2020 VCE Physics examination report

General comments

In 2020 the Victorian Curriculum and Assessment Authority produced an examination based on the adjusted 'Physics Study Design for 2020 only'. The examination provided students with the opportunity to demonstrate and apply a range of knowledge and skills.

Students are reminded to keep their physics calculators in scientific notation to avoid errors. For example, in Question 16 students were required to perform this calculation: $\lambda = 6.63\times10^{-34} / 9.1\times10^{-31}\times1.72\times10^{5}$. Students who have their calculators in floating point mode got the result 0.000000004. They were unaware of any further decimal values. Students who have their calculators in scientific mode would get the result 4.2 x 10^{-9}. Students must understand that just because their calculator has run out of digits does not mean there are not important unseen digits.

Students are advised to complete the exam in pen or a softer pencil such as HB to ensure their responses are legible when scanned.

Answers must be given in decimal form. Fractions and surds are considered working steps, not final answers. See the comments for Question 7a. in Section B as an example.

Responses to the practical investigation question (Question 18) suggest that students and teachers are not spending enough time discussing concepts such as the purpose of a hypothesis, variables within an investigation, graphing data, and obtaining data from graphs via gradients and intercepts.

Specific 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 – Multiple-choice questions

Question	% A	% B	% C	% D	Comments
1	65	3	32	1	Field lines show repulsion so both charges are the same. The field lines originate from the charges so they are both positive.
2	1	86	11	1	$g = \frac{GM}{r^2}$ $g = \frac{6.67\times10^{-11}\times1.5\times10^{23}}{(2.6\times10^{6})^2}$ $g = 1.5\ m\, s^2$
3	1	11	63	24	The force is always acting at right angles to the velocity so there is no force acting to change the magnitude of the velocity.

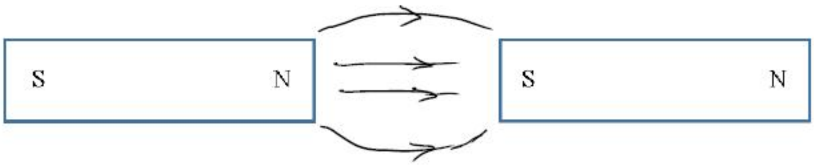
Question	% A	% B	% C	% D	Comments
4	17	58	5	21	Using $Bqv = \frac{mv^2}{r}$, it can be shown that the radius is directly proportional to velocity. If the velocity is halved, the radius is halved.
5	10	53	15	22	$\Phi = BA$ $\Phi = 0.03 \times 10 \times 10^{-4}$ $\Phi = 3.0 \times 10^{-5}$
6	2	6	89	3	$\varepsilon = B\frac{\Delta A}{\Delta t}$ $\varepsilon = 3.5 \times 10^{-4} \times \frac{0.05}{0.20}$ $\varepsilon = 8.8 \times 10^{-5}$
7	16	70	10	3	Transformers do not work with DC voltages.
8	13	25	6	56	There are only ever two forces acting on the ball: gravitational force, which is always straight down; and the string tension, which acts towards the centre of the rotation.
9	29	6	49	16	As both blocks have the same acceleration, they both have the same force to mass ratio.
10	80	5	9	6	$W = Fd$ $W = 250 \times 20$ $W = 5\ kN$
11	8	48	13	31	The kinetic energy remains constant because the magnitude of the velocity remains constant. Kinetic energy is not a vector. The momentum changes because the direction of the velocity changes. Momentum is a vector.
12	82	11	5	2	$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$ $\gamma = \frac{1}{\sqrt{1-\frac{(2.50\times10^8)^2}{(3.0\times10^8)^2}}}$ $\gamma = 1.81$
13	17	9	56	17	$E = mc^2$ $E = 6.6 \times 10^9 \times (3.0 \times 10^8)^2$ $E = 6.0 \times 10^{26}\ J$ Since this conversion occurs every second the output is 6.0×10^{26} W.
14	13	72	8	7	Diffraction is determined by the ratio λ/w.
15	8	20	11	62	I is true when considering the wave model of light. II and III are true when considering the particle nature of light.
16	2	18	2	78	Work function is directly proportional to cut-off frequency.

