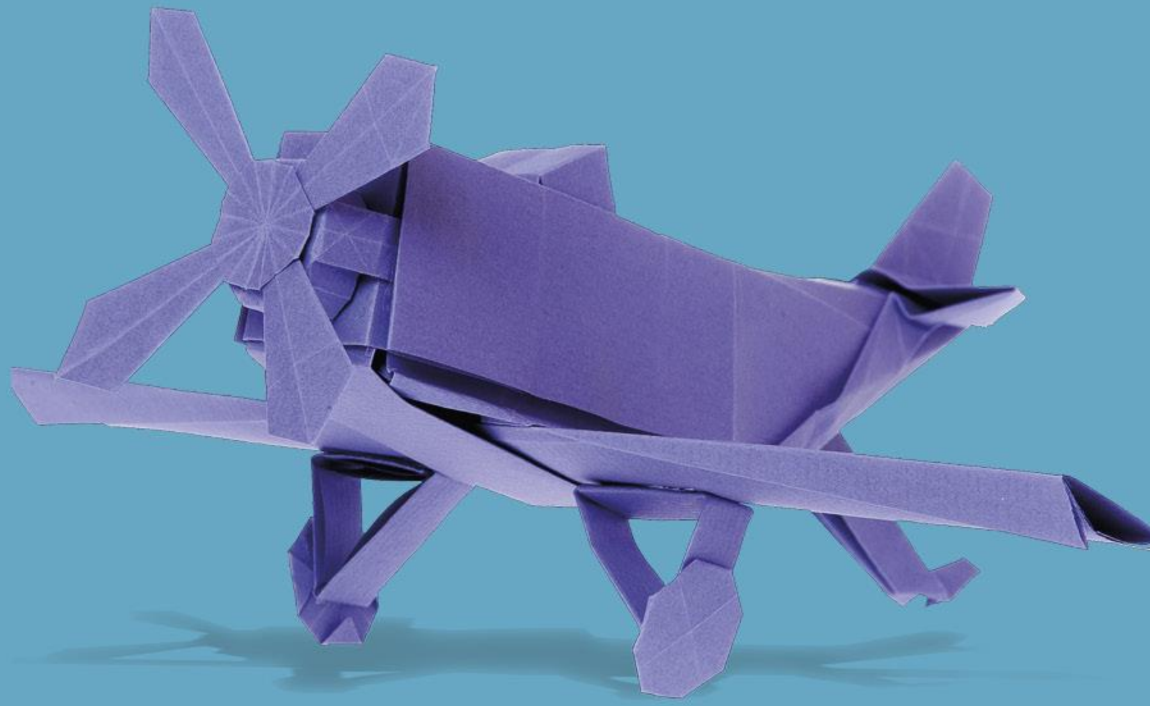
Pearson Edexcel A level Physics

Feedback on the June 2019 series – Papers 1, 2, and 3.



