2015 VCE Physics examination report

General comments

Students and teachers should note the following points in relation to the 2015 Physics examination.

- The answer space given and the number of marks allocated to a question should be used as a guide to the amount of detail required in an answer.
- Attempting a question a number of different ways will not be awarded any marks unless all methods are correct. Students are advised to neatly cross out any working that they do not want assessed.
- Students should be encouraged to set out their work clearly so assessors can follow what they have done. In questions that involve a number of steps, it is helpful if the student explains all their working.
- In questions that require explanations, students should carefully consider what the question is asking and answer accordingly. They should not simply copy information from their sheet(s) of notes, as this can result in the inclusion of irrelevant, contradictory or incorrect material.
- When responding to questions that required an explanation, many students answered in dot-point format. This may help to ensure good, concise answers. There is no need to restate the question in an answer.
- The use of equations or diagrams in questions that require an explanation can sometimes assist. It is important that diagrams are sufficiently large and clearly labelled. Graphs and sketches should be drawn with care.
- 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'. Students will not be awarded full marks if they change the unit.
- It is important that students show the numbers substituted into formulas/equations. The formula alone is generally not worth any marks.
- It is expected that formulas be copied accurately from the formula sheet provided with the examination or from the student's sheet(s) of notes.
- Derived formulas from the student's sheet(s) 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 examination. Calculations involving powers of ten sometimes caused difficulties for students. Students must ensure that the calculator is in scientific mode and that it does not truncate answers after one or two decimal places.
- The rounding-off of calculations should be done only at the end, not progressively after each step.
- Answers should be simplified to decimal form – that is, no surds and no extraneous decimals.
- Where values of constants are provided in the stem of the question or on the formula sheet, students are expected to use the number of significant figures given.
- Care needs to be taken when reading the scales on the axes of graphs.
- Arrows representing vector quantities should be drawn so that they originate from the point of application. Where appropriate, the length of the arrows should indicate the relative magnitudes.
- Students should ensure that their answers are realistic. Illogical answers should prompt students to check their working.

Areas requiring improvement included:

- the vector nature of momentum
- centripetal force
- energy conversion and conservation in springs
- complex projectile motion
- apparent weightlessness
- explaining direction of induced current using Lenz's law
- operation of transformers and how they work in a power transmission system
- understanding of series and parallel circuits
- explaining aspects of the photoelectric effect
- applying the concept of path difference in interference patterns
- explaining electron and X-ray diffraction patterns
- electron energy level diagrams and associated emissions and absorptions
- how the wave nature of matter can explain the electron energy levels.

Specific information

Note: Student responses reproduced in this report have not been corrected for grammar, spelling or factual information.
This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

The statistics in this report may be subject to rounding resulting in a total more or less than 100 per cent.

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

Question 1a.

Marks	0	1	2	Average
%	57	1	42	0.9

Using conservation of momentum:

$$M_A v_i = M_A v_f + M_B v_f$$
$$4 \times 8 = 4 \times (-2) + 8 \times v_f$$

Some students were able to calculate the correct answer of 5.0 m s^{-1}.

The most common error was to omit the negative sign for the final velocity of block A. Students should ensure that they understand the vector nature of momentum.

Question 1b.

Marks	0	1	2	Average
%	24	21	55	1.3

An analysis of the kinetic energies before and after the collision yields:

$$E_{K_i} = \frac{1}{2} \times 4 \times 8^2 = 128 \text{ J}$$

$$E_{K_f} = \frac{1}{2} \times 4 \times 2^2 + \frac{1}{2} \times 8 \times 5^2 = 108 \text{ J}$$

This indicates that the collision was inelastic.

The most common error was to subtract one block's energy from the other block's energy in the final line. Students should ensure they understand that kinetic energy is not a vector.

Question 1c.

Marks	0	1	2	3	Average
%	11	24	32	33	1.9

Impulse is the change in momentum.

$$I = M_A(v_f - v_i)$$

$$I = 4 \times (8 - (-2)) = 40 \text{ kgm s}^{-1} \text{(or Ns)}$$

The positive result indicated that the direction was to the left.

Common errors involved not recognising the vector nature of the two momenta, and giving directions that were unclear, such as drawing compass bearings without indicating how they related to the diagram.

Question 2a.

Marks	0	1	2	Average
%	48	0	52	1.1

The gravitational force on M_2 accelerates the entire system.

$$M_2 g = (M_1 + M_2)a$$

$$1 \times 10 = (4 + 1)a$$

$$\Rightarrow a = 2.0 \text{ m s}^{-1}$$

Common errors involved mixing up the masses or simple arithmetic errors. Students are advised to become familiar with an Atwood machine.