Question	% A	% B	% C	% D	Comments
17	19	7	73	2	C is the greatest emitted energy difference. Note that A is an absorption.
18	10	15	6	68	
19	84	4	2	10	
20	31	36	27	6	$E_{k\,max} = \frac{hc}{\lambda} - W$ $\therefore E_{k\,max} \propto \frac{1}{\lambda}$

Section B

Question 1

Marks	0	1	2	Average
%	7	15	78	1.7



The most common error was to draw the field lines around each magnet and ignore the question, which clearly stated ‘between the two poles’.

Question 2

Marks	0	1	2	3	Average
%	7	20	17	56	2.2

Field types	Monopoles only	Dipoles only	Both monopoles and dipoles
Gravitation	✓		
Magnetism		✓	
Electricity			✓

Most students understood that magnets only came in dipoles but were unsure of the other two.

Question 3a.

Marks	0	1	Average
%	54	46	0.5

The correct approach is to equate the force due to the electric field to the force due to the magnetic field, thus:

$$Eq = Bqv_0$$

$$v_0 = \frac{E_q}{B_q}$$

$$v_0 = \frac{E}{B}$$

Question 3b.

Marks	0	1	2	Average
%	22	2	75	1.5

$$v_0 = \frac{E}{B}$$

$$v_0 = \frac{500 \times 10^3}{0.25}$$

$$v_0 = 2.0 \times 10^6 \ m\,s^{-1}$$

The most common error was to not convert the voltage from kV to V. Students at this level are expected to be able to convert between SI prefixes.

Question 3ci.

Marks	0	1	Average
%	58	42	0.4

The correct response is Z.

Question 3cii.

Marks	0	1	2	Average
%	84	6	10	0.3

The force due to the electric field will remain unchanged as it is independent of velocity. The force due to the magnetic field will increase as it is dependent on velocity. This will result in an unbalanced force down the page towards Z.

A number of students framed their arguments around the formula $r = \frac{mv}{Bq}$ and pointed out that as v increased, r must increase. This argument alone is not valid as the radius at v_0 is infinite due to the electric field.

Many students provided only a stock statement regarding the force on a charged particle in a magnetic field. Students are reminded that questions are not testing what they can remember, but rather how well they can apply their learning to new problems.

Question 4a.

Marks	0	1	Average

Marks	0	1	Average
%	24	76	0.8

$6.37 \times 10^6 + 600 \times 10^3$

$6.97 \times 10^6\ m$

Question 4b.

Marks	0	1	2	3	4	Average
%	20	8	7	27	38	2.6

$$T = \sqrt{\frac{4\pi^2 R^3}{GM}} = \sqrt{\frac{4\pi^2 (6.97\ x\ 10^6)^3}{(6.67.x\ 10^{-11})(5.98\ x\ 10^{24})}}$$

$T = 5788\ sec$

$T = 5.79 \times 10^3 sec$ to 3 sig figs

The most common error was to not cube the radius. Most students who were able to find the period were able to report it to three significant figures.

Question 4c.

Marks	0	1	2	Average
%	65	27	9	0.4

The ICON satellite is subject only to a gravitational force towards Earth. Further, this force is constant in magnitude. This is why the satellite maintains a stable circular orbit.

Some students referred to the propulsion engines by pointing out that there is no significant friction to require a propulsion force to maintain an orbit.

The most common error was to point out that the satellite is in free fall, but this does not explain the orbit.

Question 4d.

Marks	0	1	2	3	Average
%	48	30	0.8	21	0.9

The area under the graph is given by:

$$Area = (base \times height) + (\frac{1}{2} \times base \times height)$$
$$Area = (600 \times 10^3 \times 8.2) + (0.5 \times 600 \times 10^3 \times 1.6)$$
$$Area = 5.4 \times 10^6\ J\ kg^{-1}$$
$$E = area\ \times\ mass$$
$$E = 5.4 \times 10^6 \times 288$$
$$E = 1.56 \times 10^9\ \text{J}$$

There were two common errors. The first was to not recognise the broken y-axis and to find the area of the triangle only. The second was to use the formula $E = mg\Delta h$ without realising that g is not constant over the Δh.

Question 5a.

Marks	0	1	Average

Marks	0	1	Average
%	66	34	0.3

Anticlockwise.

Most students responded with clockwise.

Question 5b.

