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Examiners' Report
June 2017

GCE Physics 8PH0 02

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Introduction

This is the second time that the Pearson Edexcel AS paper 8PH0 02, Core Physics II, has been sat by candidates.

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 candidates between GCSE and A Level. Section B contains two questions, with the first question taking inspiration from a short passage. With a total of 20 marks, Section B is designed to provide a synoptic element with responses from any part of the AS specification expected. In this case Question 16 relied on knowledge from some aspects of dc electricity and Question 17 required use of suvat equations. Candidates seemed prepared for this.

This paper enabled candidates of all abilities to apply their knowledge to a variety of styles of examination questions. Many candidates showed good progression from GCSE to AS level, with prior knowledge extended. Some questions were not answered as well as would have been expected by many candidates. Candidates would benefit from more practise in a range of different contexts to become more confident to apply the physics into different unfamiliar contexts. On this paper in Question 16(b)(ii) candidates were expected to use familiar physics contexts in an unfamiliar equation, having to use relevant equations and ratios. This may be a skill that many candidates could do with developing further.

Some practical and investigative skills were less well-developed than would have been expected, as in Question 14. Question 2 showed that many candidates were not confident with using an equation for a straight line graph. The teaching and assessment of practical skills has changed with this new specification into a more progressive approach, allowing candidates to develop their skills over time.

Analysis of multiple choice questions

Multi-choice questions were generally answered well. An 'A grade' candidate could probably be expected to score at least 6 (with Question 3 and Question 7 scoring less well at this boundary) and at least 4 or 5 marks for an 'E grade' candidate (Questions 3, 4, 6 and 7 scoring less well at this boundary).

	Content	Percentage scoring correctly	Common incorrect response	Comment
1	Use of extension v mass graph for an extended spring	56	A	The work done is found from the area under the graph. The common incorrect response showed candidates forgetting the ½.
2	Use of y=mx+c	59	A, B, C	Whilst most candidates scored the marks a significant number were not confident with rearranging equations into the format for a straight line graph.
3	Diffraction gratings	72	C	The common incorrect response was linked to wavelength increasing instead of decreasing.
4	Use of displacement v time graph to determine phase difference	61	C, D	Most candidates got this right but a significant number were not able to handle phase difference with respect to the graph and 2π.
5	Energy levels	76	A	The common incorrect response was linked to the correct direction of energy transfer but an incorrect transition of energy - not appreciating that it is the difference in energy levels that is equal to the amount of energy absorbed.
6	Use of I=P/A	56	A	The incorrect response showed that candidates appreciated that this was linked to a factor of 4 due to r2. A quick think to decide whether P increases or decreases would have helped to reconsider their answer.
7	Coherent waves	86	A, C	A pleasing high percentage of correct answers.
8	Ultrasound scanning	90	-	A pleasing high percentage of correct answers.

Question 9

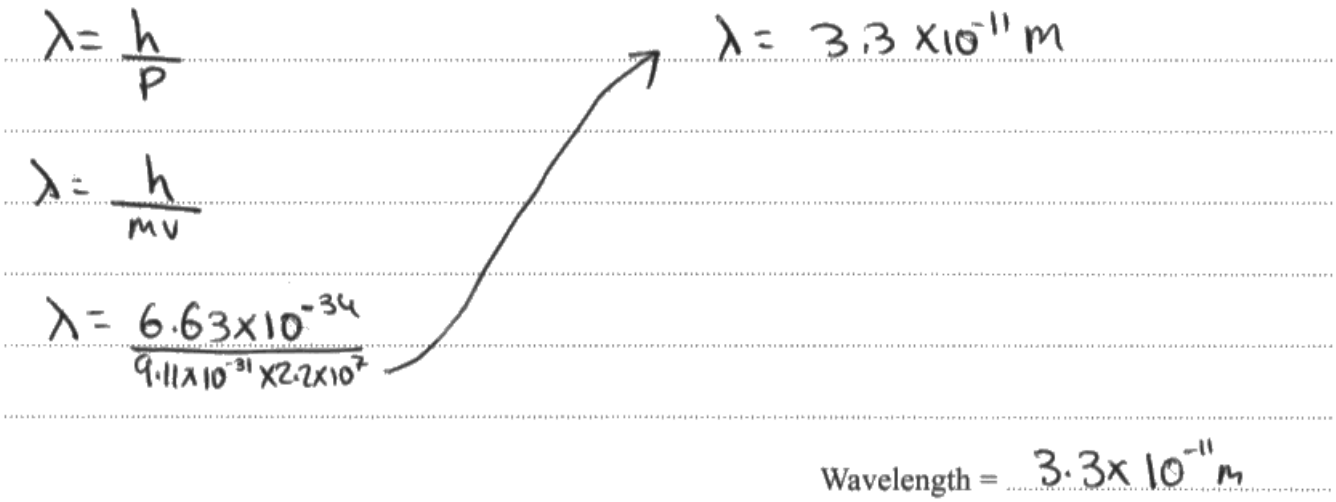
This was a three mark calculation involving the use of two equations, both given at the back of the paper. Using the de Broglie wavelength equation required a value for momentum which could be calculated using *p=mv* with the mass of an electron. This is where some candidates struggled as the mass of an electron was not given in the question, so they needed to realise that this was necessary and that the value is given at the back of the exam paper.

A small minority of candidates tried to use the equation *velocity=frequency* x *wavelength*, probably seeing that the question was about a wave, with a speed given and a wavelength required.

9 In the 1920s Louis de Broglie proposed that an electron could behave as a wave.

Calculate the wavelength of an electron that is travelling at a speed of $2.2 \times 10^7 \text{ m s}^{-1}$.

(3)



ResultsPlus
Examiner Comments

This is a 3 mark answer. The candidate has combined the two equations before substituting the values. Full marks were also awarded if a candidate had calculated the momentum first and then substituted that value into the de Broglie equation.

ResultsPlus
Examiner Tip

In calculations where the mass of an electron is required don't forget that this is given in the list of data at the back of the exam paper.

9 In the 1920s Louis de Broglie proposed that an electron could behave as a wave.

Calculate the wavelength of an electron that is travelling at a speed of $2.2 \times 10^{7}\,\text{m s}^{-1}$.

(3)

$v = \lambda f$ $v = \lambda f$

$\frac{2.2 \times 10^{7}}{1.6 \times 10^{-19}}$: $\lambda = \frac{h}{p}$ $\frac{6.63 \times 10^{-34}}{2.2 \times 10^{7}}$

$= 3.01 \times 10^{-41}$ m

ResultsPlus
Examiner Comments

This is an example of a common incorrect answer. This candidate did not know what to do with the value for *p* and has simply used the value for speed as given in the question.