Question 2b.

Marks	0	1	2	Average
%	46	0	54	1.1

By considering either mass as a free body and using the acceleration calculated in Question 2a., the magnitude of the tension was 8.0 N.

$$T = M_1 a$$
$$T = 4 \times 2 = 8 \text{ N}$$

or

$$M_2 g - T = M_2 a$$
$$1 \times 10 - T = 1 \times 2$$
$$\Rightarrow T = 8.0 \text{ N}$$

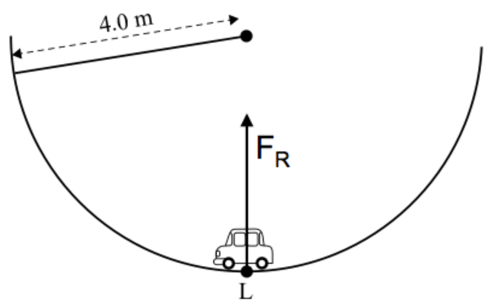
The most common errors were arithmetic.

A common alternative approach used the formula:

$$T = \frac{M_1 M_2 g}{M_1 + M_2}$$

Question 3a.

Marks	0	1	Average
%	25	75	0.8



Students were required to draw a single upwards arrow that passed through the car. Most students answered this question correctly; however, some drew an arrow pointing down.

Question 3b.

Marks	0	1	2	Average
%	51	2	47	1

The sum of the forces at the lowest point is given by:

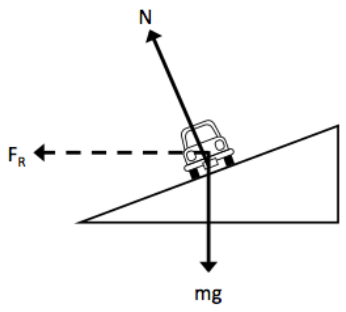
$$F = \frac{mv^2}{r} + mg$$
$$F = \frac{2 \times 6^2}{4} + 2 \times 10$$
$$F = 38 \text{ N}$$

The most common error was to assume that centripetal force was the only force present and not include the normal reaction force. Students are advised to review forces in vertical circular motion.

Question 4a.

Marks	0	1	2	3	Average
%	9	11	24	57	2.3

Three forces needed to be shown:



Students made a range of errors, including:

- drawing F_R down the slope
- labelling N as F_R
- including friction up the slope
- adding vector components of one or more forces.

Students are advised to review the differences between forces in banked corners and forces on an inclined plane.

Question 4b.

Marks	0	1	2	3	Average
%	31	3	3	64	2

The angle is given by the formula:

$$\theta = \tan^{-1}\left(\frac{F_c}{mg}\right)$$
$$\theta = \tan^{-1}\left(\frac{6}{20}\right) = 16.7°$$

or

$$\theta = \tan^{-1}\left(\frac{v^2}{rg}\right)$$
$$\theta = \tan^{-1}\left(\frac{9}{30}\right) = 16.7°$$

The most common incorrect approach was to find the force down the slope. Other students used 2.0 m s^{-1} from part a. It is imperative that students read the questions carefully, so they do not miss important pieces of information. Underlining or highlighting key terms in the question may assist students in doing so.

Question 5a.

Marks	0	1	2	Average
%	17	7	76	1.6

Most students were able to find the vertical component of the launch velocity:

$$u_v = 40\sin 30 = 20 \text{ m s}^{-1}$$

The most common error was not to proceed with the rest of the calculation and to assume that this was the height. The correct answer required students to use the following velocity to calculate height:

$v^2 = u^2 + 2ax$

$0 = 20^2 + 2 \times (-10) \times x$

$x = 20 \text{ m}$

Question 5b.

Marks	0	1	2	3	Average
%	42	13	4	41	1.5

Many students found this two-step calculation difficult. Step one was to calculate the total time of flight:

$$t = \frac{x}{v} = \frac{173}{40\cos 30} = 5.0 \sec$$

Step two was to use this time to calculate the final displacement:

$$x_v = u_v t + \frac{1}{2}at^2$$

$$x = (20 \times 5) + (0.5 \times -10 \times 25)$$

$$x = -25 \text{ m}$$

Many students attempted long and complicated processes that involved breaking the flight up into three separate phases, but this was unnecessary. Students are advised to practise these two-step problems.

Question 6a.

Marks	0	1	Average
%	13	87	0.9

$$\Delta E = mg\Delta h$$

$$\Delta E = 16 \text{ J}$$

Most students scored full marks for this question. Some students were not able to identify the process for calculating change in gravitational potential energy.