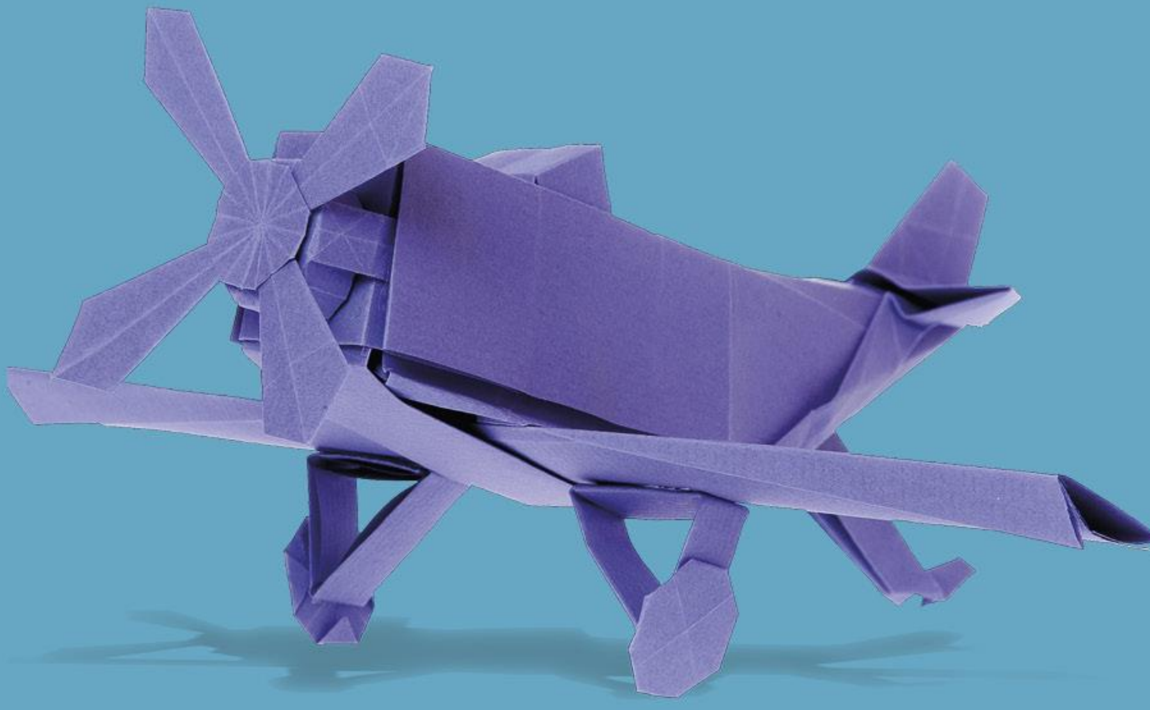
Aims and Objectives

1. Receive feedback on national performance of candidates on A level papers 1, 2 and 3 of the Summer 2019 examination series.
2. Consider the variation of candidates' performance on different questions and possible reasons why.
3. Discuss the Examiner Reports by looking at example answers to questions.
4. Address common issues and FAQs

Session Agenda

- Introduction and overview of assessment (5 minutes)
- Looking at examples of student responses from across the three papers (50 minutes)
- Common issues across the papers (5 minutes)