They have tried dividing the speed by the charge on an electron but have not gone on to use this. Some candidates did use the charge on an electron instead of mass. Without a value for mass 0 marks could be scored.

ResultsPlus
Examiner Tip

There is an expectation that some constants are used even when not specified in the question.

Question 10 (a)

The question refers to the transmitter emitting polarised waves and the receiver only detecting waves on a single plane.

This means that the receiver will detect maximum amplitude when it is aligned parallel to the polarised microwaves emitted from the transmitter, and zero amplitude when it is perpendicular to the microwaves.

The candidates were asked to **describe** what is heard. As they were not asked to explain what was heard it was not necessary to give a full explanation as to why the sound varied as it did.

Marks are not awarded for repeating phrases in the question, for example, "audible output". This needed to be related to intensity, amplitude or volume. (Loudness was also accepted.)

Describe what is heard as the receiver is rotated.

(2)

Initially the audible output should be at its highest as the polarised EM waves are of the same orientation as the receiver. As it rotates it gets quieter till it is 90° to the transmitter. As the wave plane is 90° to the receiver there is no sound. Then as it continues to rotate from 90° to 180° the sound should get louder and be at its loudest when it hits 180° again.

ResultsPlus
Examiner Comments

This candidate writes in terms of the loudness of the wave and then correctly refers to the orientation at 90° and at 180°.

The response gets both marks.

ResultsPlus
Examiner Tip

Make sure you answer a question fully. In this case, a candidate would not have gained full marks if they had not correctly referred to both 90° and 180°.

Question 10 (b)

This is a question about the interference of two waves emitted from two gaps in the context of the microwave transmitter and receiver. Candidates were expected to translate the physics of interference into different contexts.

Many candidates referred to troughs and peaks which is not terminology that is generally accepted at this level.

Explain why points of maximum and minimum intensity are detected.

(4)

When the electromagnetic wave passes through the ~~#~~ gaps in the metal plates diffraction occurs causing the spreading out of two secondary waves. When these secondary waves ~~superpo~~ interfere (meet) ~~they~~ in phase (0) they superpose constructively resulting to the formation of points with maximum intensity. When they interfere in antiphase ($(n+\frac{1}{2})\lambda$) they ~~inter~~ superpose destructively, where the resultant vector sum of their displacement is zero, forming areas where there is a minimum intensity. ~~of~~

ResultsPlus
Examiner Comments

This is a good 4 mark answer.

ResultsPlus
Examiner Tip

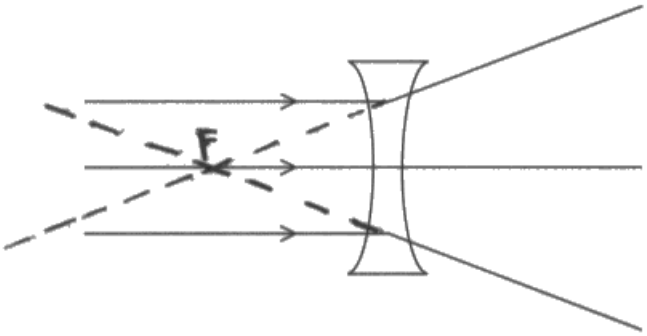
Remember that if two waves are *out-of-phase* they are not necessarily *in antiphase*. For complete destructive interference, and therefore points of zero intensity, the two waves need to be in antiphase.

Question 11 (a)

This question assesses a candidate's knowledge on how to find the focal point of a diverging lens and to then measure the focal length.

The focal length should be measured from the focal point to the central point of the lens. A common mistake was to measure to the front edge of the lens which would have resulted in a focal length of less than the required range.

(a) The diagram shows three parallel rays of light incident on a diverging lens and the path of the rays after passing through the lens. The diagram is drawn to actual size.



Add to the diagram to determine the focal length of the lens.

(2)

Focal length = 2.3cm

ResultsPlus
Examiner Comments

This response scored both marks. The two rays are drawn back to the principal axis. The mark is given for either dotted or solid lines but two lines must be extrapolated.

The focal length is measured to within the correct range for the second mark.

ResultsPlus
Examiner Tip

Use a ruler to draw any ray diagram.

Question 11 (b)

This question required the use of two equations, one to determine the focal length (or 1/ focal length) using the object and image distance, and the other that relates focal length to the power.

Calculate the optical power of the eye.

(3)

$P = \frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ $\frac{1}{f} = \frac{1}{0.024} = 41.6...$

$P = \frac{1}{0.25} + \frac{1}{0.024} = 45.6$ D

Power = 45.67 D (2dp)

ResultsPlus

Examiner Comments

All 3 marks were awarded for this response. The candidate has clearly used the equation to calculate *1/f* which is then related to *P=1/f* to give the correct answer of 45.67 and correct unit (Dioptre or D).

A common mistake was forgetting to convert cm to m.

At the top right of this candidate's answer they have used *1/f* with an incorrect value for *f*. Fortunately they went no further with this and so it was ignored. However, this was commonly seen, using *P=1/f* with an incorrect value for *f* plucked from the diagram (2.4 or 25 or 27.4 were all seen). This would have only scored one mark.

ResultsPlus

Examiner Tip

Don't forget to convert to SI units when using formulae.

Question 11 (c)

This question is assessing the candidate's knowledge that adding an additional lens would increase the overall power, which in turn decreases the focal length.

A common misconception that became apparent was that the image would be formed at the focal length in this case so that the focal length should be equal to depth of the eye. That is only the case if the rays were coming from a distant object so that they may be considered to be parallel.

State how an additional converging lens would enable the light rays from an object 25 cm in front of the eye to converge at a point on the retina.

(1)

Power = Power$_1$ + Power$_2$ ...
an additional converging lense would make the power of the eye stronger as now there are two lenses, it would make the light rays converge more, meaning a smaller focal point

(Total for Question 11 = 6 marks)

ResultsPlus
Examiner Comments

This candidate clearly understands that the power would increase and is awarded the mark.

Question 12 (a)

This question posed little problem for those who had learnt a definition for a virtual image but this had clearly not been covered by all candidates.

Those who got this correct wrote the second alternative on the mark scheme that a virtual image cannot be projected on to a screen.

(a) State what is meant by a virtual image.

(1)

a virtual image is one that cannot be projected onto a screen

ResultsPlus
Examiner Comments
This is the correct answer for 1 mark.

ResultsPlus
Examiner Tip
Make sure you understand and can describe the difference between a real and a virtual image.

(a) State what is meant by a virtual image.

(1)

an image that is not real like a reflection.