Marks	0	1	2	3	Average
%	22	24	3	51	1.8

$$\varepsilon = -N\frac{\Delta\phi}{\Delta t}$$

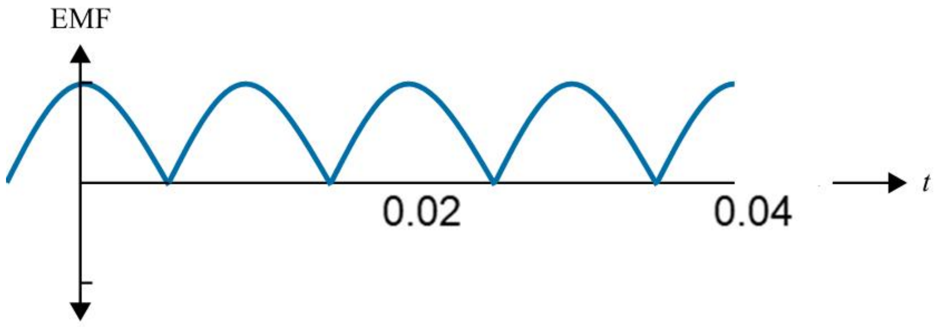
$$\varepsilon = -1 \times \frac{0.2 \times 10^{-3} \times 0.050 \times 0.035}{0.005}$$

$$\varepsilon = 7 \times 10^{-5}\ V$$

The most common errors were forgetting to convert the mT to T or incorrectly calculating the period.

Question 5c.

Marks	0	1	2	3	Average
%	33	34	26	7	1.1



The most common errors were drawing an unrectified sine or cosine wave. Most students got the period of the wave correct.

Question 5d.

Marks	0	1	2	Average
%	9	12	79	1.7

Students could offer a range of modifications that were acceptable including:

- increase field strength
- increase the number of coils
- increase the area of coil
- increase the rotation rate or decrease period of rotation.

Question 6a.

Marks	0	1	Average
%	39	61	0.6

Decrease

Question 6b.

Marks	0	1	2	3	Average
%	34	29	15	22	1.3

The loop experiences a decrease in flux into the page. Lenz's law states the induced current will produce an increasing flux into the page. Using the right-hand grip rule the induced current will flow clockwise around the loop.

Most students were able to identify there would be a change in flux, although many were unable to describe it as decreasing. Many students were also unable to link the decreasing flux to the clockwise direction of the induced current. There were a significant number of responses that stated 'anticlockwise' with no explanation of why, suggesting students do not clearly understand the application of Lenz's law.

Question 6c.

Marks	0	1	2	Average
%	68	9	23	0.6

From Figure 6a to Figure 6b, the loop is experiencing an increasing flux into the page. Applying the right-hand grip rule, the induced current will flow anticlockwise around the loop.

From Figure 6b to Figure 6c, the loop is experiencing a decreasing flux into the page. Applying the right-hand grip rule, the induced current will flow clockwise around the loop.

There were two common incorrect responses. The first was to get the two directions reversed. This was generally accompanied by erroneous or absent reasoning. The second was to attempt to describe the current flow in each figure (rather than between figures). This was also accompanied by erroneous or absent reasoning.

Students and teachers are encouraged to spend more time discussing different scenarios for applying Lenz's law.

Question 7a.

Marks	0	1	2	Average
%	18	4	78	1.6

$V_p = V_{RMS} \times \sqrt{2}$

$V_p = 12 \times \sqrt{2}$

$V_p = 17\ volts$

Students are reminded that fractions and surds are seen as part of the working process and not the final answer. Students who responded with $12\sqrt{2}$ were recognised as having demonstrated the correct working but not having demonstrated the correct answer.

Question 7b.

Marks	0	1	Average
%	17	83	0.8

$$\frac{N_p}{N_s} = \frac{V_p}{V_s}$$

$$\frac{N_p}{N_s} = \frac{240}{12}$$

$$\frac{N_p}{N_s} = 20 \text{ } or \text{ } 20:1$$

Question 7c.

Marks	0	1	2	Average
%	39	7	54	1.1

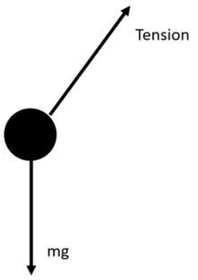
In an ideal transformer, $P_p = P_s$.

$P = VI$
$0.9 = 240 \times I$
$I = 3.8\ mA$

The most common error was to use the 12V from the secondary side of the transformer.

Question 8a.

