2012 Physics GA 1: Written examination 1

GENERAL COMMENTS

This examination was the final Unit 3 June examination for the *VCE Physics Study Design*. From 2013, a single examination covering both Units 3 and 4 will be held in November.

The number of students who sat for the 2012 Physics examination 1 was 7082.

Students and teachers should note the following points in relation to the 2012 Physics examination 1 paper and for future reference.

- In Section A, students should write in black or blue pen to ensure that their responses can be read by assessors.
- Attempting a question a number of different ways will not be awarded any marks unless all methods are correct. It is expected that students will make it clear which working is intended by crossing out the rest. Some students use an eraser to remove working; however, students are advised to neatly cross out the working they do not want marked.
- Students should to be careful with their handwriting and be encouraged to set their work out so that the assessor can follow what they have done.
- In explanation-type questions, students should carefully consider what the question is asking. Students' answers should be crafted to address this and not simply consist of information copied from their A4 sheet of notes. It is not the length of the answer, but the relevance and correctness of the points made that are critical. Students who write everything they know related to the topic often include irrelevant, contradictory or incorrect material. When this occurs, full marks are not awarded.
- Many students answer explanation-type questions in dot-point format. This is quite acceptable and often helps to ensure good, concise answers.
- The use of equations or diagrams in explanation-type questions can sometimes assist. It is important that diagrams are sufficiently large and clearly labelled.
- Students' attention should be drawn to the instruction for Section A: 'In questions where more than 1 mark is available, appropriate working should be shown'. Some credit can often be given for working even if the final answer is incorrect.
- Students are also reminded of the instruction for Section A, 'Where an answer box has a unit printed in it, give your answer in that unit'.
- It is important that students show the actual numbers substituted into formulas/equations.
- It is expected that formulas be copied accurately from the formula sheet provided with the examination or from the student's A4 sheet of notes.
- Derived formulas from the student's A4 sheet of notes may be used. However, they must be correct and appropriate for the question.
- Students need to be familiar with the operation of the scientific calculator they will use in the exam.
- Answers should be simplified to decimal form.
- Arrows representing vector quantities must be drawn so that they originate from the point of application.
- Students should ensure their answers are realistic. Ridiculous answers should alert students to check their work.

Some particular areas of concern in this paper were:

- Newton's third law of motion
- application of Newton's second law of motion
- series and parallel circuits
- conversion of units; for example, from milliamp to ampere
- force and energy in springs
- vertical circular motion.

SPECIFIC INFORMATION

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.

Section A – Core
Area of study 1 – Motion in one and two dimensions

Question 1a.

Marks	0	1	Average
%	16	84	0.9

With a kinetic energy of 5.4 J, the speed was 3.0 m s^{-1}.

This question was generally well done.

Question 1b.

Marks	0	1	Average
%	37	63	0.7

The work done by the spring was equal to the kinetic energy provided to the block, 5.4 J.

Some students attempted to apply the relationship $W = Fx$ by substituting the value of the gravitational force on the 1.2 kg mass as the force exerted by the spring. Apart from the fact that the weight of the mass was not related to the thrust of the spring, the thrust would not be constant, as required by the formula.

Question 1c.

Marks	0	1	2	Average
%	39	12	49	1.1

The kinetic energy provided was equal to the energy stored in the spring. So $5.4 = ½\, k\, x^2$ and $k = 1.7 \times 10^3$ N m^{-1}.

Many students used $F = kx$ but this was inappropriate as the force was not known at any compression. Many of these students commonly assumed that the force in the spring was constant and equivalent to the weight of the block. Others used $v^2 = u^2 + 2ax$ to determine the acceleration (incorrectly assuming it was constant) and then applied Newton's second law ($F = ma$) to get the force. Some assumed the acceleration was a constant value of 10 m s^{-2} and applied $v^2 = u^2 + 2ax$ to get x. Others confused force with kinetic energy by substituting 5.4 for F in the formula. Another incorrect method was to assume that the strain energy of the spring was somehow equivalent to a change in gravitational potential energy ($½\, k\, x^2 = mgh$).

Question 1d.

Marks	0	1	2	Average
%	22	3	75	1.6

The impulse given to the block by the spring was equal to the change in momentum of the block.
Impulse = m Δv = 3.6 N s.

Because the question asked for the impulse, some students tried to apply the formula $I = Ft$ by finding a force and a time; however, this did not work, because the force was constantly changing.