Assessment Model

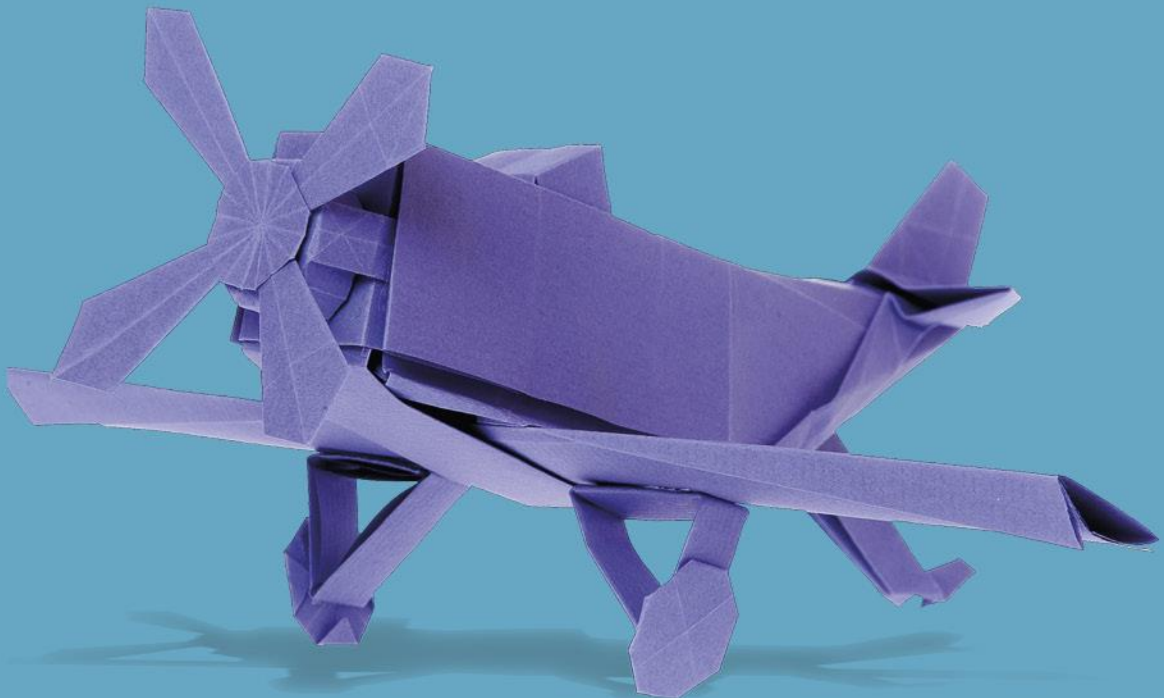


A level Physics Assessment model

Paper 1	Paper 2	Paper 3
1h 45mins 90 marks Topics 6, 7 & 8 (drawing on AS Topics 1–3) 30% of A level	1h 45mins 90 marks Topics 9 - 13 (drawing on AS Topics 1, 4 & 5) 30% of A level	2h 30mins 120 marks All topics – half the paper is practical 40% of A level

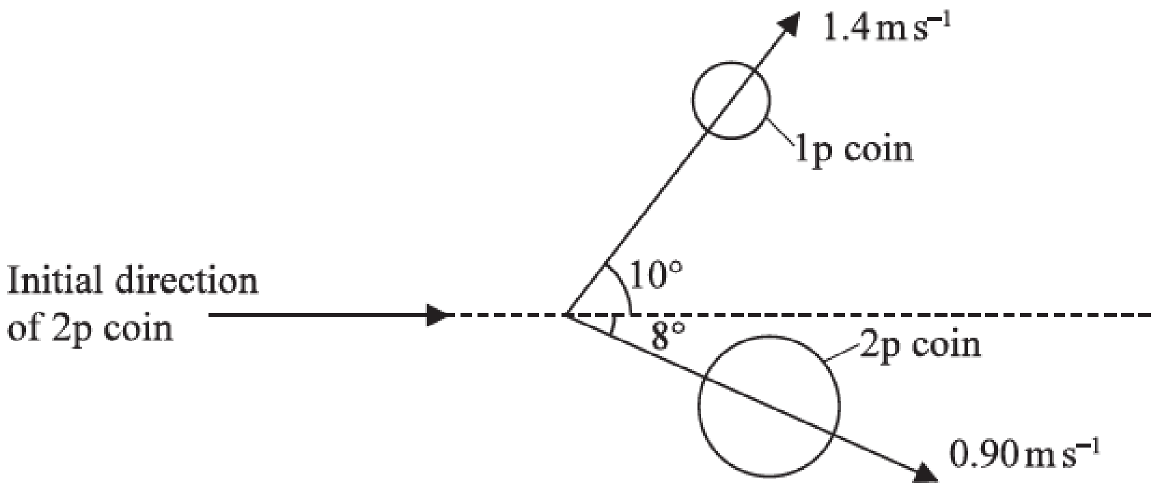
Examples of Student Responses:

Feedback strand 1: unstructured calculations



Paper 1, Q14b

(b) She arranged a collision between a 2p coin and a stationary 1p coin. She noted the directions in which the coins moved after the collision and determined their velocities.



(i) Show that the velocity of the 2p coin just before the collision was about $2\,\mathrm{m\,s^{-1}}$.

mass of 2p coin = 7.1 g

mass of 1p coin = 3.6 g

Paper 1, Q14b – example 1

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(4)

Momentum is Conserved

$0.0036\text{kg} \times 1.4\cos 10^\circ \text{ms}^{-1} + 0.0071\text{kg} \times 0.90\cos 8^\circ \text{ms}^{-1}$

$=$ ~~7.24~~ $0.0071\text{kg} \times V$

~~2.7459×10^{-3}~~ $= 0.0071\ V_1$

0.01129

$1.590.. = V_1$

$V_1 = 1.6\text{ms}^{-1}$

(ii) Show that the collision was inelastic.

(2)

Initial KE: $\frac{1}{2} \times (0.0071\text{kg})(1.590..)^2 = 8.978 \times 10^{-3}$

KE after: $\frac{1}{2} \times (0.0071\text{kg})(0.90)^2 + \frac{1}{2}(0.0036)(1.4)^2$

$= 6.404 \times 10^{-3}$

to 2sf:

in.. 9.0 mJ after 6.4 mJ

KE not conserved
Inelastic

(Total for Question 14 = 12 marks)

Paper 1, Q14b – example 2

Momentum is always conserved.