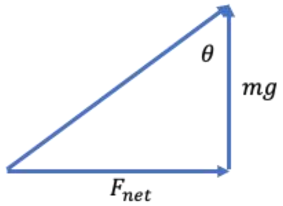
Marks	0	1	2	Average
%	37	8	54	1.2



There are only two forces acting on the ball. Many students identified the centripetal force as a force in addition to tension and weight, rather than being the result of the applying the tension force at an angle.

Question 8b.

Marks	0	1	2	3	4	Average
%	29	23	8	1	39	2.0



$F_{net} = mg\ tan\theta = \frac{mv^2}{r}$

$\therefore 9.8 \times tan25 = \frac{v^2}{0.75\ \times sin25}$

$4.6 = \frac{v^2}{0.32}$

$v = \sqrt{4.6 \times 0.32}$

$v = 1.2\ m\ s^{-1}$

There were other approaches that were also acceptable.

Most students were unable to correctly identify the trigonometric components required. Very few students drew diagrams to help them with this. Students are encouraged to draw the triangle involved to help them identify the components they require.

Question 9a.

Marks	0	1	2	Average
%	30	2	68	1.4

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

$0.5 \times 1250 \times 0.15^2 = 0.5 \times 0.20 \times v^2$

$14.06 = 0.1 \times v^2$

$v = 12\ m\ s^{-1}$

Students need to be aware that where a question asks them to show that the result is a value given in the stem (12 ms^{-1} in this case), there are no marks awarded for the final value. In these cases marks are only awarded for showing working. Students who did not show adequate working (i.e. the equivalence of SPE and KE) were not awarded full marks.

Question 9b.

Marks	0	1	2	3	Average
%	36	18	3	43	1.5

$v^2 = u^2 + 2ax; u = 0, a =- 9.8, x =- 2.5$

$v^2 = 2 \times - 9.8 \times - 2.5$

$v = 7\ m\ s^{-1}$

The impact velocity is the Pythagorean sum of the horizontal and vertical velocities.

$$c^2 = a^2 + b^2$$
$$v^2 = 12^2 + 7^2$$
$$v = 14\ m\ s^{-1}$$

This problem can also be solved by using conservation of energy.

The most common error was to calculate the vertical component only.

Question 10a.

Marks	0	1	2	3	4	Average
%	10	6	2	5	77	3.3

Applying conservation of momentum:

$$p_i = p_f$$
$$(1200 \times 12) = (2200 \times 6.5) + (1200 \times v_f)$$
$$12000 = 14300 + 1200v_f$$
$$v_f = \frac{-2300}{1200}$$
$$v_f =- 1.9\ m\ s^{-1}$$

Students were then required to indicate that the negative sign indicates the velocity is to the left.

Some students used compass bearings (east/west) for directions. Unless the student draws a compass rose to indicate what they mean by east and west this cannot be accepted.

Question 10b.

Marks	0	1	2	3	Average
%	24	14	11	52	1.9

$KE = \frac{1}{2}mv^2$

$KE = 0.5 \times 1200 \times 10^2$

$KE = 6.0 \times 10^4\ J$

$KE = \frac{1}{2}mv^2 + \frac{1}{2}mv^2$

$KE = (0.5 \times 1200 \times 1.9^2) + (0.5 \times 2200 \times 6.5^2)$

$KE = 4.9 \times 10^4\ J$

The reduction in kinetic energy indicates the collision is inelastic.

Most students recognised the collision was inelastic. Common errors occurred with the calculation of the initial and final energies. Of these, it was the final that was most commonly calculated incorrectly, with students either using -1.9 ms^{-1} or omitting the energy of one of the vehicles altogether.

Question 10ci.

Marks	0	1	2	3	Average
%	20	31	6	44	1.7

$$F_{avg} = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t}$$

$$F_{avg} = \frac{2200 \times 6.5}{40 \times 10^{-3}}$$

$$F_{avg} = 358\ kN$$

As the van's change in velocity is to the right, the force acts to the right.

Many students were able to identify the direction correctly but unable to calculate the actual value. At this level, students should be able to convert between SI prefixes, but many could not convert a correctly calculated value in Newtons into kilo-Newtons.

Question 10cii.

