
%	38	6	56	1.2

The answer was B. Momentum is always conserved before, during and after a collision.

Question 17

Marks	0	1	2	Average
%	61	4	35	0.8

The answer was B. Momentum is always conserved before, during and after a collision. This is so whether the collision is elastic or inelastic.

Question 18

Marks	0	1	2	Average
%	40	8	53	1.2

The weight was the gravity force = $G\ M\ m/R^2 = (6.67 \times 10^{-11}) \times (5.98 \times 10^{24}) \times (3.04 \times 10^5)/(6.72 \times 10^6)^2 = 2.69 \times 10^6$ N.

A common error was using the wrong radius. Many students forgot to square the radius. Less common mistakes were using the mass of the satellite (instead of the mass of Earth) to find g, or just using g = 10 or g = 9.8.

Question 19

Marks	0	1	2	Average
%	46	9	45	1

The correct answer was 5.48×10^3 seconds. This was obtained by equating the gravitational force to the centripetal force and transposing to get T = √(4π2R3/GM).

Errors included incorrectly copying the formula or incorrectly transposing the equation. There was also confusion over which mass or radius should be used. Calculator errors were also common.

Question 20

Marks	0	1	Average
%	39	61	0.6

The period will be the same. It is independent of the mass of the space station.

Area of Study 2 – Electronics and photonics

Question 1

Marks	0	1	2	Average
%	30	6	65	1.4

From the graph the potential difference across the diode would be 1 V, so the potential difference across the 500 Ω would be 5 V. By applying Ohm’s Law the current was therefore 10 mA.

Some students were unable to convert their answer to mA.

Question 2

Marks	0	1	2	Average
%	62	4	34	0.7

The diode and the 200 Ω conductor were in parallel; therefore, the voltage across them was 1 V. This left 5 V for the 500 Ω which was in series with the parallel group. By applying Ohm’s Law to the 500 Ω, the current passing through it was 10 mA. This would also pass through the ammeter.

Some students attempted to treat the diode as an ohmic conductor. The most common mistake was to think the total resistance was 700 Ω. Other common mistakes in this question were to think that the 200 ohm resistor used 1 V (correct) and the diode used 1 V (correct) and therefore the 500 ohm resistor must have used the remaining 4 V (incorrect).

Question 3

Marks	0	1	2	Average
%	22	35	43	1.2

The combined resistance of the two globes in parallel was 1 Ω. The other resistors made the total resistance of the circuit up to 2 Ω. Therefore the globes each received 12 V.

Question 4

Marks	0	1	2	Average
%	43	0	57	1.2

Since the total resistance of the circuit was 2 Ω, applying Ohm's Law gave the current as 12 A.

Many students had difficulty determining the circuit resistance.

Question 5

Marks	0	1	2	Average
%	22	5	74	1.5

Firstly, it was necessary to determine the input power, which was 0.1 W. The efficiency was therefore 50%.

Some students mixed up watts and milliwatts. Others evaluated the power in over the power out and got an efficiency value greater than 100%. Students should be encouraged to check that their answers are reasonable.

Question 6

Marks	0	1	2	Average
%	40	5	55	1.2

From the graph the resistance of the LDR was 1.0×10^4. Since the voltage across the resistor had to be twice that across the LDR, its resistance had to be double, 2.0×10^4 Ω.

Question 7

Marks	0	1	2	3	Average
%	23	21	18	38	1.7

As it got darker the resistance of the LDR increased. Since the resistor was constant, the increased resistance of the LDR meant it would receive a greater proportion of the 12 V supply. So the V_{OUT} increased.

Some students realised that the resistance of the LDR increased as it got darker; however, they then said that according to Ohm's Law an increased resistance leads to an increased voltage. This would apply if the current was constant; however, in this case it wasn't, as it decreased.

Question 8

Marks	0	1	2	3	Average
%	28	32	16	23	1.4

For the lights to come on earlier the illumination would be greater and the resistance of the LDR would be decreased. To ensure the LDR still has the same proportion of the potential difference, the resistance of R has to be decreased.

Many of the students' explanations were difficult to follow. Some suggested that changing the resistance of the LDR would somehow change the illumination.

