Examiners' Report
June 2018

GCE Physics 8PH0 02

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Introduction

This is the third time that the Pearson Edexcel AS paper 8PH0 02, Core Physics II, has been sat by students. Section A of the paper contains eight multiple choice questions followed by questions of increasing length and increasing demand. This section examines the Waves and Materials components of the course providing a transition for students between GCSE and A Level. Section B contains two questions, with the first question taking inspiration from a short passage. This section is designed to provide a synoptic element with responses from any part of the AS specification expected. In this case Question 15 relied on knowledge from some aspects of dc electricity and mechanics, whilst Question 16 required understanding of fluid mechanics. This paper enabled students of all abilities to apply their knowledge to a variety of styles of examination questions.

Many students have shown good progression from GCSE to AS level, with prior knowledge extended. Some questions were not answered as well by many students as would have been expected . Full written and open response questions, in particular, fell into this category as students struggled to explain the physics, as in Q9. students would benefit from more practice at applying familiar ideas and concepts in an unfamiliar context in order to follow through an argument and reach a conclusion, as in Q14(b)(iii). The recall of some basic mathematical equations such as the volume of a sphere was not known to some.

Analysis of Multi-choice questions

Multiple-choice questions were generally well answered. The more able student typically scored at least 7 correctly whilst an E grade student typically scored around 5 marks.

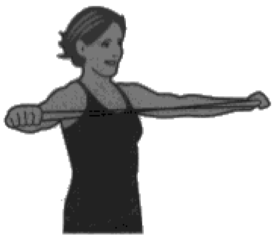
Question	description	Percentage of students with correct response	Common incorrect responses	
1	Expression for Young Modulus	87%	D	
2	Pulse Echo	84%	A	
3	Stationary waves	56%	A,C	
4	Photoelectric equation	78%	B	
5	Diffraction of electrons	60%	C,D	
6	Phase difference	54%	B,D	
7	Speed of a wave on a string	59%	C,D	
8	Mass per unit length of a string	70%	A	

Question 9

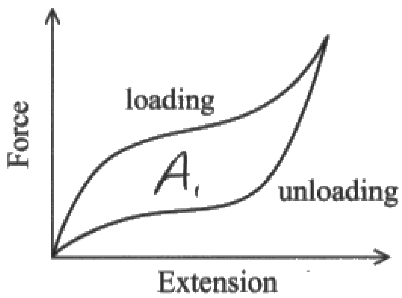
This 6-mark indicative content question proved a challenge to many. Whist it was clear that this type of the hysteresis graph was familiar to many, students struggled to describe its shape in a coherent manner. Those who were the most successful at this question started with observations from the graph (as the question suggested) and then used their knowledge of force-extension graphs to explain these observations in terms of forces and in terms of energy.

Firstly recognising that this is not a straight line graph and, secondly, that the start and end points are the same, leads to MP1 and MP2. These were the most commonly scored marks. MP3 was awarded for a comparison between the shape of the two graphs with an explanation of the differences when loading and unloading in terms of force and extension. MP4 was awarded for a comparison in the area under the graphs for loading and unloading, with an explanantion in terms of energy, for MP5. Finally, MP6 uses all of this to explain the hysteresis in terms of the transfer of heat energy, linking back to information given in the question.

9 A resistance band is a length of an elastic material that can be used for exercise. The user repeatedly applies an increasing tensile force (loading) and then releases the force (unloading).



The force-extension graph for the resistance band is shown.



The user finds that the band gets warm during use.

Describe, with reference to the graph, the behaviour of the resistance band when it is repeatedly loaded and unloaded.

*1 is equal to the area under the top curve and

* past the linear section of the graph.

(6)

As the resistance band is loaded, after a certain load, it stops obeying Hookes law ($F \propto \Delta x$)*. ~~Soon after, it stops stretching elastically~~ The elastic energy stored in the band when loading *1 is partially lost to thermal energy when loading and unloading due to internal frictional forces in the rubber band. The energy lost in this cyclic process is known as hysteresis and is represented on the graph by the area between the two curves (A_1). Throughout the whole process the band behaves elastically as it returns to zero overall extension once the cycles complete, ~~shown~~ indicating no permanent (plastic) deformation.

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Examiner Comments

This answer scores 5 indicative marking points.

MP1 in line 2. Allowance was made for the graph being approximately a straight line for small forces and extensions.

MP2 last sentence.

MP3 not awarded.

MP4 in lines 3 to 4.

MP5 in lines 4 and 5.

MP6 in lines 6 to 8. "energy lost" on its own is insufficient, but in this answer it links back to thermal energy in line 4.

The marks awarded for these 5 incative marking points plus the linkage marks gave a total of 5 for the question.

Question 10 (a)

A 2-mark calculation using the equation from the back of the examination paper for elastic strain energy.

(a) Calculate the work done on the spring.

(2)

$E = \frac{1}{2} F \Delta x$

$= \frac{1}{2} \times 29 \times 0.32$

$= 4.64 J$

Work done = $4.64 J$

ResultsPlus
Examiner Comments

A correct answer showing all working clearly.

(a) Calculate the work done on the spring.

(2)

$W = F \times s = 29 \times 0.32 = 9.28 J$

Work done = $9.28 J$

ResultsPlus
Examiner Comments

A common incorrect answer.

This student has used the equation for work done = force X distance not realising that the work done on the spring is equal to the elastic strain energy.

Question 10 (b)

A 2-mark calculation using the Hooke's law equation as given at the back of the examination paper. Students were expected to realise that, as the same spring is used, the spring constant remains the same in both (a) and (b).

(b) Calculate the extension of the spring when a force of 27 N is applied.

(2)

$f = kx$ $\qquad$ $27 = 90.625 \times \Delta x$

$29 = k \times 0.32$ $\qquad$ $\Delta x = 0.298 \text{ m}$

$k = 90.625$

Extension = 29.8cm

ResultsPlus
Examiner Comments

This student has used data from the question to calculate a value for the spring constant of the spring, k. This is then substituted back into the Hooke's law equation using the new data to arrive at a correct answer.

(b) Calculate the extension of the spring when a force of 27 N is applied.