Question 2

Marks	0	1	2	3	Average
%	60	13	10	17	0.9

There were a number of ways to approach this question. For example, the initial momentum was $1.2U_1$ and the final momentum was $2.4V_2 – 1.2V_1$. Therefore, the momentum of the 2.4 kg block after the collision was $1.2U_1 + 1.2V_2$. An alternative approach was to show that the impulse applied to each block was equal but opposite and, therefore, the overall change in momentum was zero.

Many students assumed that because the second block had a greater mass it must have a greater momentum. Some answers referred only to kinetic energy instead of momentum. Relatively few students were able to provide a clear, well-reasoned answer. Substituting into the equation for conservation of momentum was a reasonably straightforward approach to answering the question.

Question 3

Marks	0	1	2	Average
%	15	32	53	1.4

Option B was correct because it was the only arrangement that could produce a net force of zero.

In their explanations, many students assumed that the forces were equal in magnitude. Of those who selected the correct option, many assumed the forces were equally spaced. Based on the diagram, it is clear this was not the case. A minority of students thought the ring was hanging vertically or that there were forces acting which were not shown on the diagram; for example, normal reaction.

Question 4a.

Marks	0	1	2	Average
%	12	28	60	1.5

Cable A needs to support both the 2 kg and the 1 kg spheres. Therefore, the force applied would be 30 N UP.

Some students neglected the weight of the 1 kg sphere and got an answer of 20 N. Giving the direction as north was common, even though the spheres were hanging from the ceiling.

Question 4b.

Marks	0	1	2	Average
%	86	2	12	0.3

The reaction force was the gravitational attraction by the 2 kg sphere on the earth. The direction was UP on the earth or UP towards the sphere.

This question indicated that most students are confused about Newton's third law. They seem to believe that the action/reaction forces act on one body to cancel each other out. The reaction force (20 N) was generally identified as the force up provided by cable A, even though they had determined in the previous part of the question that the force in cable A was 30 N. Another common error was identifying the reaction force as the 'normal reaction' force acting on the 2 kg sphere. This error was probably based on the assumption that the sphere was sitting on a bench, even though the diagram showed it hanging from the ceiling.

Question 5a.

Marks	0	1	Average
%	44	56	0.6

At a constant speed, the net external force on the logs must be zero. So T_1 must be equal to 800 N.

Question 5b.

Marks	0	1	2	Average
%	40	1	59	1.2

To determine the tension in rope 2, students needed to analyse the forces acting on the second log. Using Newton's second law, $T_2 - 400 = 600 \times 0.5$ led to a tension of 700 N.

Many students calculated the net force acting on the second log, $F_{NET} = ma = 600 \times 0.5 = 300$ N. They neglected to include the forces which contributed to F_{NET}. Others could not work out whether to add or subtract the 400 N friction force from the net force. When applying Newton's second law ($F_{NET} = ma$), students should be encouraged to substitute all the forces acting into the left-hand side of the equation and then transpose.

Question 5c.

Marks	0	1	2	Average
%	18	6	77	1.6

By using the constant acceleration formula $v^2 = u^2 + 2ax$, the speed of the truck after 20 m was 6.0 m s^{-1}.

This question was well done. Some mathematical mistakes were made; for example, forgetting to square or take the square root.

Question 5d.

Marks	0	1	2	3	Average
%	18	45	2	36	1.6

Since rope 1 has to pull both logs and rope 2 has to pull only one log, T_1 will break. The acceleration at which it will break can be determined using Newton's second law: 2400 – 800 = 1200 × a, so a = 1.3 m s^{-2}.

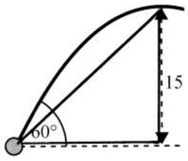
Most students were able to identify the correct rope, but few were able to determine the acceleration. As with Question 5b., many had difficulty applying Newton's second law properly. Again, students should be encouraged to substitute all the forces acting into the left-hand side of the equation and then transpose. Other errors included substituting the incorrect mass or not including the correct frictional force.

Question 6a.

Marks	0	1	2	3	Average
%	26	18	2	54	1.9

There were a number of approaches to this question, all involving the use of constant acceleration formulas to determine the vertical component of the initial speed to be 17.32 m s^{-1}. From this, the full initial speed was calculated by 17.32/sin60 = 20 m s^{-1}.

Many students were able to determine the initial vertical speed of 17.32 m s^{-1} but were unable or neglected to convert this to the total initial speed. A common error was for students to use the triangle shown below. They assumed the base angle was 60° and calculated the hypotenuse to be 17.32, which they assumed was a speed even though the opposite side of the triangle was a distance.



Question 6b.

Marks	0	1	2	Average
%	28	17	55	1.3

Constant acceleration formulas were used to determine the flight time of 3.5 s.