ResultsPlus
Examiner Comments
This shows an example of an incorrect answer from a candidate who had not learnt a definition for a virtual image.

Question 12 (b)

This question concerns refraction and total internal reflection being assessed in an unfamiliar context. The candidates were required to work through the physics of mirages to arrive at a conclusion. Mirages are formed when light is refracted by air of increasing temperature closer to the ground. The simplified model described in the question uses layers to represent the air at different temperatures. The light is refracted until the angle of refraction at a particular layer is greater than the critical angle. Then total internal reflection takes place and the light is reflected towards the observer. To the observer it appears as if the light is coming from the road and a virtual image is formed.
Most candidates carried out a calculation but the lack of correct terminology and the ability to express ideas clearly let many candidates down.
For example:
"the light hits the interface" is better expressed as "light is incident on..."
Omitting the "total" from total internal reflection.
Despite the hint in part (a) some candidates thought that since the ray is being reflected away from the road no image is formed.

Use the information to discuss whether the observer sees a mirage on the road in the position shown.

(6)

$n_1 \sin\theta_1 = n_2 \sin\theta_2 = n_3 \sin\theta_3$

$1.00032 \sin(89.59) = 1.00030 \sin\theta_2 \rightarrow \theta_2 = 89.81° > 89.64°$

The calculation above shows that light travelling from layer 1 to layer 2 striking at an angle of 89.59°, will be refracted at an angle of 89.81°. When it reaches the boundary of layer 2 to layer 3, its angle of incidence is now equal to its angle of refraction of 89.81° (alternate angles). This angle is greater than the critical angle, 89.64°, moving from layer 2 to layer 3 so the ray is totally internally reflected within layer 2 and it does not reach the road surface. So, the observer does not see the mirage.

ResultsPlus
Examiner Comments

This is a near perfect answer which scored 5 marks, missing out only on MP6.
In the first two lines a correct calculation of the refraction angle as 89.8° gains the first three marking points. It demonstrates an appreciation that the light is refracted as a refraction equation is used.
On line 7, reference is made to angle of incidence being greater than the critical angle. It was insufficient to state simply that "it" is greater than the critical angle since their calculation has determined an angle of refraction between layers 1 and 2. The candidate needed to make it clear that they are now referring to the angle of incidence at layer 2 to 3. This should then lead to total internal reflection. This candidate realises that the light does not reach the road but does not state that to the observer it appears to.

Use the information to discuss whether the observer sees a mirage on the road in the position shown.

(6)

Since the incident angle of 89.59° is smaller than the critical angle of 89.64°, refraction and partial reflection will occur.

Using Snell's law $n_1 \sin\theta_1 = n_2 \sin\theta_2$

$1.00032 \sin 89.59 = 1.00030 \sin\theta_2$

$\Rightarrow \sin\theta_2 = \frac{1.00032 \sin 89.59}{1.00030} = \theta_2 = 89.81°$ (2 dp)

Therefore the incident angle of the ray between layer 2 and 3 will be 89.81° which is greater than the critical angle of 89.64°.

Hence, total internal reflection will occur since light is travelling from a more to a less dense medium and the angle of incidence is greater than the critical angle. The light undergoing total internal reflection will reach the observer. The light reaching the observer will appear to come from the position of the mirage shown whereas this is not its true origin. Hence a virtual image of a mirage will be seen by the observer on the road in the position shown.

(Total for Question 12 = 7 marks)

ResultsPlus
Examiner Comments
This answer scores all 6 marks.

Question 13 (a)

This is a question that relies on knowledge of *weight* = *mass* x *density* and *Stokes Law.* A candidate who worked methodically from the given starting point of the derivation could achieve all three marks.

The derivation of the equation for terminal velocity has been started below.
Complete the derivation.

(3)

At terminal velocity: weight of solid sphere = drag + upthrust

$V\rho_s = 6\pi\eta r v + V\rho_l$

$V\rho_s - V\rho_l = 6\pi\eta r v$

$V(\rho_s - \rho_l) = 6\pi\eta r v$

$\frac{V(\rho_s - \rho_l)}{6\pi\eta r} = v$

ResultsPlus
Examiner Comments

All 3 marks are achieved in the first line of this response. The terms given by the candidate are written in the same order as shown in the question so it can be assumed that the candidate knows which term relates to weight, to drag and to upthrust.

ResultsPlus
Examiner Tip

Credit is not usually given to a candidate who has clearly worked backwards from the final equation.

Question 13 (b) (i)

Most candidates were able to achieve some marks on this question with full marks seen fairly frequently. Quite a number of candidates could not remember the equation for a volume of a sphere. Perhaps they had not memorised this, expecting it to be at the back of the paper. The units for viscosity were not well known although some got round this by applying units to the equation and arriving at the units in base units.

Candidates needed to make use of the equation on the previous page. Velocity *v* needed to be calculated from the information given in the question, as well as the volume of the sphere.

(b) (i) The student drops a steel sphere with a radius of 4.0 mm into a cylinder of glycerol. The sphere reaches terminal velocity and takes 3.9 s to fall 0.50 m.

Calculate the viscosity of glycerol.

density of steel = 7800 kg m^{-3}
density of glycerol =1300 kg m^{-3}

(4)

Terminal velocity $= \frac{0.50}{3.9}$
$= 0.128\ ms^{-1}$

Volume of steel $= \frac{4}{3}\pi r^3$
$= \frac{4}{3}\pi(4\times10^{-3})^3$

Viscosity, $\eta = \frac{V_g(\rho_s - \rho_l)}{6\pi r v}$

$\eta = \frac{\frac{4}{3}\pi(4\times10^{-3})^3 \times 9.81\ (7800-1300)}{6\pi(4\times10^{-3}) \times 0.128}$

$= 1.768416$
$= 1.8$

Viscosity of glycerol = 1.8 Pas

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Examiner Comments

Full marks were awarded for this response.

Speed (0.13 m/s) is calculated in the first two lines for MP1.

A calculation for volume is shown on the right hand side for MP2.
Both of these are substituted correctly into the equation on lines 5-7 to arrive at the correct final answer of 1.8. Although the unit Pa s is not given here it is written on the answer line.

ResultsPlus
Examiner Tip

Make full use of a copy of the data and formula sheet from the back of an exam paper throughout your course. That way you will become familiar with constants and formulae that are provided for you and where to find them. Some mathematical formulae such as the area of a circle and the volume of a sphere are not given. You need to learn these.

(b) (i) The student drops a steel sphere with a radius of 4.0 mm into a cylinder of glycerol. The sphere reaches terminal velocity and takes 3.9 s to fall 0.50 m.