$p = mv$

$m_2 u_1 = m_1 v_1 + m_2 v_2$

$(7.1) u = (7.1)(1.4\cos 10) + (3.6)(0.9\cos 8)$

$7.1 u = 9.79 + 3.21$

$u = 1.83\ ms^{-1}$

$u = 1.8\ ms^{-1}$

(ii) Show that the collision was inelastic.

(2)

E_k before $\neq$ E_k after for inelastic.

$\frac{1}{2} m_2 u^2 = \frac{1}{2} m_1 v_1^2 + \frac{1}{2} m_2 v_2^2$

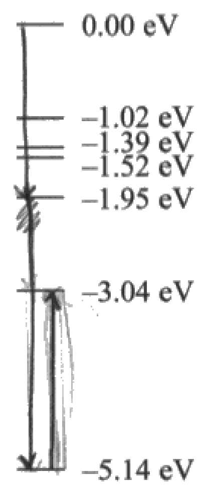
$\frac{1}{2}(7.1)(1.8)^2 = \frac{1}{2}(3.6)(1.4\cos 10)^2 + \frac{1}{2}(7.1)(0.9\cos 8)^2$

$11.5 = 2.4 + 3.1$

Since $11.5\ J \neq 5.5\ J$, the collision was inelastic.

Paper 1, Q17c – example 1

(c) The diagram shows some of the energy levels in a sodium atom.



Add an arrow to the diagram to show the transition involved in the emission of yellow light of wavelength 589 nm.

Show your working below.

(4)

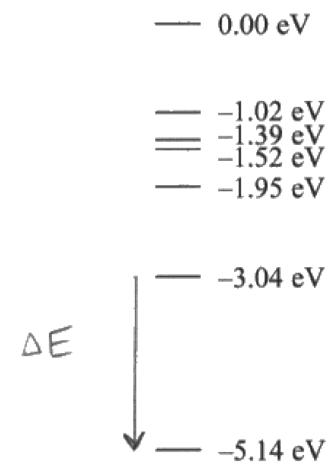
$E = hf$ $\qquad$ $v = f\lambda$

$E = 6.63 \times 10^{-34} \times 5.09 \times 10^{14}$ $\qquad$ $f = \frac{v}{\lambda} = \frac{3 \times 10^{8}}{5.89 \times 10^{-7}}$

$= 3.37467 \times 10^{-19}$ $\qquad$ $= 5.09 \times 10^{14}$

$= 2.109\,eV$

Paper 1, Q17c – example 2



Add an arrow to the diagram to show the transition involved in the emission of yellow light of wavelength 589 nm.

Show your working below.

(4)

$\Delta E = hf = \frac{hc}{\lambda} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{589 \times 10^{-9}} = 3.38 \times 10^{-19}\,J$

$= 2.10\,eV$

This corresponds to a drop from −3.04eV to −5.14eV

Paper 2, Q16a

16 The photograph shows an example of a Foucault pendulum.

This is a pendulum that consists of a massive sphere, suspended by a long wire from a high ceiling. Over time the vertical plane through which the pendulum swings appears to rotate because of the rotation of the Earth.

mass of sphere = 28.0 kg

(a) The pendulum makes 8 complete oscillations in 52.2 s.

Show that the length of the wire supporting the sphere is about 10 m.

diameter of sphere = 60.0 cm

Paper 2, Q16a – example 1

(4)

$T = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = \frac{52.2}{8} = 6.525\ \text{s}$

$\frac{T}{2\pi} = \sqrt{\frac{l}{g}}$ $\quad \frac{T^2}{4\pi^2} = \frac{l}{g}$ $\quad l = \frac{gT^2}{4\pi^2}$

$l = \frac{9.81 \times 6.525^2}{4\pi^2} = 10.6\ \text{m}$

radius $= 0.3\ \text{m}$, $\therefore$ wire $= 10.6 - 0.3$

$= 10.3\ \text{m}$

$\approx 10\ \text{m}$

Paper 2, Q16a – example 2

$T = 52.2 \div 8 = 6.525$

ms 28.0

$d = 60.0$

$T = 2\pi\sqrt{\frac{d}{g}}$

$= \frac{T}{2\pi} = \sqrt{\frac{l}{g}}$ $\left(\frac{T}{2\pi}\right)^2 g = l = 10$

$\left(\frac{6.525}{2\pi}\right)^2 \times 9.81 = 10.19$

10.2 m

Paper 3, Q8a – example 1

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(a) A stone of mass 19.6 kg is accelerated uniformly for 1.25 s before being released by a curler. The stone then decelerates uniformly to rest, travelling 32.5 m in a time of 17.5 s.