Some students who were able to determine the time taken for the ball to reach the top (or the time from top to bottom) neglected to double it for the total time of flight. Others used a constant acceleration formula but substituted the total initial speed (20 m s^{-1} from Question 6a.) instead of only the vertical component. Those using derived formulas from their A4 sheet of notes often encountered difficulties. Sometimes the formula was copied incorrectly or it was not applicable to the situation. On other occasions it was clear that students did not understand what the variables in the formula referred to.

Question 7a.

Marks	0	1	2	Average
%	19	4	77	1.6

Using the centripetal force formula, $F = mv^2/r$, and substituting the breaking force of the string, the maximum speed would be 6.0 m s^{-1}.

This question was well done, although some students converted the mass of 0.20 kg to 200, 0.20 × 10^{-3} or 20 before substituting it into the formula. Others used a derived formula, [$v = \sqrt{(g R)}$], which did not apply to this situation.

Mathematical errors in transposing the formula were evident in some students' responses, while others simply assumed an acceleration of 10 m s^{-2}.

Question 7b.

Marks	0	1	Average
%	25	75	0.8

An arrow from position P, pointing directly down the page, was required.

Many students did not attempt this question. In some cases it was not clear whether students were simply careless with their drawing of the arrow or did not understand what would happen. Students should be encouraged to take care when asked to draw vectors.

Question 7c.

Marks	0	1	2	3	Average
%	49	16	18	17	1

Since the ball was travelling at a constant speed, the net (centripetal) force required was the same at the top and bottom. At the top, the tension and weight combine to provide the net force $T_{top} + mg = mv^2/r$, so $T_{top} = mv^2/r - mg$. At the bottom, $T_{bottom} - mg = mv^2/r$, so $T_{bottom} = mv^2/r + mg$. It was not necessary to use equations; a clear explanation or a carefully drawn diagram could have been used.

It appears that many students attempted to answer this question from their A4 sheet of notes without reference to the context of the question. There was frequent reference to a normal reaction force that did not exist. Some students had this non-existent reaction force pointing towards the centre of the circle, while others had it pointing outwards. At the top of the circle, the ball was often said to be weightless. Many students had various combinations of normal reaction, weight, tension, centripetal and net forces acting. If students use diagrams to assist their explanation, they should ensure that the diagrams are sufficiently large, clearly drawn and labelled.

Question 8a.

Marks	0	1	2	3	4	Average
%	29	9	7	10	45	2.3

The force needed to maintain circular motion, $4\pi^2 Rm/T^2$, is provided by the gravitational force, GMm/R^2. Equating these, the radius of the orbit was $R = \sqrt[3]{\frac{GMT^2}{4\pi^2}} = \sqrt[3]{\frac{(6.67\times10^{-11})(7.36\times10^{22})(7200)^2}{4\pi^2}} = 1.86 \times 10^6$. Therefore, the height above the moon's surface was $1.86 \times 10^6 - 1.74 \times 10^6 = 1.21 \times 10^5$ m.

Many students' mathematical or calculator skills let them down. Some students who knew they had to perform a subtraction to get the altitude found the radius of the moon to be greater than the radius of the orbit they had determined. These students did not seem to realise that they had *Apollo 11* orbiting at a radius that put it inside the surface of the moon. When unrealistic situations, such as this one, arise, students should be encouraged to check their work. A common error was to use the radius of the moon to evaluate the strength of the gravity field at the moon's surface and then use this to determine the radius of the orbit of *Apollo 11*. Students should be encouraged to show the actual substitution into the formula. Without working, incorrect answers cannot be awarded any marks.

Question 8b.

Marks	0	1	2	Average
%	26	29	45	1.2

Weightlessness exists only where the gravitational field strength is zero. Apparent weightlessness occurs when gravity is the only force acting, the object is in free fall or the normal reaction force is zero. Astronauts in orbit around the moon experience apparent weightlessness.

Common incorrect statements included 'weightlessness is when no forces are acting on you' and 'weightlessness is when there is zero net force acting'. Some students believed that gravity ceases to exist away from Earth.

Area of study 2 – Electronics and photonics

Question 1

Marks	0	1	2	Average
%	9	9	82	**1.7**

By determining the resistance of the parallel section to be 100 Ω and adding the series component, the total resistance was 250 Ω.

Most students did well, although a significant number could not handle the combination of series and parallel. Common errors included adding all resistors as if they were in series or combining them as if they were all in parallel. Another common problem was some students' inability to handle the mathematics involved when adding the parallel resistors.

Question 2a.