Calculate the viscosity of glycerol.

density of steel = 7800 kg m^{-3}
density of glycerol = 1300 kg m^{-3}

0.4 cm
0.004 m

(4)

$\frac{4}{3}\pi r^3$

$\frac{4}{3}\pi(4\times10^{-3})^3 = 2.68\times10^{-7}$

$v = \frac{V_g(\rho_s - \rho_l)}{6\pi r\eta}$

$\eta = \frac{(2.68\times10^{-7}\times9.81)(7800-1300)}{6\pi(4\times10^{-3})(\frac{5}{39})}$

0.50 m / x m × 3.9 s / 1 s

$= \frac{5}{39}$

$\eta = 1.7684186$

$\eta = 1.8$

$\frac{kg\,m^{-3}\times m^3}{ms^{-2}}$

$kg\,m^{-1}s^2$

Viscosity of glycerol = 1.8 ~~kg m s^{-2}~~

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Examiner Comments

This is an example of a candidate achieving the correct numerical answer who has given incorrect units. The candidate has had a valid attempt to determine alternative units using base units (their working is shown) but has unfortunately not arrived at a correct answer so achieves 3 marks. Alternative units accepted are kg m^{-1} s^{-1} or N s m^{-2}.

ResultsPlus
Examiner Tip

If you cannot remember the unit a useful skill is to substitute units into an equation to arrive at alternative units for a quantity.

(b) (i) The student drops a steel sphere with a radius of 4.0 mm into a cylinder of glycerol. The sphere reaches terminal velocity and takes 3.9 s to fall 0.50 m.

Calculate the viscosity of glycerol.

density of steel = 7800 kg m^{-3}
density of glycerol =1300 kg m^{-3}

(4)

$s = \frac{d}{t}$

$s = \frac{0.50}{3.9} = 0.128 \text{ m/s}$

$6\pi r n v = gV(\rho_s - \rho_l)$ $\quad \frac{m/s^2 \cdot m^3 \cdot kg/m^3}{m \cdot m/s}$

$n = \frac{gV(\rho_s - \rho_l)}{6\pi r v}$

$n = \frac{9.81 \times \frac{4}{3}\pi \times (4\times10^{-3})^3 \cdot (7800 - 1300)}{6 \times \pi \times 4\times10^{-3} \times 0.128}$

$n = 1.77$

Viscosity of glycerol = 1.77 kg/s3

ResultsPlus
Examiner Comments

This response gets 3 marks.
It has the correct numerical answer but incorrect units.

Question 13 (b) (ii)

This requires a practical application of Stokes law. The question was not well answered.

A wider cylinder should be used as Stokes law applies when the sphere is falling in laminar flow and so reaches a steady velocity.

(ii) There are two cylinders available for the student to use. One cylinder has a diameter of 1.5 cm and the other has a diameter of 5.0 cm.

State and justify which cylinder the student should use in order to gain a more accurate value for the viscosity of glycerol.

(2)

The 5.0 cm cylinder as the wider tube will allow the ball to fully experience stokes law as it has a higher change of a laminar flow.

(Total for Question 13 = 9 marks)

ResultsPlus
Examiner Comments

This is an example of a rare correct answer which was awarded 2 marks.

(ii) There are two cylinders available for the student to use. One cylinder has a diameter of 1.5 cm and the other has a diameter of 5.0 cm.

State and justify which cylinder the student should use in order to gain a more accurate value for the viscosity of glycerol.

(2)

The ~~smaller~~ larger (5 cm) cylinder should be used to minimise the ball bearing hitting the edge causing friction.

ResultsPlus
Examiner Comments

Although the candidate has chosen the correct cylinder no marks are scored as the reason is incorrect.
A common insufficient answer was to mention that the ball would hit the sides of the cylinder.

(ii) There are two cylinders available for the student to use. One cylinder has a diameter of 1.5 cm and the other has a diameter of 5.0 cm.

State and justify which cylinder the student should use in order to gain a more accurate value for the viscosity of glycerol.

(2)

The bigger cylinder (5.0cm) as in the smaller cylinder the sphere would be touching the edges of the cylinder where there isn't laminar flow so the results would be inaccurate.

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Examiner Comments

A candidate may score marks by giving a reason in terms of the wider cylinder or why not the narrower cylinder. This candidate scores 1 mark for the idea that the narrower cylinder does not have laminar flow. The implication then is that the wider cylinder does have laminar flow.

Question 14 (a)

This is a question where a candidate could have scored full marks if they had learnt a definition for a longitudinal wave. It seemed as if candidates had not expected this question.

For MP2 there needed to be reference to oscillations of particles and the direction in which these oscillations occur - parallel to the direction of the propagation of the wave.

(a) Explain how a sound wave travels through air.

(2)

A sound wave is a longitudinal mechanical wave, that results from the oscillations of particles (requiring a medium) in the direction of propagation of the wave

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Examiner Comments

This is an example of an answer scoring 2 marks.

Longitudinal wave for MP1.

Particles oscillating in the direction of the propagation of the wave for MP2.

ResultsPlus
Examiner Tip

When describing a longitudinal wave it is important to mention the particles.

(a) Explain how a sound wave travels through air.

(2)

~~Sound~~ ~~Sound~~ Sound waves need a medium to travel through since they are longitudinal, ~~they~~ so they transfer energy through the help of the air particles.

ResultsPlus
Examiner Comments

This response was awarded one mark only for longitudinal waves. The candidate has the idea of the transfer of energy through particles but has not expressed this well.

Question 14 (b) (i)

On the first day students only took two measurements but felt the need to take a third measurement on the second day. This is because the two results taken on the second day were very different to each other so a third measurement would establish which the anomaly was.

(i) Deduce why the students thought it necessary to make a third measurement on day 2.

(1)

because the first 2 results were very different.

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Examiner Comments

This is an example of an answer which was awarded the mark.
It is insufficient to state that the readings were not in agreement as this does not establish in which way the results were not in agreement.

(i) Deduce why the students thought it necessary to make a third measurement on day 2.

(1)

Because the 2nd value on day 2 looks to be an anomaly

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Examiner Comments

Before taking the third measurement the students would not have known which result was the anomaly. This response is not awarded a mark.

Question 14 (b) (ii) - (iv)

This question was an analysis of a straightforward practical that can be easily carried out at school.

(ii) Many candidates were correctly able to calculate uncertainty.

(iii) A use of *v=s/t.* The most common error was to use *s=80 m,* forgetting the factor of 2.

(iv) Most students offered suggestions but these were often too vague showing little progress from GCSE. For example: simply stating 'human error' is insufficient, but qualifying this by stating 'human reaction time' is accepted. After completing an experiment in the lab thinking about the results obtained will be of benefit, asking questions such as 'how accurate is our result?', 'how could we make it more accurate and reduce uncertainties?', 'what other factors need to be taken into account?'...