Question 6b.

Marks	0	1	2	Average
%	17	2	81	1.7

This question required students to apply Hooke’s law:

$$SPE = \frac{1}{2}kx^2$$

$$SPE = 0.5 \times 50 \times 0.8^2$$

$$SPE = 16 \text{ J}$$

A small number of students identified that the energy lost in Question 6a. was the energy gained in this question and this was also a correct approach. The most common incorrect answer involved not converting centimetres to metres. Students are advised to become familiar with the units used in their formulas.

Question 6c.

Marks	0	1	2	3	Average
%	58	6	1	36	1.2

This question was very difficult for most students. The highest-scoring responses identified the total energy as the sum of three energy types:

$$E_T = (mgx) + (\frac{1}{2}kx^2) + (\frac{1}{2}mv^2)$$
$$16 = \quad 8 \quad + \quad 4 \quad + \quad E_K$$
$$\Rightarrow E_K = 4 \text{ J}$$

From this point, the velocity could be calculated from the kinetic energy:

$$E_K = \frac{1}{2}mv^2$$
$$4 = 0.5 \times 2 \times v^2$$
$$v = 2 \text{ m s}^{-1}$$

The most common errors were to assume that all the spring potential energy or all the gravitational potential energy had been converted to kinetic energy.

Students are advised to familiarise themselves with systems involving multiple energy types.

Question 6d.

Marks	0	1	2	Average
%	59	15	25	0.7

The correct graph was graph C.

While most students were able to recognise the correct graph, many could not adequately explain the change in acceleration in terms of the two forces (gravitational and spring), where one stays constant while the other varies.

Question 7a.

Marks	0	1	Average
%	14	86	0.9

10 hours 15 minutes equates to 36 900 seconds

The most common error was to use 24 hours (Earth).

Question 7b.

Marks	0	1	2	3	Average
%	24	10	12	55	2

Most students were able to demonstrate the combination of uniform circular motion and gravitation:

$$\frac{GMm}{r^2} = \frac{4\pi^2 rm}{T^2}$$
$$\therefore r = \sqrt[3]{\frac{GMT^2}{4\pi^2}}$$

The substitution proved more difficult:

$$r = \sqrt[3]{\frac{6.67\times10^{-11}\times5.8\times10^{26}\times36\ 900^2}{4\pi^2}}$$

The final radius was calculated as 1.1×10^8 m.

The most common errors were to use the wrong central mass (either the mass of Earth or the mass of the spacecraft) or to make mathematical errors involving powers and roots.

Question 7c.

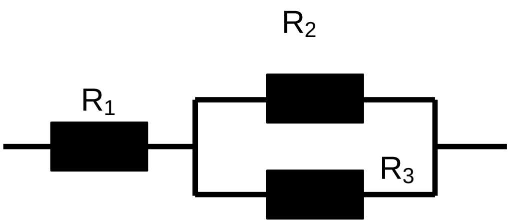
Marks	0	1	2	3	Average
%	19	17	22	41	1.9

Students struggled to adequately explain apparent weightlessness as the result of the presence of a gravitational force or field, but the absence of a normal or reaction force. The most common error was to state that the astronauts would not feel weightless, then correctly explain apparent weightlessness. This implied that a number of students thought that apparent weightlessness would feel different to true weightlessness. Students are advised to be more thorough in understandings and explanations of the sensation of weightlessness.

Area of study – Electronics and photonics

Question 8a.

Marks	0	1	2	Average
%	10	4	85	1.8



Most students were able to draw the network shown above. Placing the series resistor after the parallel resistors was also correct.

There was a wide range of incorrect answers, and many students tried to create circuits that often resulted in short circuits.

Question 8b.

Marks	0	1	2	3	Average
%	27	17	2	54	1.8

	Voltage drop (V)
R_1	6 V
R_2	3 V
R_3	3 V
R_4	

The most common errors made by students were to assume that each resistor dropped 3 V or that each of the parallel resistors dropped 1.5 V. Students are advised to become familiar with simple series and parallel circuits.

Question 9a.

Marks	0	1	2	Average
%	26	29	45	1.2

The correct response was to identify the LED and describe the action as 'converting electrical signal to light.' The most common errors involved being unable to identify the correct component or, more commonly, being unable to explain the action in terms of the energy change.

Question 9b.

Marks	0	1	2	Average
%	17	32	51	1.4

The correct response was to identify the photodiode; however, the LDR was also accepted. The description of the action was to 'convert light to electrical signals.'

Question 10a.

Marks	0	1	Average
%	2	98	1

Reading from the graph, the correct answer was 15 kΩ.