Marks	0	1	2	Average
%	18	27	55	1.4

$$F_{avg} = \frac{\Delta p}{\Delta t} = \frac{m\Delta v}{\Delta t}$$

$$F_{avg} = \frac{1200 \times (-1.9 - 10)}{40 \times 10^{-3}}$$

$$F_{avg} = -358\ kN$$

As the car's change in velocity is to the left, the force acts to the left.

Students were not required to perform the calculation. Those who indicated that this was an example of Newton's third law and, therefore, that the force would have the same magnitude but opposite direction were also awarded full marks.

There was a small number of students who determined that a new calculation was required and then demonstrated incorrect physics.

Question 11a.

Marks	0	1	2	Average
%	64	15	21	0.6

The distance of 8.61 light-years is the proper length in Earth's frame of reference. The proper time in the Earth's frame of reference is:

$$t = \frac{d}{v} = \frac{8.61}{0.8}$$
$$t = 10.76\ yr$$

This time is the dilated time in the astronaut's frame of reference. The proper time as measured by the astronaut is:

$$t = t_0\gamma$$
$$10.76 = t_0 \times 1.67$$
$$t_0 = 6.44\ years$$

Many students understood a light-year as a measure of time rather than distance. The range of workings indicates a varied level of understanding of proper time and dilated time.

Question 11b.

Marks	0	1	2	Average
%	37	39	24	0.9

The time measured by the astronaut will be proper time because the clock is stationary in the astronaut's frame of reference.

While most students were able to identify the time as proper time, many struggled with the explanation. Some incorrect reasonings included statements that 'anything the astronaut observes is "proper" since it is the astronaut doing the observing', 'the astronaut measures proper time because he is stationary inside the spaceship' and 'the shorter time is always proper time'.

Some students confused a frame of reference as a physical creation, such as a spaceship, rather than something applied to an observer.

Question 12a.

Marks	0	1	2	Average
%	21	69	10	0.9

The bright fringe in question is the fourth bright fringe so the path difference is four wavelengths. The fact that the fringe is a bright fringe indicates that constructive interference is occurring.

The most common error was to simply refer to constructive interference in general and not discuss the path difference of four wavelengths. Students are reminded that questions are rarely asking for general information and they should read carefully to identify the specific aspects of the question being asked.

Question 12b.

Marks	0	1	2	3	Average
%	40	31	2	28	1.2

$$\Delta x = \frac{\lambda L}{d}$$

Where $\Delta x = \frac{1.26 \times 10^{-2}}{4} = 3.15 \times 10^{-3}$

$$3.15 \times 10^{-3} = \frac{\lambda \times 2.00}{4.0 \times 10^{-4}}$$

$$\lambda = 630\ nm$$

The most common error was to use 1.26 x 10^{-2} m as the actual delta x value rather than divide it by four first.

Question 13a.

Marks	0	1	2	Average
%	33	1	66	1.3

$$v = f\lambda$$

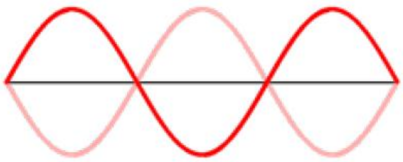
$$v = 250 \times 1.6$$

$$v = 400\ m\ s^{-1}$$

The most common error was to use 0.8 as the wavelength.

Question 13b.

Marks	0	1	2	Average
%	10	26	64	1.5

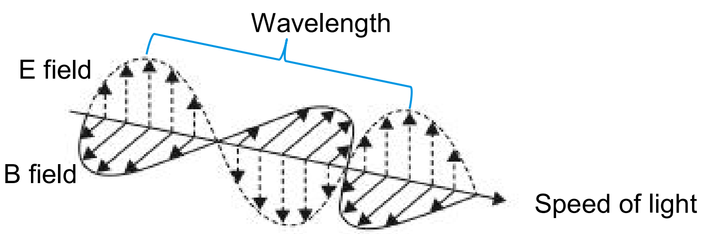


The most common error was to draw two solid sine waves rather than the waveform envelope. Figure 12 was described as 'the standing wave envelope' in the question stem so students had a model of what was required.