(ii) Calculate the percentage uncertainty in the mean value of time on day 1.

(2)

$\frac{0.51 - 0.43}{2} = 0.04$ $\frac{0.04}{0.47} \times 100\% = 8.51\%$

Percentage uncertainty = 8.5%

(iii) Calculate the difference in the value for the speed of sound between day 1 and day 2 obtained from these results.

(2)

s = ~~80~~ 160 s = vt $t_1 = 0.47$ $t_2 = 0.46$

$v = \frac{s}{t}$ $v_1 = \frac{80 \times 2}{0.47} = ~~170~~ 340$

$v_2 = \frac{80 \times 2}{0.46} = 348$ ~~difference =~~

Difference in speed = 7.4m/s

(iv) The students state that the difference in the speed of sound between day 1 and day 2 is due to the change in air temperature.

Explain whether the results obtained are sufficient for this statement to be made.

(2)

Only two reliable time values were found for each temperature. Only a slight increase in speed was found, but the difference in the speed values ~~is~~ may be due to the uncertainties in the average times.

ResultsPlus

Examiner Comments

This response was awarded full marks in all parts - (b)(ii), (iii) and (iv).

Question 14 (c) (i)

This was a challenging question assessing the application of the reduction in the energy in waves as they move through a distance and standing waves.

Points A and B are nodes in the standing wave formed from destructive interference between the outgoing wave from the loudspeaker and the reflected wave from the reflecting board. These waves at point B will have similar amplitude as they have travelled similar distances and so near destructive interference occurs and the intensity at B is almost zero. At A the two waves have travelled different distances and so will have different amplitudes. The destructive interference will not be as complete, and so the intensity at A is greater than it is at point B.

(i) Explain why the intensity at point B is less than the intensity at point A.

(3)

firstly because the microphone is further away from the speaker also the sound waves would've lost more energy by the time they reach B compared to A hence the less intense the sound is at B.

ResultsPlus

Examiner Comments

This is an example of a common 1 mark answer. This candidate has ignored the fact that this is a standing wave but achieves 1 mark for MP1.

(i) Explain why the intensity at point B is less than the intensity at point A.

(3)

- Both A and B are points of minimum intensity (or nodes) where the waves meet out of phase.
- As the waves travel further away from source, wave energy decreases. (Oscillation amplitude decreases.
- Since point B further away from loudspeaker than A, it has lower intensity.

ResultsPlus

Examiner Comments

This candidate recognises this as a standing wave (line 1) and understands that intensity of a wave decreases with distance travelled (lines 3 and 4). Sadly they have not built on this and the final bullet point ignores the standing wave. The response scores 2 marks.

Question 14 (c) (ii)

As explained in the question there is a standing wave set up between the loudspeaker and the reflecting board. The distance between nodes in a standing wave is equal to half the wavelength. The low points shown in the graph are the nodes (destructive interference) so the distance from A to B will be one wavelength or the distance between adjacent nodes is half a wavelength.

Taking a measurement from the graph between A to B gives one wavelength as 0.16 m.

Most candidates used the correct equation but could score no more than one mark if they did not use a wavelength equal to 0.16 m.

(ii) Use the graph to determine a value for the speed of sound.

frequency of sound wave = 2.0 kHz

(3)

$v = \lambda f$

λ = distance between two maxima (crests)

= ~~0.08 m~~ 0.16 m

$v = ~~0.08~~ 0.16 \times 2000$ Hz

$v = 320 \text{ ms}^{-1}$

Speed of sound = 320 ms^{-1}

ResultsPlus
Examiner Comments

This correct answer scores 3 marks.
A common, incorrect answer was 160 m s^{-1} having used a value for wavelength of 0.08 m which is the distance between adjacent nodes - a candidate not appreciating that the graph is representing a standing wave.

Question 15

This question provided an open response to explain the observations made in the photoelectric effect. This lack of scaffolding assessed a candidate's ability to recognise what was relevant in order to explain the bullet points in the question.

There was a tendency for some to write far more than was necessary. Be very wary of repeating the information in the question. The points that are made are referring to frequency so answers were expected that made the link to energy of the photon or energy of the photoelectron. Some who did make the link to energy did not always make it clear whether they were referring to photons or electrons. The equation *E=hf* was often seen just written down without any reference to photons. This would have gained no credit as the candidate did not fully demonstrate that they understood the significance of the equation, only that they knew it was relevant.

Some answers failed to mention photons (or equivalent) at all, or to fully answer the question making no reference to waves.

Discuss how the photon model of electromagnetic radiation can explain these observations and why the wave model of electromagnetic radiation cannot.

(6)

The photon model says that $E=hf$ so the energy of each photon depends on the frequency, and since photons must have a certain energy to release electrons, this will only occur if the incident radiation is above a certain threshold frequency. If it is below this, photons don't have enough energy and so no electrons are released. It also explains that the kinetic energy depends on frequency, again because $E=hf$. Wave model does not explain these observations because it suggests that if any frequency is shone long enough it should have the required energy because energy is constantly transferred; this is not so. It also suggests that kinetic energy of electrons released should depend on intensity, not frequency, because a higher intensity should transfer more energy, but this does not happen.

(Total for Question 15 = 6 marks)

* and each photon (a discrete packet of electromagnetic radiation) interacts with a single electron.

ResultsPlus
Examiner Comments

This response scores 5 marks.

Indicative point 1: at the very end.

Indicative point 2: lines 1 and 2 - equation stated and linked to energy of photon.

Indicative point 3: lines 3 to 8.

Indicative point 4: not seen.

Indicative point 5: lines 8 to 12.

Indicative point 6: lines 12 to 14.

Total number of indicative points = 5 which gives 3 marks plus 2 linkage marks giving a total of 5 marks.

ResultsPlus
Examiner Tip

Consider using bullet points to write a well-structured, concise answer. Just ensure that the points made are in a logical order and points are clearly linked.

Discuss how the photon model of electromagnetic radiation can explain these observations and why the wave model of electromagnetic radiation cannot.

(6)

e = hf where h is constant so e and f are proportional to eachother. The threshold frequency is the minimum frequency at or past which electrons can be emitted. The equation shows that if f isn't high enough then e, the energy, won't be high enough either and the electrons are only emitted after a minimum energy. ~~[illegible]~~ Even if the energy isn't enough but it's on the metal plate for a while the electron won't be emitted, this would theoretically work with waves, if the energy built up however it doesn't which is why when the correct amount of energy is present then the electrons are emitted immediately

ResultsPlus
Examiner Comments

This response scores 1 mark.