(2)

$\frac{29}{27} = \frac{0.32}{x}$ Z A

$29x = 8.64$

$x = 0.30$

Extension = 30 cm

ResultsPlus
Examiner Comments

This student has bypassed the need to determine a value for the spring constant by equating the ratios of extension to force for the two situations. Rearranging the equation they then reach a correct value for the extension.

ResultsPlus
Examiner Tip

Be careful with units. Usually it is wise to convert cm to m. However in this question it was not necessary to do this as long as the correct unit for extension was given at the end.

When calculating the force, extension should be in SI units.

Question 11 (a)

A question assessing the student's ability to judge factors that might affect the accuracy of measurements.

Many students indicated the need for repeats and this was one of the more common responses seen. However, they could not score the mark if they then failed to state that a mean should be determined.

There were many responses referring to using thin /sharp pencils which did not score a mark. Also parallax, which did not score a mark as the protractor would have been flat on the paper and so parallax would not have been an issue.

(a) **State two precautions the student should take to improve the accuracy of these measurements.**

(2)

The angles used should be sufficiently large so that the percentage uncertainty is reduced. The light ray used must be thin so that the uncertainty in position is reduced.

ResultsPlus
Examiner Comments

This student scores 2 marks - for the use of large angles (one mark) and thin rays (second mark).

Neither of these were commonly seen.

ResultsPlus
Examiner Tip

Accuracy is an indication of how close a measurement is to the true value

Question 11 (b)

(i) Comment on whether the student has recorded his measurements of i and r to the correct number of significant figures.

(2)

~~A~~ Yes he did because the protractor has a resolution of 1° and all of his measwements are ~~[illegible]~~ recorde to the nearest degree.

(ii) Calculate the percentage uncertainty in the value of r when $i = 50°$.

(2)

$$\frac{1/2}{50} \times 100 = 1\%$$

Percentage uncertainty in r = 1.0%

ResultsPlus
Examiner Comments

(b)(i) Correct use of the term resolution means that this student could access full marks. A correct conclusion is given to the suggestion of a resolution of 1 degree.

(b)(ii) An attempt at a percentage uncertainty calculation using an uncertainty of 0.5 has been made. Unfortunately they have used an angle of 50 degrees (= i) instead of the correct 29 degrees, (angle r when i=50 degrees). This mistake was not uncommon.

ResultsPlus
Examiner Tip

Students would benefit from revising the glossary in appendix 10 of the specification. Use of these key terms can help to raise the level of a students' written responses.

(i) Comment on whether the student has recorded his measurements of i and r to the correct number of significant figures.

(2)

Yes, because the resolution of the protractor is 1°, so they can only measure to the nearest whole degree.

(ii) Calculate the percentage uncertainty in the value of r when $i = 50°$.

(2)

$r = 29$

$29 \pm 0.5°$

$\cancel{0.5 \times 29 = 14.5}$

$\frac{0.5}{29} = 0.01724 \times 100 = 1.72\%$

Percentage uncertainty in r = 1.72%

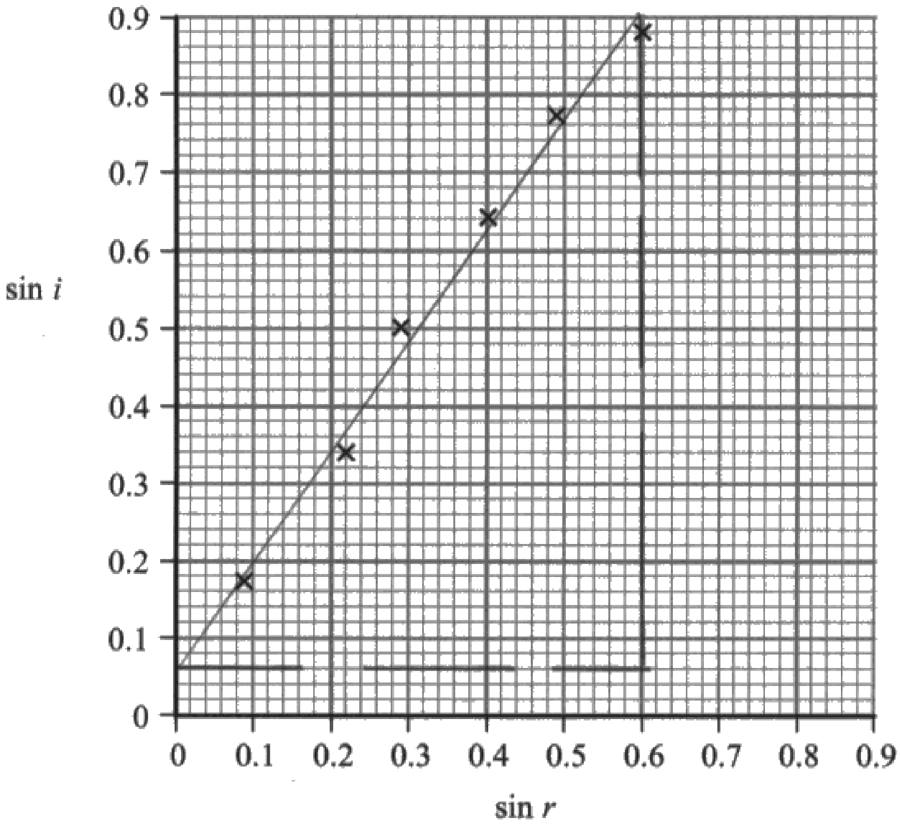
ResultsPlus
Examiner Comments

A correct answer scoring full marks.

Question 11 (c)

In part (c)(i) the line of best fit proved a challenge for many students. The line was judged by an even spread of points lying either side of the line. The final point at sinr=0.6 could have been treated as an anomaly and ignored.

(c) The student plots his results on a graph of sin *i* against sin *r*.



The refractive index for three types of glass is shown.

Type of glass	Refractive index
Silica	1.458
Crown	1.755
Flint	1.925

(i) Draw a line of best fit.

(1)

(ii) Deduce which type of glass the rectangular block is made from.

(3)

$n = \frac{\sin i}{\sin r} = \frac{0.84}{0.59} = 1.42$

Type of glass Silica

ResultsPlus
Examiner Comments

(i) An acceptable line of best fit for this student. They have not treated the final point as an anomaly and have an even spread of points either side of the line.