Question 9

Marks	0	1	2	Average
%	52	1	47	1

From 5 ms – 15 ms and 25 ms – 35 ms the amplification is not linear, so these regions should be avoided when determining the amplification. At 5 ms the amplification ratio was 10/0.2 or 20/0.4 = 50.

Many students had the ratio inverted and obtained an amplification of less than 1; however, students should have realised that this was not a realistic answer. Others mixed up volt and millivolt in the ratio. It was common for students to ignore the clipping and attempt to determine the amplification in this region.

Question 10

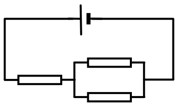
Marks	0	1	2	3	Average
%	19	9	21	51	2.1

The required graph had a negative gradient passing through the origin. The graph flattened out, indicating clipping at +/-200 mV, -/+10 V.

The most common error was commencing the clipping at +/-300 mV.

Question 11

Marks	0	1	2	3	Average
%	16	12	0	71	2.3



A common error was to have two parallel branches, one with two resistors and the other with one resistor. Many students included a short circuit.

Section B – Detailed studies

The table below indicates the percentage of students who chose each option. The correct answer is indicated by shading.

Question	% A	% B	% C	% D	% No Answer	Comments
Detailed Study 1 – Einstein's special relativity						
1	9	10	61	19	1	
2	57	10	16	16	1	The distance measured in the proper frame of reference was 1.0 km. Susanna was in a moving frame so the distance from her perspective was contracted. $L = L_0/\gamma = 1.0/2.29 = 0.44$ km.
3	5	22	70	2	1	
4	20	69	6	4	1	
5	16	40	13	29	1	Newton's laws apply in inertial frames of reference. Option B was an accelerating frame.
6	8	56	24	10	2	The distance and time were both measured by the observers on the planet, so distance = speed x time = $0.85c \times 784 \times 10^{-6}$ = 200 km.
7	54	10	10	24	2	The robot was in the moving frame relative to where the time was measured. So time as measured by the robot was dilated $= t_0/\gamma = 784/1.9 = 413$ µs.
8	49	6	13	31	2	Proper time is measured by a clock and is the time between two events that occur at the same place as the clock.

Question	% A	% B	% C	% D	% No Answer	Comments
9	5	66	5	22	1	
10	24	50	16	7	3	$E = mc^2$. So $3.38 \times 10^{-11} = 2 \times m \times 9 \times 10^{16}$. Therefore $m = 1.88 \times 10^{-28}$ kg.
11	34	19	28	16	4	By substituting the appropriate values into $KE = (\gamma-1)m_oc^2$, $\gamma = 2.29$. This lead to $v = 0.9c$.
12	75	6	6	10	3	
Detailed study 2 – Materials and their use in structures						
1	7	3	11	79	0	
2	3	88	5	4	0	
3	6	2	90	1	0	
4	7	8	80	4	1	
5	3	14	75	7	1	
6	2	93	3	1	1	
7	2	7	5	85	1	
8	45	13	28	11	2	Total strain energy = Area under graph x Volume = $[\frac{1}{2} \times 300 \times 10^6 \times 1.5 \times 10^{-3}] \times [10^{-4} \times 10] = 225$ J
9	3	5	77	14	1	
10	10	13	10	66	1	Torque about support P gave 1200x2 + 600x3 = Qx4, which led to Q = 1050.
11	4	12	8	74	1	
12	3	86	6	3	2	
Detailed study 3 – Further electronics						
1	3	3	90	3	0	
2	20	61	12	7	0	
3	12	66	17	4	1	
4	11	3	84	2	0	
5	76	15	3	6	0	
6	8	16	68	8	0	
7	5	68	20	6	0	
8	35	1	49	15	0	The circuit resistance is the same, so from Figure 7 the capacitor would discharge 63% in about 0.01 s. From Figure 8 it was about 0.015 seconds from when the voltage started to drop until it started to increase again. In that time the capacitor would discharge by more than 63%.
9	16	19	59	6	1	The maximum voltage remains unchanged at 6 V. However, the smaller resistor means a reduced time constant and therefore a greater ripple.
10	34	13	49	3	0	The output voltage is determined by the Zener diode, so the maximum is still 6 V. Since the time constant was the same, the ripple would be similar.
11	10	33	42	15	1	The average voltage was approximately 5 V and the current was 20 mA. Using P = VI = 5 x 0.020 = 0.10 W.
12	2	61	6	30	0	