This is a poor answer, with no mention of photons. *E=hf* is stated but with no reference to energy of photons so this gains no credit.

Although poorly expressed MP5 is just about awarded in the second half. With only one indicative point seen there can be no linkage and therefore no linkage mark awarded.

ResultsPlus
Examiner Tip

Photons are an important concept in physics and use of photons is expected when writing about the photoelectric effect.

Discuss how the photon model of electromagnetic radiation can explain these observations and why the wave model of electromagnetic radiation cannot.

(6)

The photon model tells us about the particle nature and behaviour of light, e.g. in photoelectric effect, a packet of energy (a photon) gives energy to an electron and if this energy is greater than the metal's work function, a photoelectron may be emitted. One photon can only cause 1 electron to be emitted. $E=hf$; the higher the frequency of the photon, the more energy it has, thus producing more energetic photoelectrons. Intensity will increase the number of photoelectrons emitted also. If the frequency of the photons is low, it will have less energy so it may not surpass the work function, but also, it may have a lower frequency than the threshold frequency, which will also make it impossible for photoelectrons to be emitted. Interference or diffraction do not explain these observations

ResultsPlus
Examiner Comments

This answer starts off well.

Indicative point 1: line 3 and also lines 5 and 6.

Indicative point 2: lines 5 to 7.

Indicative point 3: lines 4 and 5.

There is no clear reference to waves.

Indicative points = 3 which gives 2 marks + 1 linkage mark: total 3 marks.

Question 16 (a)

The most common reason given was the need for no further calculation, and most candidates were able to gain at least 1 mark.

Using two devices instead of one increases the overall uncertainty in the measurement. Most candidates did not appreciate this.

(a) Resistance can be measured directly using an ohmmeter or indirectly using measurements from a voltmeter and ammeter.

Describe **two** benefits of using an ohmmeter compared to using a voltmeter and an ammeter.

(2)

A Voltmeter and Ammeter would mean you would need to Calculate the resistance yourself.

An ohmeter doesn't require Current like a Voltmeter and can be

ResultsPlus
Examiner Comments

This is an example of a common 1 mark answer.

There was a misconception that an ohmmeter does not need a current. Whilst it should not be used with an external power source it does produce its own small current.

ResultsPlus
Examiner Tip

Make sure you know how to measure resistance using an ohmmeter as well as using a voltmeter and an ammeter.

(a) Resistance can be measured directly using an ohmmeter or indirectly using measurements from a voltmeter and ammeter.

Describe **two** benefits of using an ohmmeter compared to using a voltmeter and an ammeter.

(2)

It is more accurate as you are measuring it directly less room for error and there is less equipment that is needed to be set up

ResultsPlus
Examiner Comments

This answer failed to score any marks as it is too vague.

(a) Resistance can be measured directly using an ohmmeter or indirectly using measurements from a voltmeter and ammeter.

Describe **two** benefits of using an ohmmeter compared to using a voltmeter and an ammeter.

(2)

+ As the ohmeter only has one source of uncertainty whereas the other method can compound the uncertainties of the two measurements using a calculation.
+ Using an ohmeter will require less components.

ResultsPlus
Examiner Comments

This response scores 2 marks.

They have the idea that one device will have less uncertainty compared to two and that a calculation is needed when using an ammeter and voltmeter. (It is assumed that 'the other method' is the ammeter and voltmeter.)

There is nothing of credit in line 4.

Question 16 (b) (i)

Increasing the length of a wire increases overall resistance, so the applied force will cause the length and hence the resistance to increase.

(i) State and justify how the applied forces change the resistance of the wire.

(2)

$R = \frac{\rho l}{A}$ if the force is applied, the A will have a minimal decrease but the l will have a large increase making R, the resistance, larger

ResultsPlus
Examiner Comments

This answer scored both marks. Reference to a change in the cross-sectional area is ignored but this candidate also refers correctly to the length and justifies their answer with the relevant equation.

ResultsPlus
Examiner Tip

Take note when a question asks you to 'justify'. In this case it can be done by quoting an equation and referring to the quantities in the equation.

Stating that the 'resistance changes' is insufficient. This is stated in the question.

(i) State and justify how the applied forces change the resistance of the wire.

(2)

The applied forces increase the length of the wire and because $R \propto \frac{\rho l}{A}$, if the length increases so does the resistance, because the resistivity and the cross-sectional area stay the same.

ResultsPlus
Examiner Comments

This is a good 2 mark answer.

Question 16 (b) (ii)

This was a question involving the substitution of values into an unfamiliar equation.

Candidates needed to use two ideas:

- that ΔR/R = 0.1% = 0.001
- that strain ε = Δw/w and so ε = Δw/0.05.

With both of these substituted into the equation, the equation can then be rearranged to find change in width.

Calculate the change in the width of the strain gauge.

$w = 5.0$ cm
$GF = 2.0$

(3)

$2 = \frac{0.1}{100\varepsilon}$ $\varepsilon = \frac{0.1}{\frac{100}{2}} = 5 \times 10^{-4}$

$5 \times 10^{-4} = \frac{\Delta w}{w}$ $5 \times 10^{-4} \times (5 \times 10^{-2}) = \Delta w = 2.5 \times 10^{-5}$ m

Change in width = 2.5×10^{-5} m

ResultsPlus
Examiner Comments

This answer scored all 3 marks.

0.1/100 can be seen on the first line of working and a value for the strain calculated. On the second line of working the correct expression for the strain has then been used to determine the change in width.

ResultsPlus
Examiner Tip

The ratio between two values may be given as a numerical value between 0 and 1, or as a percentage.

Calculate the change in the width of the strain gauge.

$w = 5.0$ cm
$GF = 2.0$

(3)

$\varepsilon = \frac{\Delta x}{x}$ GFRR let $R = 1\,\Omega$

$GF = \frac{\Delta R}{\varepsilon R}$

$\varepsilon = \frac{\Delta R}{GFR} = \frac{1 \times 10^{-3}}{2 \times 1\,\Omega} = 2 \times 10^{-3}$

$\Delta x = \varepsilon x = 2 \times 10^{-3} \times 0.05 = 2.5 \times 10^{-5}$

Change in width = 2.5×10^{-5} m

ResultsPlus
Examiner Comments

This also scores 3 marks.

This candidate has arrived at a value for the ratio of the resistances by making an assumption that R=1 and so the change in resistance is 1×10^{-3}. This is numerically equal to expressing 0.1% as a fraction.

A common mistake seen was to substitute (ΔR)/R = 1.001, a correct manipulation of the % change in R (0.1%) which has then been added to 1.0. Remember, the ratio (ΔR)/R cannot be greater than 1, since the change in resistance is (considerably) less than 100%.