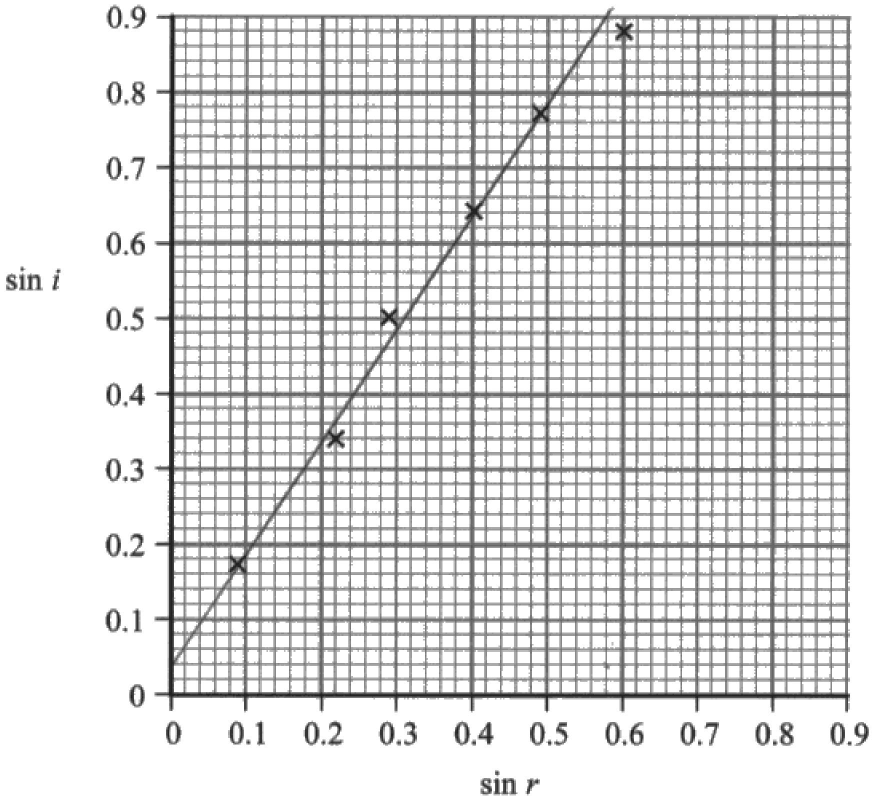
(ii) A gradient has been calculated, using a large range for sini and sinr shown clearly with the drawing of the triangle on the graph. Refractive index is calculated correctly with a correct conclusion.

Some students used the data points from the stem of the question instead of calculating a gradient so would have been unable to score MP1.

ResultsPlus
Examiner Tip

When calculating gradients use as large a range of the x and y axes as possible but it must be at least half the height or width of the graph. It is good practise, and makes it clear to the examiner if the triangle is drawn on the graph. This can also avoid errors with calculating the change in x and the change in y, especially when (as is the situation here) the line does not go through the origin.

(c) The student plots his results on a graph of sin *i* against sin *r*.



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(i) Draw a line of best fit.

(1)

(ii) Deduce which type of glass the rectangular block is made from.

(3)

$\frac{0.9 - 0.04}{0.58 - 0} = 1.482759$

$= 1.4830$ $1.483 \approx 1.458$

Type of glass Silica

ResultsPlus
Examiner Comments

The line of best fit is sufficient for the mark. The final point has been treated as an anomaly and ignored. There are three points on the line and two other points sitting equidistant either side of the line, constituting an even spread of points. The line has not been forced through the origin.

ResultsPlus
Examiner Tip

When drawing lines of best fit, do not force the line through the origin.

Question 12 (a)

Students demonstrated an understanding of energy levels This has been a common theme in past papers, but in the context of energy gained from the absorption of photons. The context in this question, with energy gained from collisions, was clearly less familiar and this caused some difficulties. Some students confused this with the photoelectric effect with photons absorbed and photoelectrons emitted. Marks could not be awarded for repeating information from the question.

12 In 1925 Franck and Hertz were awarded the Nobel Prize in Physics "for their discovery of the laws governing the impact of an electron upon an atom".
In one of their experiments, a beam of high-speed electrons is fired through mercury vapour.

An electron in the beam collides with a mercury atom, which becomes excited. The atom returns to its initial state by emitting electromagnetic radiation of a single frequency.

(a) Explain why excited atoms only emit certain frequencies of radiation.

(5)

excited atoms have descrite energy levels where ~~for~~ electrons, can exist where electrons can only exist at certain energy levels ~~or~~, when ~~excited~~ atoms are excited, electrons move to a higher energy level, when electrons move back to lower energy level, they release electromagnetic radiation in form of photons, as there are descrite energy level differencies only certain changes are possible, therefore as $E = hf$, only certain frequencies are emited as Energy difference is proportional to frequency of the photon. therefore only certain frequencies are of radiation are emited.

ResultsPlus
Examiner Comments

MP1 awarded in line 1 despite the misspelling of discrete. However, "electrons exist in certain energy levels" would not have been accepted as it does not convey the same meaning.

MP2 lines 4 and 5.

MP3 line 6.

MP4 and MP5 in the last 4 lines.

ResultsPlus
Examiner Tip

This response, of over 10 lines, contains only one sentence, making it more difficult to read.

12 In 1925 Franck and Hertz were awarded the Nobel Prize in Physics "for their discovery of the laws governing the impact of an electron upon an atom".
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An electron in the beam collides with a mercury atom, which becomes excited. The atom returns to its initial state by emitting electromagnetic radiation of a single frequency.

(a) Explain why excited atoms only emit certain frequencies of radiation.

(5)

An election moves up an energy level to it's excited state. ~~This~~ ~~e!~~ The electron then moves down an energy level back to it's previous/ original energy level. The energy from this move is given out as a photon. The photon's energy is equal to the energy level difference. Since energy levels are discrete only certain changes (differences) are possible. As $f=hf$ therefore only certain frequencies are emitted.

ResultsPlus
Examiner Comments

MP1 in line 5. Since the student is referring to electrons rather than atoms.