Question 10b.

Marks	0	1	2	3	Average
%	21	8	4	67	2.2

To solve this, students needed to apply the voltage divider formula:

$$\frac{V_{out}}{V_{in}} = \frac{R_2}{R_1 + R_2}$$

$$\frac{10}{60} = \frac{15}{R + 15}$$

$$\Rightarrow R = 75 \text{ k}\Omega$$

The most common error with this approach was to confuse R_1 and R_2.

A number of students used a simpler ratio of voltages to resistances. This approach was equally valid.

Students are advised to ensure they know which resistor is R_1 and which is R_2 when they apply the voltage divider equation.

Question 11a.

Marks	0	1	2	Average
%	26	1	73	1.5

The gain is given by:

$$A = \frac{V_{out}}{V_{in}} = \frac{5}{100 \times 10^{-3}}$$

$$A = 50$$

The most common error was not to convert mV to V.

Question 11b.

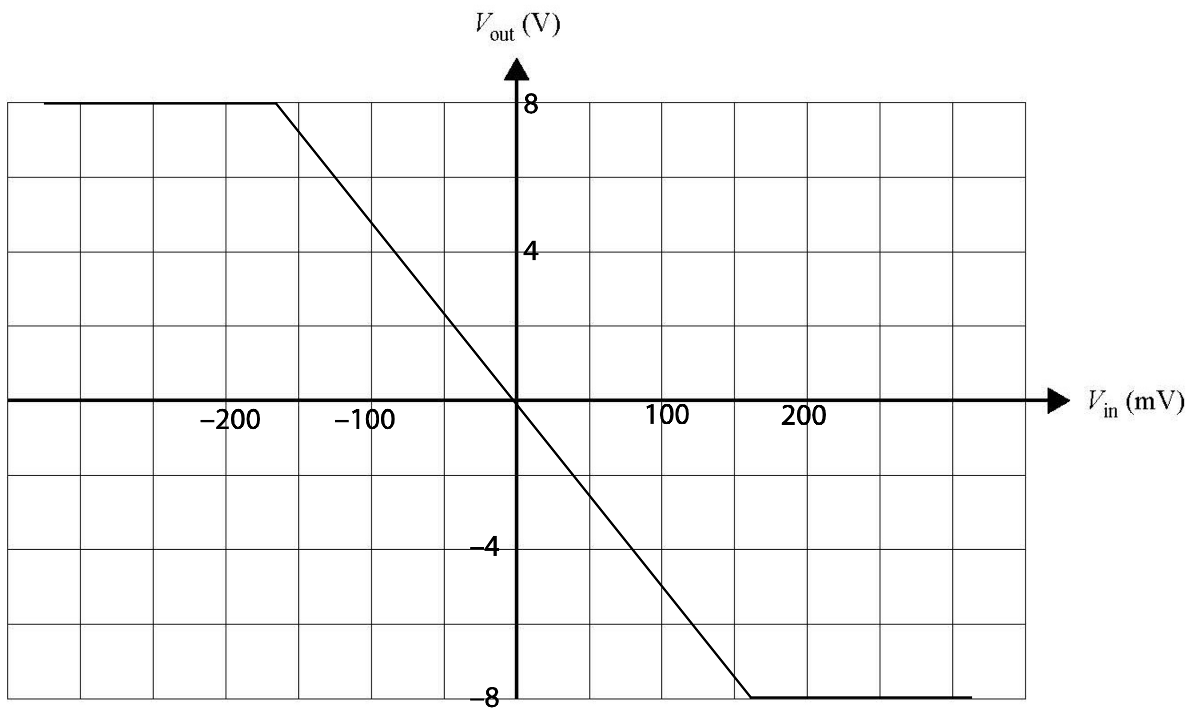
Marks	0	1	2	3	Average
%	13	28	49	10	1.6

Students were required to identify that the amplifier was inverting and that it demonstrates clipping, and provide some explanation as to the cause of the clipping, such as the amplifier is operating outside its linear region or V_{out} has exceeded the maximum output voltage. Most students were able to discuss clipping but did not identify the inverting nature of the amplifier.

Students are advised to review the performance of amplifiers. They should also avoid terms such as 'saturation' and 'cutoff' as these apply to simple transistor amplifiers and may not apply to the amplifier in the question, which could be more complex.

Question 11c.

Marks	0	1	2	3	Average
%	15	13	25	47	2.1



Around half of the students were able to draw the correct characteristic curve.

A number of students did not label their axes, which made it impossible to identify the gain or the onset of clipping. Students must ensure that they label the axes of any graphs they produce.

Area of study – Electric power

Question 12a.