Calculate the average useful power developed by the curler in accelerating the stone.

(4)

$s = 32.5$
$u = ?$
$v = 0$
$a =$
t

$s = 32.5$
$u = ?$
$v = 0$
$a = X$
$t = 17.5$

$v^2 = u^2 + 2as$ $\quad v = u + at$

$\frac{v-u}{t} = a$

$v^2 = u^2 + 2\left(\frac{v-u}{t}\right)s$

$0 = u^2 + 2\left(\frac{0-u}{17.5}\right)32.5$

$a = \frac{3.71}{1.25} = 2.97\,ms^{-2}$ $\quad \frac{26u}{7} = u^2$ $\quad u = 3.71\,ms^{-1}$

$\frac{1}{2} \times 19.6 \times (3.71)^2 = 135.2\,J$ $\quad \frac{135.2}{1.25} =$

Average power = 108 W

Paper 3, Q8a – example 2

Pearson Edexcel

(a) A stone of mass 19.6 kg is accelerated uniformly for 1.25 s before being released by a curler. The stone then decelerates uniformly to rest, travelling 32.5 m in a time of 17.5 s.

Calculate the average useful power developed by the curler in accelerating the stone.

(4)

$s = 32.5$
$u = 3.71$
$v = 0$
$a = ?$
$t = 17.5$

$s = \frac{(u+v)t}{2}$

$2s = (u+v)t$

$u = \frac{2s}{t} - v$

$u = \frac{2 \times 32.5}{17.5} - 0$

$u = 3.71 \text{ ms}^{-1}$

$v = u + at$

$a = \frac{v-u}{t}$

$a = \frac{0 - 3.71}{17.5}$

$a = -0.212 \text{ ms}^{-2}$

$W = mad$

$W = 19.6 \times 0.212 \times 32.5$

$W = 135.2$

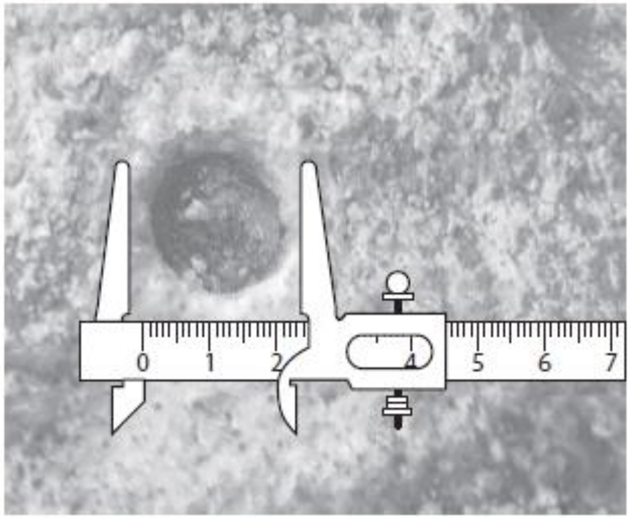
$P = \frac{E}{t} = \frac{135.2}{17.5} = 7.73 \text{ W}$

Average power = 7.73 W

Paper 3, Q12a

12 Impact craters are formed when meteorites strike the surface of a planet. A student investigated some factors that might influence the formation of impact craters. He did this by dropping spheres of modelling clay into a tray of sand.

The diameter of the crater produced by each sphere was measured using vernier calipers as shown.



This process was repeated for spheres of different diameters.

Paper 3, Q12a – example 1

Determine the factor by which the kinetic energy of the sphere just before impact increases when the sphere diameter is increased from 2.0 cm to 4.0 cm.