MP2 line 2 the idea that an electron moves down an energy level.

MP3 line 3.

MP4 lines 4 and 5 linking energy changes to frequency.

MP5 lines 4 to 6.

ResultsPlus
Examiner Tip

Marks are not awarded for repeating information in the question. Use the information given but add further detail.

Question 12 (b)

When the electron collides with the mercury atom its speed, and hence its kinetic energy, decreases as it tranfers energy to the atom during the collision. The amount of energy transferred is equal to the difference in the kinetic energy of the electron before and after the collision. The wavelength emitted by the mercury atom corresponds to the total energy absorbed by the mercury atom.

As this is a "deduce" question, having calculated a value for wavelength, candidates are expected to use the data in the table to state which type of radiation is emitted.

(b) An electron travelling with a speed of $2.5 \times 10^6 \text{ m s}^{-1}$ collides with a stationary mercury atom and continues at a speed of $2.1 \times 10^6 \text{ m s}^{-1}$.

The table gives a range of wavelengths for ultraviolet, visible and infrared radiation.

Type of radiation	Typical range of wavelengths / m
ultraviolet	2.0×10^{-7} to 4.0×10^{-7}
visible	4.0×10^{-7} to 7.8×10^{-7}
infrared	7.8×10^{-7} to 1.0×10^{-3}

Deduce the type of radiation that is emitted by the stationary mercury atom.

(4)

$kE_1 = \frac{1}{2}mv^2 = \frac{1}{2} \times 9.11 \times 10^{-31} \times (2.5 \times 10^6)^2$

$= \cancel{\ldots \times 10^{-24}}\ 2.846875 \times 10^{-18}$ J

$kE_2 = \frac{1}{2} \times 9.11 \times 10^{-31} \times (2.1 \times 10^6)^2$

$= 2.008755 \times 10^{-18}$ J

$\Delta kE = 8.3812 \times 10^{-19}$ J

$E = hf \quad f = \frac{E}{h} = \frac{8.3812 \times 10^{-19}}{6.63 \times 10^{-34}}$

$= 1.26\ldots \times 10^{15}$

$v = f\lambda \quad \lambda = \frac{v}{f} = \frac{3 \times 10^8}{1.26 \times 10^{15}} = 2.37 \times 10^{-7}$ m (3s.f.) $\quad 2 \times 10^{-7} < \lambda < 4 \times 10^{-7}$

Type of radiation Ultraviolet

ResultsPlus
Examiner Comments

This is a correct 4 mark answer.

In the first 5 lines the student has correctly calculated the kinetic energy of the electron at each of the two speeds and then subtracted their answers to calculate the change in energy of the electron due to the collision.

They have then correctly calculated the frequencey (lines 6 and 7) and the corresponding wavelength (last line) to obtain an answer within the accepetable range (2.37 rounds to 2.4). For the final mark a conclusion of ultraviolet is given.

(b) An electron travelling with a speed of 2.5×10^6 m s^{-1} collides with a stationary mercury atom and continues at a speed of 2.1×10^6 m s^{-1}.

The table gives a range of wavelengths for ultraviolet, visible and infrared radiation.

Type of radiation	Typical range of wavelengths / m
ultraviolet	2.0×10^{-7} to 4.0×10^{-7}
visible	4.0×10^{-7} to 7.8×10^{-7}
infrared	7.8×10^{-7} to 1.0×10^{-3}

Deduce the type of radiation that is emitted by the stationary mercury atom.

(4)

$2.5 \times 10^6 - 2.1 \times 10^6 = 0.4 \times 10^6 \text{ ms}^{-1}$

$E = \frac{1}{2} m v^2$

$E = \frac{1}{2} \times 9.1 \times 10^{-31} \times (0.4 \times 10^6)^2$

$E = 7.29 \times 10^{-20}$

$E = hf$

$\frac{7.29 \times 10^{-20}}{6.63 \times 10^{-34}} = f = 1.1 \times 10^{14}$ Hz

$\lambda = \frac{c}{f}$

$\lambda = \frac{3 \times 10^8}{1.1 \times 10^{14}}$

$\lambda = 2.7 \times 10^{-6}$ m $\therefore$ infrared

Type of radiation Infrared

ResultsPlus
Examiner Comments

In this response the difference in the two speeds has first been determined and then this value substituted into the formula for kinetic energy. This is incorrect as the value obtained is not the change in the kinetic energy of electron. This mistake was often seen.

However they have scored MP2 and MP4. Whilst their final numerical answer is incorrect, and so not achieving MP3, they have made a correct conclusion (infrared) based upon their answer and so can score MP4.

Question 13 (a)

A wavefront is a line or surface along which all the points on a wave are in phase. (This enables a measurement of wavelength to be made from the distance between wavefronts).

Many students were unsure on this. They had the idea but were unable to express it concisely.

13 Huygens' principle states that every point on a wavefront is a source of wavelets which spread out at the same speed.

(a) State what is meant by a wavefront.

(1)

A line or surface on a wave where every point is in phase.

ResultsPlus
Examiner Comments

This answer gains the mark. The student did not need to write both line and surface for the mark.

ResultsPlus
Examiner Tip

Students should memorise this.

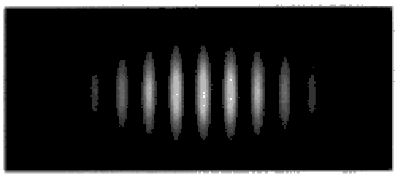
Question 13 (b) (i)

Any idea that a laser should not be shone towards the eye.

Unqualified reference to the wearing of goggles was commonly seen but was not accepted.

is a full wavelength.

(b) In an experiment to demonstrate interference of light, monochromatic light from a laser is shone onto two narrow slits. A series of light and dark lines is observed on a screen placed a distance away from the slits.



(i) State one safety precaution that should be taken with this procedure.

(1)

The laser should not be rotated or directed at a person's eye as it can cause serious damage.

ResultsPlus
Examiner Comments

Scores 1 mark.

Question 13 (b) (ii)

This question required the idea of evidence, or lack of.

Students would benefit from gaining an appreciation of the history of the development of the wave-particle duality concept.