Marks	0	1	2	3	Average
%	13	15	19	53	2.2

The force was found using:

$$F = nBIl$$

$$F = 10 \times (2 \times 10^{-3}) \times 4.0 \times 0.04$$

$$F = 3.2 \times 10^{-3} \text{ N}$$

The direction was given by the right-hand slap rule (or equivalent), which was **up**.

The most common errors were omitting the *n* = 10 value or failing to convert centimetres to metres. Correct use of formulas and the ability to convert between units are considered core skills for Physics students, and they are advised to be familiar with these skills.

Question 12b.

Marks	0	1	Average
%	20	80	0.8

The correct answer was B.

Question 12c.

Marks	0	1	2	3	Average
%	40	20	7	33	1.3

Calculation of EMF is done using Faraday's law:

$$EMF = \frac{n \times B \times A}{t}$$

$$EMF = \frac{10 \times (2 \times 10^{-3}) \times (0.04)^2}{0.125}$$

$$EMF = 0.26 \text{ mV}$$

The most common errors were the omission of the *n* = 10 value and the failure to convert centimetres to metres. Some students also struggled with the calculation of the value for *t*.

Question 12d.

Marks	0	1	2	3	Average
%	25	32	27	16	1.4

Students were required to identify the need to replace the split-ring commutator with slip rings, that the slip rings would maintain a constant connection throughout the rotation and that the rotating loop would have an AC current generated in it as it rotated.

Very few students gained high marks for this question because they relied on stock phrases from their A3 sheet of notes, which did not contain the specific information required. Students are advised that the stock phrases and definitions on their A3 sheet of notes are unlikely to be sufficient in the examination. Students must practise responding to the question asked.

Questions 13a. and 13b.

13a.

Marks	0	1	2	Average
%	79	10	11	0.4

13b.

Marks	0	1	2	Average
%	64	3	34	0.7

Figure 14c

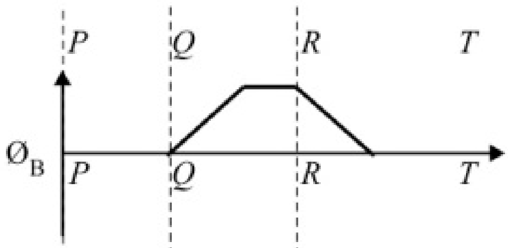
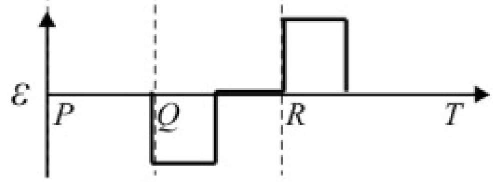


Figure 14d



These questions proved very difficult for most students. The majority of responses were illogical and showed that students struggled with induction in a loop. Students are advised to further improve their skills in this important area.

Question 13c.

Marks	0	1	2	3	4	Average
%	22	25	22	16	15	1.8

Students were required to identify the initial change in flux, which was **down and increasing**. Students were then required to identify the appropriate physical law, which was Lenz's law, and identify the nature of the induced flux, which was **up and increasing**. Students were then required to link this to the induced current using, for example, the right-hand grip rule. Finally, they needed to state in which direction the current would flow **through the voltmeter**, which was *X* to *Y*.

While most students were able to identify some of these points, many were not able to produce a sufficient explanation. Students are advised to practise writing detailed responses to questions where there are a number of steps in explaining a situation fully.

Question 14a.

Marks	0	1	2	Average
%	33	2	64	1.3

Frequency is the reciprocal of the period, so:

$$f = \frac{1}{40 \times 10^{-3}}$$

$$f = 25 \text{ Hz}$$

The most common error was to fail to convert the time to seconds.

Question 14b.

Marks	0	1	2	Average
%	16	48	36	1.2

Since the transformer had a turn ratio of 45:1, the peak input voltage is given by:

$$V_P = 45 \times 300 = 13\,500 \text{ V}$$

This was then converted to RMS:

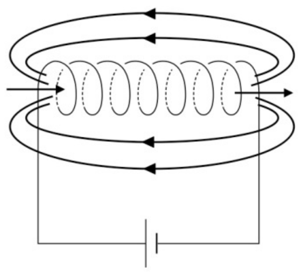
$$V_{RMS} = \frac{V_P}{\sqrt{2}}$$

$$V_{RMS} = \frac{13\,500}{\sqrt{2}} = 9550 \text{ V}$$

The most common error was to find the RMS voltage of the waveform shown.

Question 15

Marks	0	1	2	Average
%	21	34	45	1.3



The most common errors were to fail to adequately show the shape of the field or to draw lines that touched or crossed.