Marks	0	1	2	Average
%	22	6	71	**1.5**

The potential difference across D1 was 2 V, therefore the potential difference across the resistor was 10 V. Using Ohm's law, the current through the resistor was 100 mA.

Some students did not subtract the diode voltage to get the voltage across the resistor. Many students forgot or were unable to convert the calculated answer of 0.1 A to 100 mA.

Question 2b.

Marks	0	1	2	Average
%	32	13	55	**1.3**

The potential difference across the branch containing R_2 was 8 V. Since the diode D2 required a voltage of 3 V, the voltage across R_2 was 5 V.

Many students thought that each of the parallel branches would share the battery voltage, that is, 4 V each. It was also common for students to subtract the voltages of both D1 and D2: 8 – 3 – 2 = 3 V. Others attempted to apply the voltage divider formula.

Question 2c.

Marks	0	1	2	Average
%	60	6	33	**0.7**

Using Ohm's law for R_2, the current through it was 33 mA. Similarly, the current through $R_1$was 60 mA. Adding these together gave a total current of 93 mA.

A large number of students attempted to determine the resistance of the parallel combination by using $1/R_{TOTAL} = 1/100 + 1/150$. These students neglected the diodes entirely.

Question 2d.

Marks	0	1	2	3	4	Average
%	61	1	4	1	33	**1.4**

The power supplied to D1 was $P = V \times I = 2 \times 0.1 = 0.2$ W = 200 mW. Since the light output of D1 was 150 mW, the fraction converted was 0.75. For D2, the power supplied was 300 mW and the light output was 200 mW. So the fraction converted was 0.66 and, therefore, D1 was the more efficient diode

The most common error was for students to use the input current with the output power to determine non-existent output voltage; for example, for D1 $V_{OUT} = P_{OUT}/I_{IN} = 0.150/0.100 = 1.5$ V. Another common error involved using the output power and the activation voltage of the diode to incorrectly calculate the current; for example, $I = 0.150/2 = 0.075$ A.

Question 3a.

Marks	0	1	2	3	Average
%	24	8	2	66	2.1

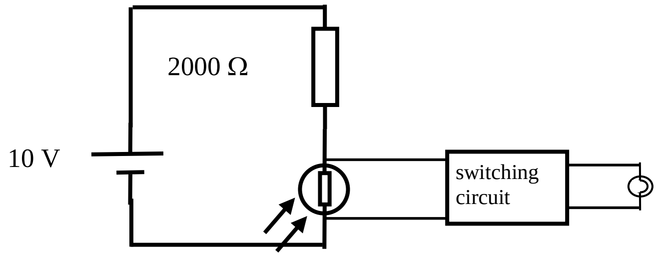
Since the current in the circuit was 2.5 mA, Ohm's law could be used to determine that the total resistance in the circuit was 4000 Ω. The resistor was 3000 Ω, therefore the resistance of the LDR was 1000 Ω. Thus, based on the graph, the light intensity was 10 lux.

A common mistake was to correctly determine that the total circuit resistance was 4000 Ω but then take this as the resistance of the LDR, leading to an answer of 1 or 2 lux.

Question 3b.

Marks	0	1	2	3	4	Average
%	18	21	21	7	33	2.2

The required circuit was



Common errors included placing the switching circuit in series with the battery, resistor and LDR. This was unusual given the relatively standard circuit design required in this type of circuit. Another common error was connecting the switching circuit in parallel with the resistor.

Question 4a.

Marks	0	1	Average
%	33	67	0.7

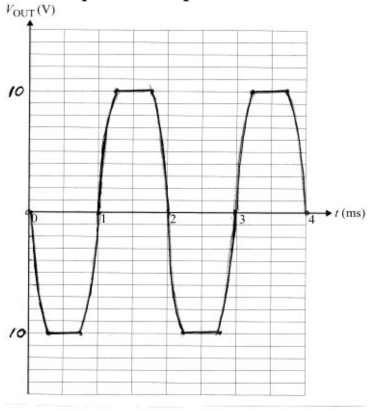
The voltage gain was the magnitude of the gradient, which was 250. Negative 250 was also acceptable.

Some students either did not read the scale on the horizontal axis properly or simply neglected to convert their reading from millivolts to volts. Others attempted to get the gradient by using run/rise.

Question 4b.

Marks	0	1	2	3	Average
%	9	9	11	71	2.5

The required output was:



This question was well done, but some students forgot to invert and others did not show clipping or the appropriate scale. Students should be encouraged to give the non-clipped sections a sinusoidal shape rather than just drawing straight lines.