(ii) Thomas Young first demonstrated the principle of this experiment in 1803 in support of the theory that light behaves as a wave.

Give a reason why some scientists at the time did not accept the wave theory of light.

(1)

Many though of light as a particle as did Newton which was a leading figure in physics at the time.

ResultsPlus
Examiner Comments

This scores the mark for the last alternative on the markscheme "support for the particle model" as they have stated that the support came from an eminent scientist.

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Examiner Tip

A significant number of students referred to Einstain or the photoelectric effect, neither of which were around in 1803.

(ii) Thomas Young first demonstrated the principle of this experiment in 1803 in support of the theory that light behaves as a wave.

Give a reason why some scientists at the time did not accept the wave theory of light.

(1)

As ~~the~~ there was very little evidence until then to support the theory.

ResultsPlus
Examiner Comments

An example of a response that scores for the first alternative "lack of evidence".

Question 13 (c) (i)

Part (c) is assessing the student's knowledge of a core practical. The explanation of interference patterns is well visited but this question considers only one part of the interference pattern when the two slits are equidistant from the screen.

To explain the existence of a bright line requires three points to be made about each of: the path difference, the phase difference and whether this is constructive or destructive interference.

In this case as the slits are equidistant from point 0 (as stated in the question), there is zero path difference. Consideration of the path difference was often missing. Some students mentioned path difference as a whole number of wavelengths which did not allow them to score the mark, as this was not specific enough.

The waves are in phase at this point which gives constructive interference and hence a bright line. MP2 and MP3 were more commonly seen.

(i) Point O is a point equidistant from the two slits.

Explain why there is a bright line at this point.

(3)

There is no path difference between the coherent secondary waves that reach That point at that point.
So the waves are in phase
and there is constructive interference.

ResultsPlus
Examiner Comments

This response scores 3 marks.

ResultsPlus
Examiner Tip

Superposition is accepted in place of interference, but not superimposition.

(i) Point O is a point equidistant from the two slits.

Explain why there is a bright line at this point.

(3)

The path difference of the waves that meet at point O is zero, and the waves are in phase. This means that there is constructive interference so a maximum is ~~seen~~. produced.

ResultsPlus
Examiner Comments

A correct 3-mark answer.

MP1 line 1. This mark was least commonly awarded as students did not mention path difference.

MP2 line 2

MP3 line 3

Question 13 (c) (ii)

Drawing on knowledge that the path difference between the two waves is one whole wavelength the only acceptable answer is 600 nm.

Question 14 (a) (iii)

This is a real image as it is formed on the other side of the lens to the object.

Most students realised that this was a real image. An explanation alluding to the rays passing through the image was a common response although some found it difficult to express with clarity.

(iii) State, with justification, whether the image is real or virtual.

(1)

It is a real image as it is on the opposite side of the lense to the object.

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Examiner Comments

A perfect answer.

A common response was to state that "the image was formed on the other side of the lens". This does not make it clear that object and the image are on different sides of the lens.

Question 14 (a) (i) - (ii)

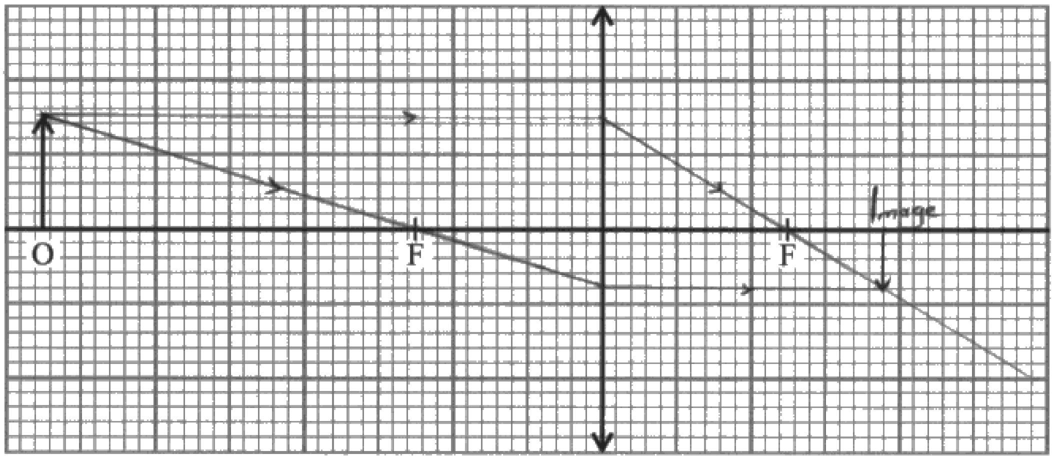
It was encouraging to see that students generally used a ruler and sharp pencil to complete the ray diagram. Those students who were unable to recall how to draw the paths of the rays were unlikely to score well in the whole of this question totalling 5 marks.

Some students did not realise where the rays changed direction and drew rays that seemed to change direction in random places.

Care needs to be taken in drawing the rays, using both a ruler and the lines on the graph paper as a guide. A small inaccuracy on the left hand side of the diagram could lead to a larger inaccuracy in locating the position of the image on the right hand side.

14 A camera uses a converging lens to produce an image.

(a) The diagram represents an object O and a converging lens.



(i) Complete the ray diagram to determine the position of the image.

(3)

(ii) Determine the magnification of this image.

(2)

$m = \frac{v}{u}$

$= \frac{0.8\text{ cm}}{1.5\text{cm}}$

$= 0.53$

Magnification = 0.53

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Examiner Comments

This response shows the paths of two rays correctly drawn using a ruler with the image drawn in the correct position. Three marks is scored in part (a)(i).

In (a)(ii) the magnification is correctly calculated using the ratio of the height of image to height of object. Alternately a ratio of image distance to object distance could be calculated.

ResultsPlus
Examiner Tip

Whilst the position of the image can be located by drawing just two rays, it is good practice to add the third ray because if the three rays do not all meet in the same place, this can highlight when the path of one ray has been incorrectly drawn.

Question 14 (b) (i)

The requirement in this question was for the description of a method. Therefore the emphasis should be on measurements that need to be made. The focal length is the distance between the lens and the position of the image formed from an object at infinity or (approximately) an object at a large distant from the lens.