Calculate the change in the width of the strain gauge.

$w = 5.0$ cm
$GF = 2.0$

(3)

$2.0 = \frac{\Delta R}{\varepsilon R}$

$\varepsilon = \frac{\Delta x}{x}$

$\frac{\Delta x}{x} = 1 \times 10^{-3}$

$\left(\frac{\Delta x}{0.005}\right)$

$\varepsilon = \frac{\Delta x}{0.005}$

$2.0 = \frac{\frac{\Delta R}{R}}{\left(\frac{\Delta x}{0.005}\right)}$ → $\frac{0.1}{\left(\frac{\Delta x}{0.005}\right)100}$

$\left(\frac{\Delta x}{0.005}\right)200 = 0.1$ $= 2.5 \times 10^{-5}$ m

Change in width = ...

ResultsPlus
Examiner Comments

This response also scores 3 marks.

In the last two lines of the working both correct substitutions are made: ε=Δx/0.05 and ΔR/R=0.1/100.

Rearranging the equation then gives the correct numerical answer for the final mark.

Question 16 (c)

This is about the ability to detect a change in the resistance - the longer the wire the greater the change in resistance. It is the change in resistance that needs to be measured.

The answer should be a comparative answer since you are giving a comparison between two different things: the zig zag pattern and not using the zig zag pattern.

(c) Explain the benefit of arranging the wire in a zigzag pattern.

(2)

The zigzag pattern allows a bigger change in the length of wire therefore this increases the change in resistance.

ResultsPlus
Examiner Comments

This is a good 2 mark answer.

'bigger change in length' - comparative answer.

'increases the change in resistance' - a comparative answer describing a change in resistance.

ResultsPlus
Examiner Tip

An answer is comparative by using the adjectives 'longer', 'shorter', 'greater' etc.

(c) Explain the benefit of arranging the wire in a zigzag pattern.

(2)

More wire can be placed in a small area and can be stretched equally.

ResultsPlus
Examiner Comments

This answer scores zero. 'More wire' is not specific enough.

(c) Explain the benefit of arranging the wire in a zigzag pattern.

(2)

can get more change in length (multiplied.)

ResultsPlus
Examiner Comments

This is a typical 1 mark answer - links to an increase in length but no mention of the change in resistance.

Question 17 (a)

Section B can cover any part of the AS specification. On Paper 2, one question will contain a written passage. Question 17 on this paper is the passage question. Candidates are expected to read through the passage and then answer questions. The questions can be framed such that candidates are expected to use information given in the passage or use the information in the passage to provide a stimulus from which the questions can build.

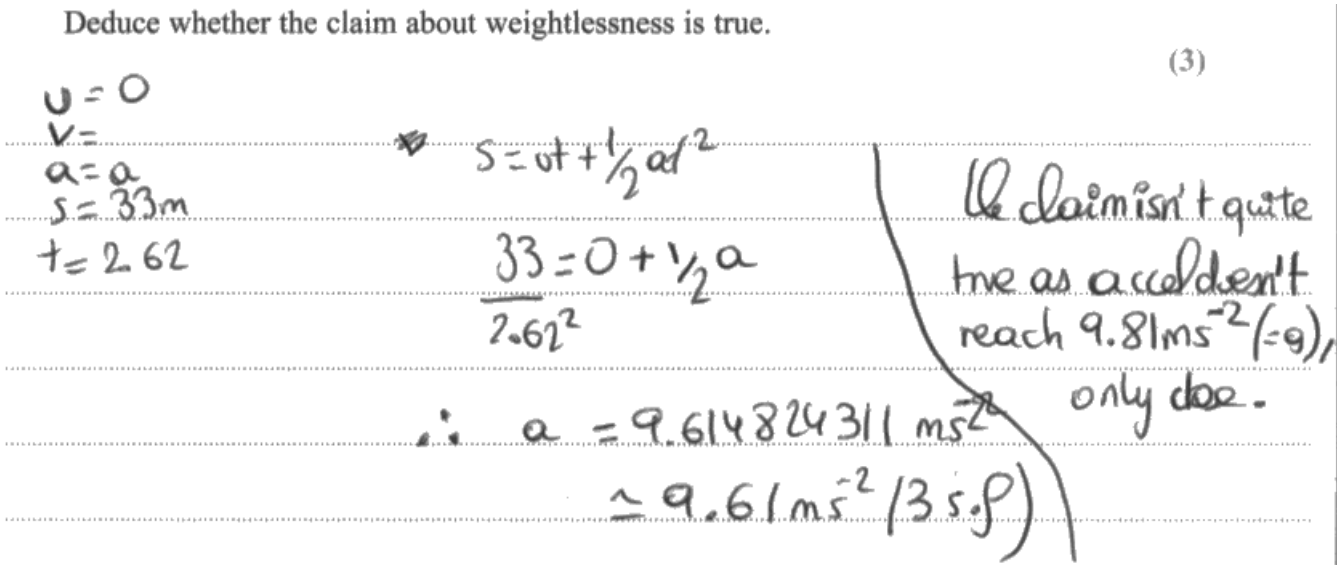
Both parts (a) and (b) require the candidate to make a conclusion. The command word 'deduce' indicates this.

The candidate is asked to deduce whether the claim about weightlessness is true. Candidates are expected to know that a falling object will feel weightless if their acceleration is equal to *g*. In order to answer the question, the acceleration of the rider needs to be calculated and this value compared to 9.81 m s^{-2}.

This requires correct use of a suvat equation, or a combination of suvat equations.

Deduce whether the claim about weightlessness is true.

(3)



ResultsPlus
Examiner Comments

This response scores 3 marks.

The candidate has used the correct suvat equation to calculate a value for acceleration of 9.61 m s^{-2}. They then give a valid conclusion by comparing 9.61 to 9.81.

The conclusion needs to be consistent with their calculated value. In this case, a correct calculated value may give one of two conclusions:

- is not weightless since 9.61 is less than 9.81

OR

- is nearly weightless since 9.61 is approximately equal to 9.81.

ResultsPlus
Examiner Tip

If two values are being compared in order to make a conclusion, then the two values being compared must be the same type of quantity, in this case both accelerations.

Deduce whether the claim about weightlessness is true.

(3)

$\frac{33}{2.62} = 12.595419 85\ ms^{-2}$

$\approx 12.6\ ms^{-2}$

$g = 9.81\ ms^{-2}$ $12.6 > 9.81$ therefore the claim about weightlessness is true.

ResultsPlus

Examiner Comments

This response scores 1 mark.