Question 5

Marks	0	1	2	3	Average
%	25	21	22	32	1.6

The function of the modulation device is to use the input signal to vary the intensity (or brightness) of the light beam. The light beam transfers the information from the modulator to the demodulator. The demodulation device produces an electrical output signal with an amplitude that depends on the change in intensity (or brightness) of the light beam. There was a variety of acceptable ways to express these points.

The level of detail provided in many answers was inadequate. To simply state that the modulator turned electrical energy into light energy was insufficient. Likewise, stating that the function of the modulation device was to modulate the light beam really does not explain anything.

Section B – Detailed studies

Detailed study 1 – Einstein's special relativity

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
1	25	2	1	72	0	Option D was incorrect because the speed of light depends on the refractive index of the medium through which it is travelling. The refractive index depends on the electrical properties of the medium. Therefore, option A was correct.
2	6	21	4	68	0	
3	10	4	70	14	2	
4	13	73	5	9	0	
5	4	3	90	2	1	
6	21	15	7	56	1	Total energy = rest mass energy + kinetic energy $= m_oc^2 + 9.00 \times 10^{-11}$ $= (1.67 \times 10^{-27})(9.0 \times 10^{16}) + 9.00 \times 10^{-11}$ $= 2.4 \times 10^{-10}$ (option D)
7	7	23	64	6	1	A large number of students chose option B (2.0). As the Lorentz factor has both a square and a square root, these students may have thought they would negate one another.
8	46	21	21	11	1	Since $t = \gamma t_o$, therefore $t_o = t/\gamma$ where t_o is the proper time and γ is always greater than 1. Thus t_o is always less than t.
9	6	3	13	77	1	
10	15	18	49	16	2	Spaceship B was moving at a speed of $0.866 \times (3.0 \times 10^8)$ m s^{-1} relative to the stationary spaceship A. The contracted length that spaceship B had to travel was 10 m. Therefore, the time taken was $10/[0.866 \times (3.0 \times 10^8)] = 3.85 \times 10^{-8}$ s.
11	70	5	13	10	1	
12	8	63	12	14	3	

Detailed study 2 – Materials and their use in structures

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
1	6	66	5	23	0	Most students realised that the pole was in compression. However, the pole supported only the vertical components of the force in the ropes. The horizontal components were cancelled by the other ropes.
2	91	4	3	2	0	
3	6	5	82	7	1	
4	12	2	1	84	0	
5	86	2	3	9	0	
6	85	4	1	10	0	
7	6	18	64	10	2	The energy per cubic metre was obtained from the area under the graph. This was then multiplied by the volume of the sample to give the total energy.
8	7	16	24	51	1	Taking torques about the securing bolt. F at support × 20 = 12 000 × 10 × 30, so F = 180 000 N.
9	12	58	18	11	1	Taking torques about the support. Bolt force × 20 = 12 000 × 10 × 10, so Bolt force = 60 000 N. Alternatively, the net vertical force = zero. $F_{support}$ – weight – F_{bolt} = 0. 180 000 – 120 000 – F_{bolt} = 0. So F_{bolt} = 60 000 N. The support force was the answer to Question 8. However, students should be aware that consequential marks are not awarded for multiple-choice questions.
10	2	89	4	5	1	
11	3	6	89	2	1	
12	4	3	88	4	1	

Detailed study 3 – Further electronics

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
1	6	82	9	2	0	
2	86	5	3	5	0	
3	3	17	64	16	0	
4	41	30	21	8	1	The power that had to be dissipated from each diode was VI = 0.7 × 140 × 10^{-3} = 0.1 W, so the required area was 0.1/100 = 0.001 m^2.
5	18	14	53	14	1	Current always passes through two diodes. So the voltage out of the rectifier = 15.2 – (2 × 0.7) = 13.8 V.
6	16	13	62	8	1	

Question	% A	% B	% C	% D	% No Answer	Comments
7	17	58	18	6	1	The time constant was now 10 ms, which was half of what it was before. Therefore, the total resistance must have been halved. This means R = 100 Ω.
8	18	17	54	10	1	The original frequency was 50 Hz, so with the bridge rectifier, A, B and C are possibilities. Since the time constant was 10 ms, option C was correct.
9	9	5	64	20	1	The Zener diode must be reversed biased (options C and D). The resistor must be in series to take up the excess voltage. Option D had the resistor in parallel, which would result in the output being the same as the battery.
10	11	12	15	61	2	
11	58	8	12	20	1	The display indicated only half-wave rectification. So the problem was with the rectifier. One of the diodes was not operating.
12	11	28	19	40	2	The reduced load resistor would result in a higher current. Therefore, there would be a greater voltage drop across resistor A and a reduced voltage output.