The image of a distant object can be projected on to a screen and the distance between the screen and the image is measured. Alternatively, using parallel rays from a ray box, since rays from a common point at infinity will be parallel when they are incident on the lens. The focal length is the distance between the lens and the point at which the rays converge.

(b) In some cameras, lenses of different focal lengths can be used. A particular camera can use a lens of focal length 50 mm or a lens of focal length 200 mm. Both lenses are made from the same material.

(i) Describe a method to determine an approximate value for the focal length of a converging lens.

(2)

Pass 3 parallel waves through the lense. Pass one through the optical centre, one above, and one below. Where these parallel rays meet will be the focal point roughly. Now measure from the optical centre to this point and

ResultsPlus
Examiner Comments

Correct description using parallel rays and a correct measurement for the focal length has been stated.

ResultsPlus
Examiner Tip

The focal length is the distance from lens to image.

Question 14 (b) (ii)

Rays of light are refracted on passing through a lens. The thicker lens will cause more refraction and a shorter focal length as the rays of light converge at a point closer to the lens.

For MP1 correct reference to refraction was required. References to reflection or diffraction were also seen and scored no mark.

For MP2 rays converge or meet at a point closer to the lens. It is incorrect here to state that the rays meet at the focal point. This is only true if the rays arriving at the lens are parallel.

(ii) Explain why the lens with the shorter focal length is thicker at its centre.

(2)

Because it is a more powerful lens. The light will refract more, if the lens is thicker, meaning the light rays will meet and focus on a point closer to the lens, therefore a shorter focal length.

ResultsPlus
Examiner Comments

Correct reference to refraction for MP1. For MP2 the rays are meeting at a point closer to the lens.

Question 14 (b) (iii)

Students found this question challenging. The unfamiliar context required students to use their knowledge of the magnification of a lens (m=v/u) as a starting point and use this to follow through a logical argument to arrive at a conclusion.

Students answering this question most successfully started with the equation m=v/u . Firstly, making the observation that photograph 2 is more magnified. Secondly, although this was not commonly stated, establishing that u is the same in both photographs. Then it can be seen from the equation that v must be larger. This then leads to a larger f from the thin lens formula arriving at the 200 mm lens. This seemed counter intuitive to many. A significant number deduced that one or either of the two lenses was more powerful and so produced a more magnified image. These students were not distinguishing between situations involving near and far objects and were probably thinking about the image produced by a magnifying glass.

Deduce which lens was used to take photograph 2.

(5)

Using $\frac{1}{u} + \frac{1}{v} = \frac{1}{f}$ and $m = \frac{V}{U}$

- the images magnification is higher in photo 2.
- U doesnt change therefore is V increases F has to increase
- As F increases with magnification Photograph 2 has to have a larger F, which means it uses the 200 mm focal length lense

ResultsPlus
Examiner Comments

A 5- mark answer. This student has stated relevent equations and starting with a high magnification has used the equations to follow through an argument, leading to the correct conclusion.

MP1 lines 2 and 3.

MP2 lines 4 and 5.

MP3 line 4.

MP4 line 5.

MP5 correct conclusion in last 2 lines.

Deduce which lens was used to take photograph 2.

(5)

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

As the focal length increases, the value of $\frac{1}{u} + \frac{1}{v}$ decreases. The value of $\frac{1}{u}$ stays the same as u is the distance from the object and is constant. This means that $\frac{1}{v}$ must decrease and v, the distance of image must increase which will produce an image with a greater magnification. Therefore, the greater the focal length, the greater the magnification, photograph 2 is taken using the 200mm lens.

ResultsPlus
Examiner Comments

Another 5-mark answer. In this response that student has followed the argument in the reverse order starting with the assumption that the focal length increases and using the thin lens formula.

MP1 line 6.

MP2 line 5.

MP3 line 3

MP4 line 2.

MP5 last 2 lines.

Deduce which lens was used to take photograph 2.

(5)

Photograph 2 was taken with the lens of focal length 200mm as the focal length is greater so the image distance will also be greater. Similarly, photograph 1 was taken with the lens of focal length 50mm as the focal length is shorter so image distance will be less. Photograph two is able to focus at a further distance

ResultsPlus
Examiner Comments

This response scores 3 marks all in the first 3 lines. The second half of the response is repeating what has already been said but for the alternative lens.

ResultsPlus
Examiner Tip

The term "zooming in" was frequently seen. Whilst a common photographic term, this is not a physics term and so needed clarifying for MP1.

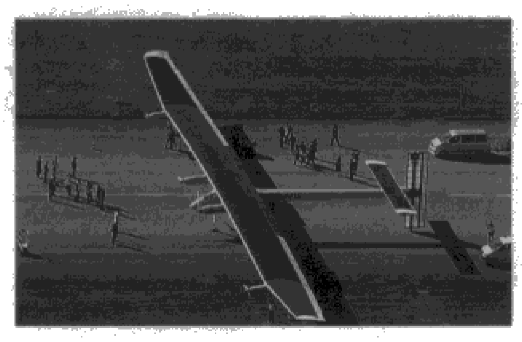
Question 15 (a)

In high intensity light the rate of incident photons is greater. Since one photon is absorbed by one electron, more electrons are released every second. A greater rate of electrons pass through the external circuit creating a larger current and the batteries charge more quickly.

Some key ideas of physics were being assessed in this question.

- a higher intensity of light means the rate of incident photons is greater
- one photon is absorbed by one electron
- linking an increase in the rate of electrons with an increase in current

15 Read the passage and answer the questions below.



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The Solar Impulse 2 is a solar-powered plane that completed a round the world trip in 2016 without using fossil fuels.
The wings are covered in thin solar panels, keeping the total mass of the plane and pilot at 1600 kg. The need to reduce the weight limits the efficiency of the solar panels to 23%. However, in daylight, these panels generate enough energy to run the four 7.5 kW electric motors that keep the plane airborne and to fully charge the batteries that power the plane during the night. The batteries take about 6 hours to fully charge.
In daylight the plane flies at a height of 8500 m to harness the most sunlight, and at night descends to 1500 m. This descent makes use of the gravitational potential energy gained during the day to help the plane get through the night.
(Source: www.solarimpulse.com)

(a) The solar panels consist of a series of photocells connected to an external circuit that includes the batteries. When light strikes the photocells, electrons gain energy and are able to move through the external circuit so that the batteries charge up.