Many students drew their diagrams in faint pencil, which made them very hard to see. Students are reminded that the examination instructions state, ‘Write using black or blue pen’.

Question 16a.

Marks	0	1	2	Average
%	25	0	75	1.5

The current in the globe was the same as the current in the wires.

$$I = \frac{P}{V} = \frac{4.0}{2.0} = 2.0 \text{ A}$$

Question 16b.

Marks	0	1	2	Average
%	36	21	44	1.1

This question relied on the current from Question 16a. The voltage drop in the lines is given by:

$$V_{drop} = RI$$

$$V_{drop} = 4.0 \times 2.0 = 8 \text{ V}$$

When the 2 V for the globe is added, the supply voltage is found to be 10 V.

The most common error was to substitute 2 Ω for the line resistance, rather than 4 Ω.

Question 16c.

Marks	0	1	2	3	Average
%	24	13	1	62	2

The power lost in a resistive load is given by:

$$P_{loss} = I^2 R$$

$$P_{loss} = 2.0^2 \times 4$$

$$P_{loss} = 16 \text{ W}$$

The most common error was to use 2 Ω for the resistance.

Question 16d.

Marks	0	1	2	3	Average
%	43	4	0	53	1.7

This was a two-step problem, with the first step being to evaluate the current in the globe side of the transformer which was 2.0 A.

Using the 10:1 ratio the current in the transmission lines is 0.2 A.

Many students were able to calculate the globe current (or carry it across from Question 16a.) but either made no attempt to calculate a line current or gave a line current of 20 A.

Students are advised to thoroughly revise transformers.

Question 16e.

Marks	0	1	2	Average
%	30	12	57	1.3

The power loss is given by I^2R, which in this case is 0.16 W, given that the current is now 0.2 A.

A common error was to use the incorrect current from Question 16d. in the correct formula, which gave 1.6 kW. This answer is inconsistent with transformer theory, and students should have realised that the answer was illogical.

Question 16f.

Marks	0	1	2	3	4	Average
%	25	15	16	30	16	2

Students were required to give a real-world example; the most obvious of which was real electricity distribution. They were then required to explain that transformers allow the same power to be delivered using higher transmission voltages and lower transmission currents. Finally, students were required to articulate that lower currents lead to lower power loss in accordance with $P_{loss} = I^2R$.

Very few students were able to provide coherent answers. Many students omitted the point that the total power transmitted must remain constant. Students must practise answering questions such as this.

Area of study – Interactions of light and matter

Question 17a.

Marks	0	1	2	3	Average
%	21	14	27	38	1.8

Students were required to, firstly, identify the band as bright. The reason for the brightness is constructive interference. Students had a number of ways of explaining why the interference was constructive at this point. The simplest was to state that the path difference was zero.

Some students stated ‘constructive interference’ but then went on to talk about the general process for constructive interference involving whole multiples of the wavelength. This was incorrect in this setting.

Student responses indicated that understanding of the concept of path difference is an area that requires attention. Many students wrote answers such as, ‘both beams have the same path difference’, but this was illogical. Students are advised to revise Young’s double-slit experiment.

Question 17b.

Marks	0	1	Average
%	27	73	0.8

The correct answer is C.

Question 18a.

Marks	0	1	Average
%	12	88	0.9

From the graph, the frequency is 5×10^{14} Hz.

Question 18b.

Marks	0	1	2	Average
%	38	4	59	1.2

Planck's constant can be calculated from the gradient of the graph:

$$h = \frac{rise}{run} = \frac{2-0}{(10-5)\times10^{14}}$$

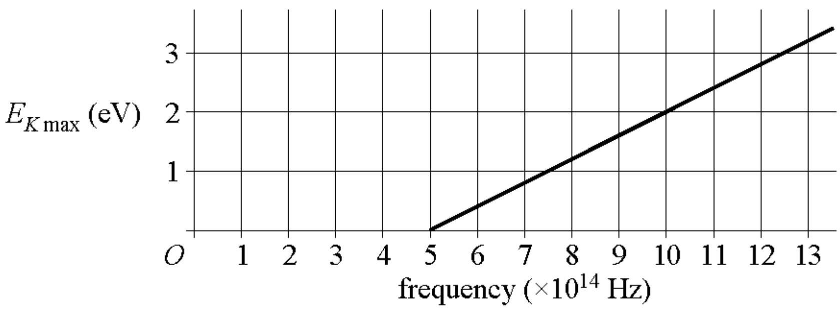
$$h = 4\times10^{-15}$$

Any reasonable values could have been used and all were acceptable.