This candidate has not carried out the calculation correctly (they have calculated a velocity not an acceleration). However, they have compared their answer with 9.81 and made a correct conclusion consistent with their calculated value. They can therefore still achieve MP3.

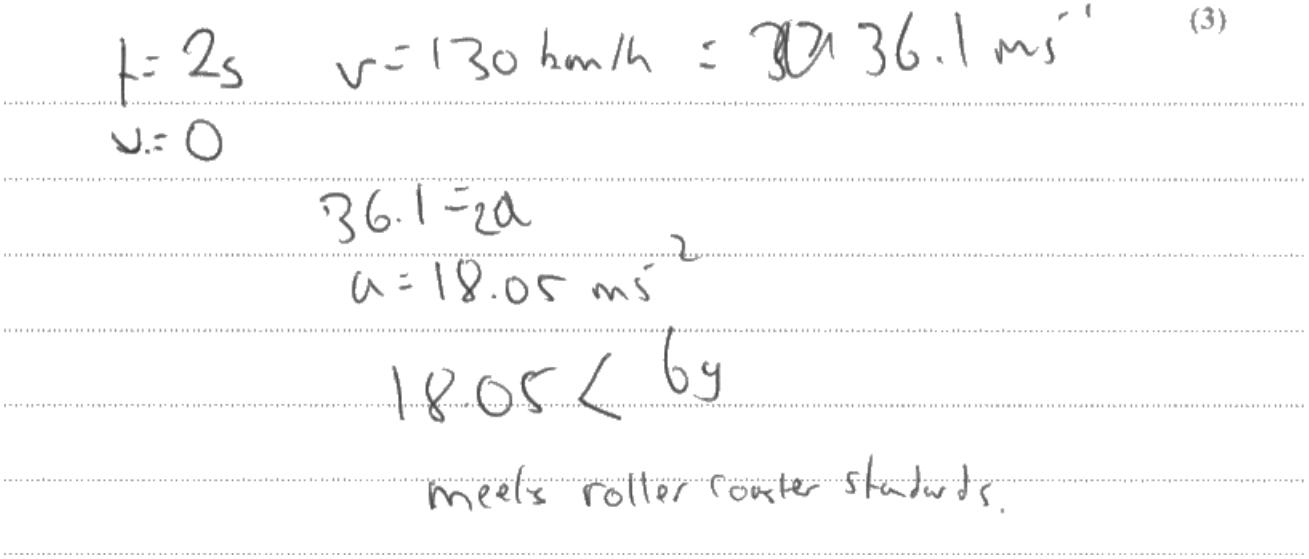
Question 17 (b)

This is another question in which candidates are expected to reach a conclusion, this time about the acceleration reached by the launched coasters. Candidates need to use the information given in the passage (3rd paragraph) to calculate an acceleration and then compare this to 6g as mentioned in the passage.

Many candidates were successful but a common mistake was in the conversion of km h^{-1} to m s^{-1}.

(b) As mentioned in the passage, large accelerations can also be achieved by *launched coasters* which launch the cars horizontally from their starting position.

Use the data in the passage to deduce whether the acceleration achieved in this way meets roller coaster standards. (3)



ResultsPlus
Examiner Comments

This response scores 3 marks.

It is a correct answer with correct units.

A comparison is made to 6g and a conclusion is given.

ResultsPlus
Examiner Tip

Don't forget units. This was one of only a few questions on this paper where unit errors started to appear, maybe caught out by the style of question, but a significant number gave m s^{-1} as the unit for acceleration.

Question 17 (c)

This was a challenging question at the end of the paper. Two marks, MP1 and 3, were given for making observations from the graph and so were accessible to most candidates, and so were the most common marks given. The other marking points relied on the application of physics in the given context of a rollercoaster to answer the question. The passage gave stimulus to guide candidates in the correct direction.

Discuss how the use of steel, rather than wood, has made the construction of faster and taller roller coasters possible.

(5)

Wood has much lower breaking stress
Steel is much stronger material and has a
higher youngs modulus so is stiffer.
Steel shows little extension/strain under high
stress whereas wood does. Steel has higher
elastic strain energy.

ResultsPlus
Examiner Comments

This response scores 3 marks.

Marking points 1 and 3 can be seen in the first 3 lines.

MP1: line 1 'wood has lower breaking stress' and also the alternative 'steel is stiffer' in line 3.

MP2: in line 4 comparison of extension under a given stress.

MP3 in line 2 - steel is stronger.

Discuss how the use of steel, rather than wood, has made the construction of faster and taller roller coasters possible.

(5)

Steel has a much larger ~~you~~ Young's modulus value. It is able to withstand much larger force with little change in the shape. It can overcome the force of the ~~the~~ Earth 'pull' accelerating (N_2 : F = ma)

The ultimate tensil stren of steel is much greater ~~than~~ than that of wood and breaking stress much greater which means steel can withstand a much larger force befor breaking, it is a stronger material. Because of the strength of steel, (high UTS) you can use much len which structures (smaller A). ~~the density of steel is smaller A~~

The smaller cross sectional area of steel used, despite its density allows faster construction as the parts made of steel are lighter.

(Total for Question 17 = 11 marks)

ResultsPlus

Examiner Comments

This is a strong 4 mark answer - and almost 5. The candidate has a good understanding of the graph and has linked this to the relevant points about the roller coaster in order to answer the question.

MP1: line 1, 'steel has a larger Youngs Modulus'.

MP2: lines 2 and 3 reference larger forces to little change in shape.

MP3: line 7 steel is stronger.

MP4: line 8 to the end - linking of force with A (cross sectional area).

MP5: very close in lines 3 and 4 but has not clearly linked faster cars with larger forces. It would be better written as 'withstand larger forces from the faster cars'. Also very close in the last three lines: they just needed to link smaller dimensions to the increased height in order to answer the question.

Paper Summary

This paper provided candidates with a wide range of contexts from which their knowledge and understanding of the physics contained within this unit could be tested. Whilst a sound knowledge of the subject was evident for many, sometimes candidates struggled to find the language to use in order to write precise and unambiguous answers. This will have prevented marks being awarded.

Based on their performance on this paper, candidates are offered the following advice:

- More practise of a wider range of questions in different contexts is needed in order to become more confident in applying physics in unfamiliar contexts.
- Carry out thorough analysis after practical work to consider factors involved that may or may not have affected the results and why.
- Learn definitions thoroughly. It seemed as if the description for a longitudinal wave, Question 14(a), and the definition for a virtual image, Question 12(a), were unexpected by many.
- Look at the number of marks available for the question and ensure you include a sufficient number of different points in your answer. Remember that you gain no credit for simply repeating the question.

Grade Boundaries

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