Explain why the batteries charge more quickly in high intensity light.

(4)

At high intensity, there are more photons per second hitting the photocells. ~~This means~~ One photon collides with one electron and transfers all of its energy to it causing a photoelectron to be released. At high intensities, the more photons collides with the electrons so more photoelectrons are released. More photoelectrons released causes a greater current.

ResultsPlus
Examiner Comments

A good 4-mark answer.

Line 1: more photons per second for MP1.

Line 2: the idea of a one to one interaction between photons and electrons for MP2.

Line 5: "more photoelectrons" also linked to an increased rate from line 1 for MP3.

Line 6: more current.

MP1 and MP3 could not be awarded unless there was a clear reference to rate or number per unit time. MP4 needed to refer to a quantity in the external circuit that was greater as a result.

Many students incorrectly referred to an increase in the energy of photons in high intensity light, transferring a greater energy to the electrons, leading to an increased current.

Explain why the batteries charge more quickly in high intensity light.

(4)

THE HIGHER THE INTENSITY THE HIGHER THE
NUMBER OF PHOTONS PER SECOND.
ONE PHOTON EMMITS ONE ELECTRON
∴ MORE ELECTRONS EMMITTED PER SECOND
∴ GREATER CURRENT IN THE CIRCUIT THAT
CHARGES THE BATTERIES FASTER

ResultsPlus
Examiner Comments

Scores 4 marks.

MP1 lines 2 and 3

MP2 line 3

MP3 line 4

MP4 lines 5 and 6

ResultsPlus
Examiner Tip

A high intensity of light means that there are more photons per second.

A large current means the rate of flow of electrons is greater.

Question 15 (b)

To determine the energy generated the power must first be determined using P=I x A. The power can then be substituted into E = P x t ensuring that the time (8 hours) is converted into seconds.

Use of the two relevent equations for intensity and power were often well done. Many students did not multiply the energy by an efficiency of 23% limiting their score to two marks. This information is within the passage (5th line).

(b) The solar panels are illuminated with an average light intensity of $1300\,\mathrm{W\,m^{-2}}$ over an 8 hour period in any day.

Calculate the electrical energy generated by the solar panels in one day.

(4)

upper area of wings = $200\,\mathrm{m^2}$

$$1300 = \frac{P}{200}$$

$$P = 26\,0000\,W$$

$$P = \frac{W}{t} \rightarrow 260000 = \frac{W}{8 \times 3600} = 7488 \times 10^6\ J$$

$$\frac{23}{100} \times 7488 \times 10^6 = 1.7\cancel{2} \times 10^9$$

Energy = 1.71×10^9 J

ResultsPlus
Examiner Comments

MP1 top two lines of working, for using P = I x A, arriving at P=260000W

MP2 third line of working, for using E = P x t with time converted to seconds, arriving at E = 7488 MJ

MP3 last line of working, multiplying by efficiency of 23% to give correct final answer.

ResultsPlus

Examiner Tip

Highlight key points made in the passage to help you remember that they are there as you answer the questions.

Question 15 (c)

Using E = P x t with information given in the passage. There are four motors each with a power of 7.5 kW.

(c) During the night the motors are switched off for 4 hours.
Calculate the battery energy saved by switching off the motors.

(2)

$= 4 \times (7.5 \times 1000) \times (4 \times 60 \times 60)$

$= 432000000$

$= 432$ MJ

Battery energy saved = 432 MJ

ResultsPlus
Examiner Comments

A correct 2-mark answer. The answer may be given in any correct unit MJ, kJ, J.

ResultsPlus
Examiner Tip

Don't forget to convert kW to W, and time from hours to seconds.

Question 15 (d)

Using change in gravitation potential energy = mass x g x change in height with information given in the passage.

(d) The plane flies at the greater height during the day. At night it glides down to the lower height over a period of 4 hours, with the motors switched off.

Calculate the change in gravitational potential energy as the plane glides down.

(2)

GPE = mgh = 1600(9.8)(8500−1500)

= 1.1 × 10⁸ J

Change in gravitational potential energy = 1.1 × 10⁸ J

ResultsPlus
Examiner Comments

A correct answer.

Question 15 (e)

There needs to be an appreciation that, at night, the motors need to use as small amount as energy as possible.

Air resistance is greater at faster speeds or, at lower heights where the air is more dense. With more air resistance the motors would need to provide a greater forward force and therefore require more energy. The plane flies at a lower speed at this lower height to conserve battery energy.

(e) After four hours the engines are switched on again.

Explain whether the plane should fly at a slower horizontal speed at its lower height.

(3)

the plane should fly at a slower horizontal speed at a lower height as there is increased air resistance due to the air being more dense, so it will require a greater force to reach the same speed, which would use up more power from the battery.

ResultsPlus
Examiner Comments

A good 3-mark answer.

(e) After four hours the engines are switched on again.

Explain whether the plane should fly at a slower horizontal speed at its lower height.

(3)

The Earth's atmosphere is denser as it gets closer to the surface. This means that at a lower height, the plane will experience more drag forces, requiring more energy in order to keep itself at the same horizontal speed it was before. Therefore, in order to make efficient use of the energy it has, the plane should fly at a slower horizontal speed at its lower height.

ResultsPlus
Examiner Comments

This is a well written answer scoring 2 marks. This answer scores MP1 and MP3 but has not referred to force from the motors to gain MP2.

Question 15 (f)

(f) Comment on how projects such as the Solar Impulse 2 might be of benefit to society at large.

do not pollutes.

(1)

The developpment of renewable energies is essential, as other tipes of energie are to poluting

ResultsPlus
Examiner Comments

Many students referred to the idea that solar planes would provide a "greener" or "more environmentally friendly" method of flying. Use of these terms do not generally gain credit as they are vague terms showing little progress from GCSE. The emphasis for this question is on the advancement of the technology, not necessarily linked solely to air travel.

ResultsPlus
Examiner Tip

In this response the mark is secured in the first five words, as it conveys the advancement of technology.