Question 14

Marks	0	1	2	3	Average
%	13	11	32	45	2.1

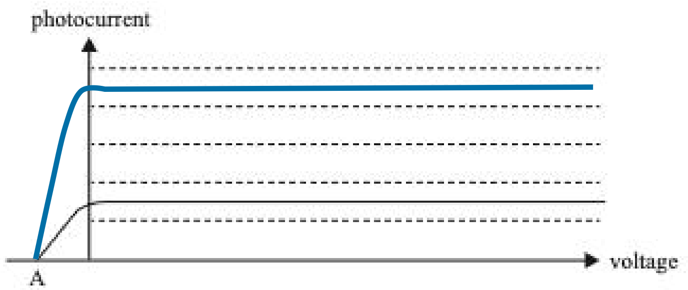
The most common error was to indicate the wavelength incorrectly. Typically, students indicated the distance from one of the E field peaks to the next B field peak or vice versa.



Question 15a.

Marks	0	1	2	Average
%	31	18	52	1.2

Of the two possible errors, more students drew an incorrect photocurrent than drew an incorrect stopping voltage.



Question 15b.

Marks	0	1	Average
%	30	70	0.7

The correct answer is stopping voltage.

The most common error was to identify it as 'threshold voltage', which implied students were confusing this graph with a graph of kinetic energy versus frequency.

Question 15c.

Marks	0	1	Average
%	68	32	0.3

The stopping voltage is sufficient to turn back even the most energetic photoelectrons.

The most common error was to refer to work function in some way. Students wrote about the energy required to be emitted from the metal.

Question 16a.

Marks	0	1	2	Average
%	24	25	51	1.3

$$KE = \frac{1}{2}mv^2$$

$$KE = 0.5 \times 9.1 \times 10^{-31} \times \left(1.72 \times 10^5\right)^2$$

$$KE = 1.35 \times 10^{-20}\ J$$

$$KE = \frac{1.35 \times 10^{-20}}{1.6 \times 10^{-19}} = 0.08\ eV$$

The most common error was to leave the result in joules.

Question 16b.

Marks	0	1	2	3	Average
%	49	12	7	32	1.2

$$\lambda_e = \lambda_{X-ray}$$

$$\lambda_e = \frac{h}{p} = \frac{6.63 \times 10^{-34}}{9.1 \times 10^{-31} \times 1.72 \times 10^5}$$

$$\lambda_e = 4.24 \times 10^{-9}$$

$$E_{X-ray} = \frac{hc}{\lambda} = \frac{4.14 \times 10^{-15} \times 3.0 \times 10^8}{4.24 \times 10^{-9}}$$

$$E_{X-ray} = 293\ eV$$

Most students were able to identify that the identical patterns indicated that the wavelengths were the same. However, many students were then unable to complete the remaining mathematical process. Students must think about how they plan to show their working before they commence writing.

Question 17a.

Marks	0	1	Average
%	40	60	**0.6**

668 nm

The lowest energy has the longest wavelength.

The most common error was to give 403 as the answer.

Question 17b.

Marks	0	1	2	Average
%	38	3	59	1.2

$$f = \frac{c}{\lambda} = \frac{3.0 \times 10^{8}}{588 \times 10^{-9}}$$

$$f = 5.1 \times 10^{14}\ Hz$$

The two most common errors were to not convert the wavelength to metres and leave it as 588, or to try to use the formula for the de Broglie wavelength.

Question 17c.

Marks	0	1	2	Average
%	49	33	17	0.7

Only certain energies are visible because the electrons exist only in certain discrete energy levels. As the electrons transition between these energy levels they can emit only discrete amounts of energy.

Many responses answered the question in one of two ways: either they restated the question as a statement (e.g. 'Only discrete energies are seen because atoms can only absorb and emit discrete energies'), or they provided nonsensical responses (e.g. 'Electrons in disallowed orbits result in destructive interference which is why no emission occurs').

There were also a number of responses that either focused entirely on the quantisation of electron shells or the process of transition without linking the two concepts. This suggested some students were copying stock responses from their A3 sheets.

Question 18a.

Marks	0	1	2	Average
%	18	19	63	1.4

The brightness of the globe will be decreased. Students could then refer to reduced current, increased voltage drop in the cables or increased power lost in the cables.

The most common errors were to state that the brightness would decrease without a valid reason or state that the brightness would increase.

Question 18b.

Marks	0	1	2	Average
%	17	24	58	1.4

The independent variable is the resistance of the cables. The dependent variable is the current in the cables.

The most common errors were to state the resistance of the cables is the dependent variable and vice versa or to make a generic statement about variables.