The most common error was to attempt to use $E = hf$, which was inappropriate. Students who made no attempt to calculate a gradient and simply stated Planck's constant from the supplied formula sheet were not awarded any marks as the question clearly required them to calculate it from the data.

Question 18c.

Marks	0	1	Average
%	45	55	0.6

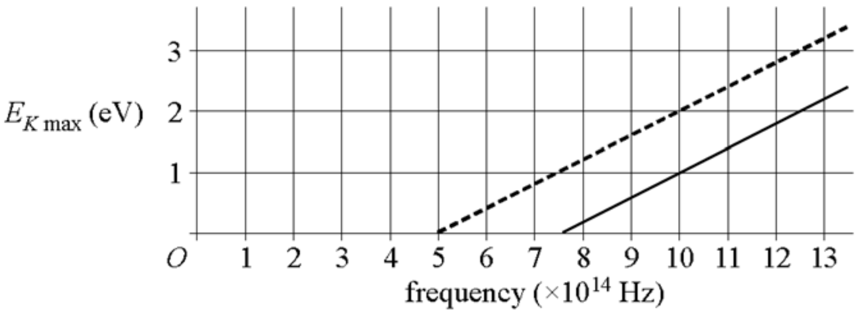


The correct line was drawn on top of the existing dotted line.

There was a range of incorrect responses, including the incorrect gradient and the incorrect location. Students are advised to review the findings of the photoelectric effect experiment.

Question 18d.

Marks	0	1	Average
%	45	55	1



The most common errors were to draw the incorrect gradient or to locate the *x*-axis intercept at 10.

Question 19a.

Marks	0	1	2	3	4	Average
%	29	3	8	5	56	2.6

Applying $E = hf$ to all the frequencies gives energies of 109 eV, 92 eV and 17 eV. Analysis of the energy levels shows that n = 2 has an energy of 92 eV, while n = *3* has an energy of 109 eV.

The 17 eV emission comes from a transition from n = 3 to n = 2.

Question 19b.

Marks	0	1	2	Average
%	33	10	57	1.3

Applying $E = hf$ yields an energy of 30 eV, which indicates a transition from n = 3 to n = 2.

Question 20a.

Marks	0	1	2	Average
%	28	22	50	1.2

Students were expected to identify the photoelectric effect as the evidence for the particle nature. They were then required to expand on this by referring to a specific finding within the PE experiment, such as the existence of a threshold frequency or the lack of time delay for the emission of photoelectrons.

A few students referred to reflection as evidence and this was accepted as long as the reasoning was correct.

A significant number of students had difficulty with this question. Students are advised to be thoroughly familiar with wave/particle duality.

Question 20b.

Marks	0	1	2	Average
%	69	8	23	0.6

Students were expected to identify electron diffraction as the evidence. They were then required to expand on the idea that diffraction is a wave phenomenon.

Many students referred to Young's double-slit experiment. However, it should be understood that Young did not experiment with electrons, so this approach was not appropriate. Students who identified that the same result would have occurred had the experiment been done with sufficiently high energy electrons were awarded marks, but few students explained this well.

Question 21a.

Marks	0	1	2	3	Average
%	51	10	17	23	1.1

Students were required to identify the wave nature of electrons. They were then required to explain the standing wave theory, where $n\lambda = 2\pi r$. Finally, they were required to identify that the different allowed orbits had different whole values of *n*.

While most students knew that 'standing waves' was a key term, they could not apply it in a coherent way. Of further concern was the number of students who seemed to believe that the electrons wobble or follow a sinusoidal path around the nucleus. It should be understood that the Bohr model of the atom is a simplistic model and the electrons do not orbit at all. Even if they did, they would not follow a sinusoidal path. Students should familiarise themselves with de Broglie's work.

Question 21b.

Marks	0	1	2	Average
%	55	5	40	0.9

The following is an example of a high-scoring response.

Students who tried to draw a strip of paper joined end to end with a sinusoidal wave pattern on it generally had difficulty identifying the standing wave nature of the wave function in the orbit.

Question 22

Marks	0	1	2	Average
%	34	9	57	1.3

Applying the de Broglie wavelength formula:

$$\lambda = \frac{h}{mv}$$

$$v = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.0 \times 10^{-11}}$$

$$v = 7.3 \times 10^{7}\ \text{m s}^{-1}$$

The most common error was to use the wrong Planck's constant. This gave an answer of $4.5 \times 10^{26}\,\mathrm{m\,s^{-1}}$, which is illogical.