(f) Comment on how projects such as the Solar Impulse 2 might be of benefit to society at large.

(1)

They show that solar power is the way forward and help advance solar technologies.

ResultsPlus
Examiner Comments

Scores one mark for the idea of advancing solar technologies.

(f) Comment on how projects such as the Solar Impulse 2 might be of benefit to society at large.

(1)

They encourage research into areas such as solar ~~p~~ power, which have many practical applications for the public.

ResultsPlus
Examiner Comments

A good one mark answer.

Question 16 (a)

Using the information in the question it should be established that the resultant force F is equal to 0 as the balloon has reached a constant upwards speed and the vertical forces are balanced.

With F=0, to calculate the viscous drag force, the upthrust and weight need to be determined.

weight = (mass of balloon + helium) x g

upthrust = (density of air) x volume of balloon x g

The weight was commonly calculated correctly. Of those students who remembered how to calculate upthrust, a common mistake was the recall of the volume of sphere, with the equation for the area of a circle often seen.

$\rho = \frac{m}{V}$

16 A small helium balloon is released into the air. The balloon initially accelerates upwards.

The resultant force F on the balloon is given by

$$F = \text{upthrust} - \text{weight} - \text{viscous drag}$$

(a) Eventually the balloon reaches a constant upwards speed.

Calculate a value for the viscous drag force acting on the balloon at this speed.
The balloon may be considered as a sphere with radius 12 cm. $= 0.12\,m$

(4)

density of air = $1.2\,kg\,m^{-3}$
mass of unfilled balloon = 4.0 g
mass of helium in balloon = 1.2 g $= 5.2g = 5.2\times10^{-3}kg$

$U = \rho_f \times V_s \times g$ $\quad W = mg$

upthrust = weight + viscous drag F

$\frac{4}{3}\pi(0.12)^3 \times 1.2 \times 9.81 = 9.81 \times (5.2\times10^{-3}kg) + \cancel{6\pi\eta r v}$

$F = \left(\frac{4}{3}\pi(0.12)^3 \times 1.2 \times 9.81\right) - \left(9.81 \times 5.2\times10^{-3}\right)$

$F = 0.03419643$

Viscous drag force = 0.0342 N

ResultsPlus
Examiner Comments

A 4-mark answer.

Line 1: the student has written out the expression for upthust with F=0 scoring MP1.

Line 2: the student has shown working for each of the terms upthrust and weight. In this case it can be assumed that the F corresponds to viscous drag from their expression on the first line.

Line 3 and 4: substitution of correct values leading to a correct answer.

16 A small helium balloon is released into the air. The balloon initially accelerates upwards.

The resultant force F on the balloon is given by

$$F = \text{upthrust} - \text{weight} - \text{viscous drag}$$

(a) Eventually the balloon reaches a constant upwards speed.

Calculate a value for the viscous drag force acting on the balloon at this speed. The balloon may be considered as a sphere with radius 12 cm.

(4)

density of air = $1.2\,\text{kg}\,\text{m}^{-3}$
mass of unfilled balloon = 4.0 g
mass of helium in balloon = 1.2 g

upthrust = $V\rho g$ (volume x Density x gravity)
upthrust = $(12\times10^{-2})^2\pi \times 1.2 \times 9.81$
upthrust = 0.533 N
weight = mg weight = $(5.2\times10^{-3}) \times 9.81$
weight = 0.051 N
upthrust − weight = viscous drag
0.533 − 0.051 = 0.482 N

Viscous drag force = 0.482 N

ResultsPlus
Examiner Comments

This student has carried out the correct method but has used an incorrect formula for the volume of a sphere (on line 2) so cannot score MP3 and MP4. This was a common mistake.

ResultsPlus
Examiner Tip

Learn the formula for the volume of a sphere.

16 A small helium balloon is released into the air. The balloon initially accelerates upwards.

The resultant force F on the balloon is given by

$$F = \text{upthrust} - \text{weight} - \text{viscous drag}$$

(a) Eventually the balloon reaches a constant upwards speed.

Calculate a value for the viscous drag force acting on the balloon at this speed.
The balloon may be considered as a sphere with radius 12 cm.

(4)

density of air = $1.2\,\text{kg}\,\text{m}^{-3}$
mass of unfilled balloon = 4.0 g
mass of helium in balloon = 1.2 g

$\rho = \frac{m}{V}$

U = mass of air displaced by balloon

$= \rho \times V = 1.2 \times \frac{4}{3}\pi(12)^3 = 8.69 \times 10^{-3}$

Weight = ~~[illegible]~~ $m \times g$

$= (4 + 1.2) \div 1000 \times 9.81 = 0.051012$

F = 0 (constant speed)

$0 = 8.69 \times 10^{-3} - 0.0510 - x$

x = viscous drag $= 8.69 \times 10^{-3} - 0.0510 = -0.0423$

Viscous drag force = -0.0423 N

ResultsPlus
Examiner Comments

This answer shows another common mistake. On the second line they have attempted to calculate the upthrust but have omitted g.

Question 16 (b)

There needed to be a link between viscosity and temperature. On a warmer day viscosity increases creating a larger force opposing the motion of the balloon.

(b) The viscosity of the air decreases as the balloon rises.

On a warmer day a balloon of the same total mass and radius rises at a lower constant upwards speed.

Give a reason why.

(1)

Because the viscosity of the air increases during higher temperature, which makes speed lower.

ResultsPlus
Examiner Comments

Scores one mark on the first line.

Paper Summary

This paper provided candidates a wide scope in which to demonstrate their understanding of the physics within the AS specification. Questions included both short and long written responses, aswell as short and multi-step calculations.

Based upon the performance on this paper, students would benefit from:

- memorising key mathematical formulae that are not provided on the paper, such as the volume of a sphere
- memorising definitions, for example in this paper, the definition of a real image and of a wavefront.
- learning to recognise and apply the relevent physics in unfamiliar situations
- further practise at writing a coherent argument to form a logical conclusion
- practise at evaluating practical investigations and calculations of uncertainties
- practise at drawing a line of best fit on a graph of real data to give an even spread of points either side of the line.

Grade Boundaries

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