There were a number of students who simply stated that the independent variable is the resistance, but this was not sufficient as it does not discriminate between the resistance of the cables and the resistance of the globe.

Question 18c.

Marks	0	1	2	Average
%	62	3	35	0.7

$V = RI$

$V = (R + r)I = RI + rI$

$rI = V - RI$

$r = \frac{V}{I} - R$

$r = \frac{24}{I} - R$

Students struggled to demonstrate what was required. Many attempted to substitute values from the table into the equation (which results in different values for R) and then claimed the results were close enough to support their demonstration. Demonstrating that an equation works for a set of values is not a proof.

Question 18d.

Marks	0	1	2	Average
%	12	1	87	1.7

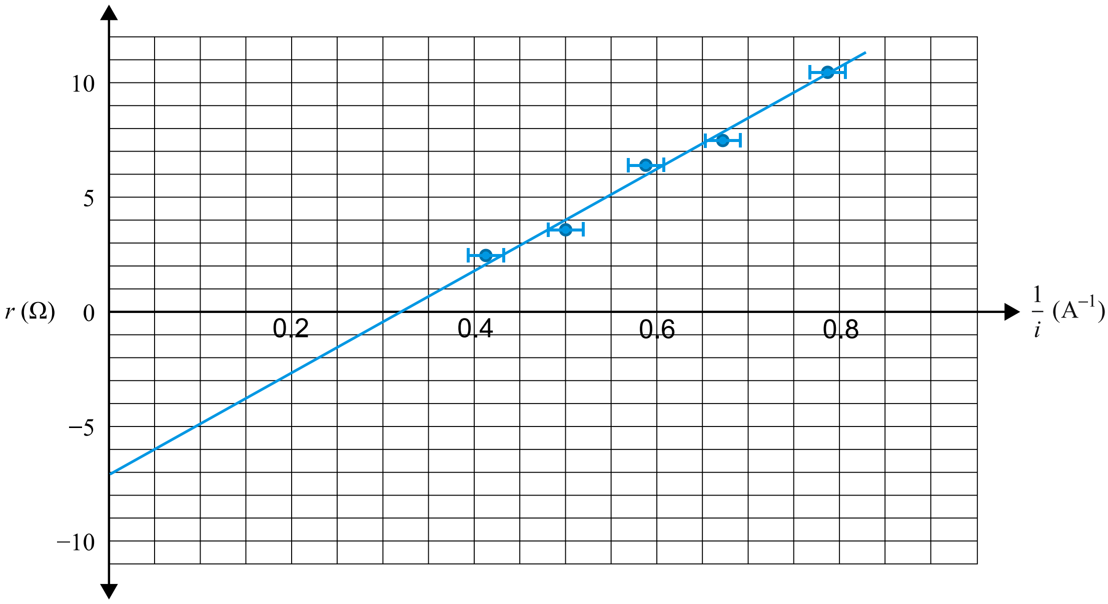
The correct values, from top to bottom, are: 0.42, 0.50, 0.59, 0.67 and 0.77.

There were a number of students who rounded the values to one decimal place. While this was not penalised, it did affect their ability to accurately plot their data and analyse it. Students are warned against rounding. The data in the tables had at least two significant figures and students should retain this level of detail in their working.

There were also students who responded with fractions ($\frac{1}{2.4}, \frac{1}{2.0}, \frac{1}{1.7}$, etc). This was not accepted as it is restating information provided in the question. The column header gives the form of the fraction as $\frac{1}{i}$ and the column header for the preceding column is i.

Question 18e.

Marks	0	1	2	3	4	5	6	Average
%	14	2	2	4	9	20	50	4.5



Most students were able to demonstrate the skills required. Students who did not score well generally did so for all parts of Question 18, suggesting they had little understanding of experimental process or data visualisation.

A number of students truncated the x-axis, which prevents using the y-intercept for analysis. Unless students are sure they will not need the y-intercept, they should not break the x-axis when plotting data.

Question 18f.

Marks	0	1	2	Average
%	64	4	31	0.7

The value for R is found from the y-axis intercept.

The correct value is 7Ω and allowance was made for students' plotting of their data.

The most common error was to find the gradient of the graph.

Many students attempted to use the equation from Part c as though this equation was, in some way, the conclusion to the experiment and could be relied upon to provide answers that should have been found from the graph.

Students are advised to put more effort into developing and practising the skills associated with experimental design and data visualisation.