Section B

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

Detailed study 1 – Einstein's special relativity

Question	% A	% B	% C	% D	% No Answer	Comments
1	6	16	74	4	0	
2	19	32	5	44	0	Option C was incorrect as light propagates through space. Options A and D implied that the speed of light is different for different observers. One of Einstein's postulates is that the speed of light is the same for all observers.
3	3	8	51	38	1	
4	71	15	9	4	0	
5	15	17	16	52	1	
6	15	12	12	61	0	
7	17	3	6	74	1	
8	82	3	8	7	1	
9	10	10	74	6	1	
10	17	43	17	22	1	Option A was incorrect as in its own frame, the mass will be unchanged. Option C did not take into account the relativistic increase in the mass of the particle. Option D suggested that the rest mass can increase, but this is not correct.
11	25	59	7	8	1	

Detailed study 2 – Materials and their use in structures

Question	% A	% B	% C	% D	% No Answer
1	96	3	1	0	0
2	59	28	2	11	0
3	5	6	75	14	0
4	6	61	1	32	0
5	8	50	30	11	1
6	3	6	9	82	0
7	7	74	6	12	0
8	13	6	67	13	0
9	1	2	22	74	0
10	11	12	67	9	1
11	5	13	26	56	1

Detailed study 3 – Further electronics

Question	% A	% B	% C	% D	% No Answer	Comments
1	7	7	49	36	1	240 V_{RMS} = 340 V_P. The turn ratio is 20:1, so the CRO voltage would read 340/20 = 17 V. A large number of students selected option C, suggesting that they forgot to convert from RMP to peak voltage before dividing by 20.
2	4	6	87	3	0	
3	55	18	9	18	0	
4	8	3	78	11	0	
5	11	76	7	7	0	
6	22	19	19	40	0	The period of the AC signal is 20 ms, while the time constant (RC) of the circuit is 10 ms. In two time constants the signal is expected to drop to about 14% of the peak. 14% × 13.4 = 1.9 V, indicating that option D was correct.
7	12	61	5	22	0	
8	35	11	53	2	0	
9	60	13	12	15	0	
10	8	55	15	23	0	
11	12	20	38	30	0	If the Zener diode fails, the voltage across the load resistor will reach the full peak of $10\times\sqrt{2}=14.14$ minus the diode voltage drops (about 1.4 V), giving just over 12 V. A significant proportion of students selected option D, suggesting that they forgot to convert from RMS to peak voltage.

Detailed study 4 – Synchrotron and its applications

Question	% A	% B	% C	% D	% No Answer	Comments
1	3	78	6	13	0	
2	81	7	8	4	0	
3	5	83	2	10	0	
4	50	10	16	25	0	
5	4	7	6	83	0	
6	3	8	78	11	1	
7	5	80	9	5	0	
8	6	74	12	7	0	
9	19	48	18	15	0	Peaks will only exist where $\frac{n\lambda}{2d}<1$. Since at n = 4 this equates to exactly 1, there will only be one more peak (option B).
10	19	16	55	9	0	
11	30	13	52	4	0	

Detailed study 5 – Photonics

Question	% A	% B	% C	% D	% No Answer	Comments
1	21	13	21	46	0	Students should remember that while lasers are monochromatic and coherent, LEDs are not.
2	10	10	38	42	0	Students should draw on their knowledge of electron behaviour from the interactions of light and matter section of the study to recall that light is only emitted from electrons that transition from a higher energy band to a lower one, and that this process is spontaneous.
3	4	21	71	4	0	
4	38	21	35	6	0	Options B, C and D were implausible, suggesting that students need to review causes of attenuation.
5	10	56	8	23	2	
6	33	35	23	8	0	To gather as much light as possible, the fibre will need a large cross-sectional area and a high acceptance angle.
7	25	60	6	8	0	
8	52	29	10	8	0	
9	23	23	44	10	0	The purpose of the graded-index fibre is to have the light take a more sinusoidal path through the fibre by decreasing the refractive index as the radius increases. This causes the light to travel faster when it is further from the centre of the fibre.
10	38	13	42	8	0	High data transmission rates are achieved using single mode fibres. The question stated 'a single wavelength', so option A did not apply.
11	38	6	15	42	0	The question stem stated that 'no light is lost from the sides', so there can be no increase in intensity. If the liquid has a higher refractive index it will encourage light loss through refraction.

Detailed study 6 – Sound

Question	% A	% B	% C	% D
1	2	94	2	3
2	3	8	79	10
3	6	80	12	3
4	18	71	10	2
5	69	20	8	2
6	6	8	66	19
7	2	84	10	3
8	6	6	6	81
9	7	4	4	84
10	8	71	19	2
11	7	17	13	62