(3)

$m = \rho \times V$ $\qquad$ $mgh = mgh$

$V = \frac{4}{3}\pi(0.01)^2$ $\qquad$ $\rho \frac{4}{3}\pi(0.01)^2 = \frac{4}{3}\pi(0.02)^2 \rho$

$V = \frac{4}{3}\pi(0.02)^2$ $\qquad$ $0.0001 \cdot 0.0004$

increases by factor of 4

Factor = 4

Paper 3, Q12a – example 2

Determine the factor by which the kinetic energy of the sphere just before impact increases when the sphere diameter is increased from 2.0 cm to 4.0 cm.

(3)

Density = $\frac{M}{V}$ M = Density × volume

$\frac{4}{3}\pi(2)^3 = 33.50$ $\frac{4}{3}\pi(4)^3 = 268.08$

volume = $\frac{4}{3}\pi r^3$ volume increases b 8

so mass increases by 8 so E_k increases by 8

Factor = 8

Paper 3, Q12a – example 3

Determine the factor by which the kinetic energy of the sphere just before impact increases when the sphere diameter is increased from 2.0 cm to 4.0 cm.

(3)

$V = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi \frac{d^3}{8} = \frac{1}{6}\pi d^3$

$m = \rho V = \frac{1}{6}\pi \rho d^3$

$E_K = \frac{1}{2}mv^2 = \frac{1}{12}\pi \rho d^3 v^2$, v is constant as $a = 9.81$ for any mass

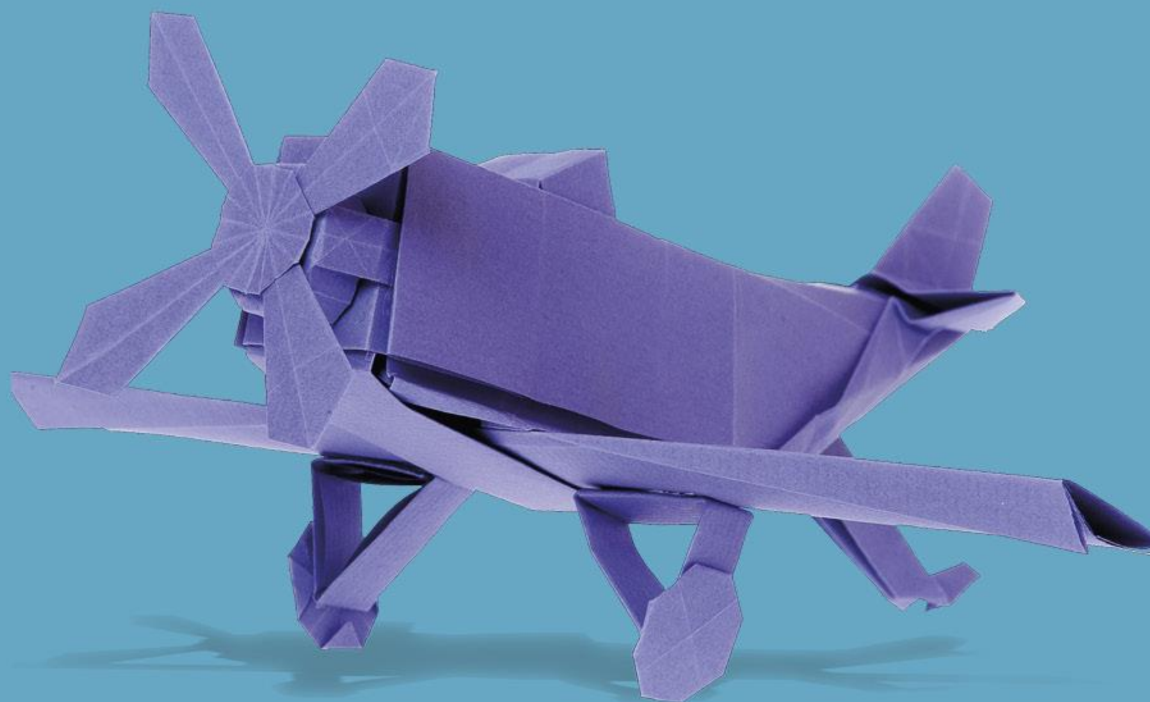
, ρ is constant

if d doubles E_K increases by $2^3 = 8$

Factor = 8

Examples of Student Responses:

Feedback strand 2: deduction questions



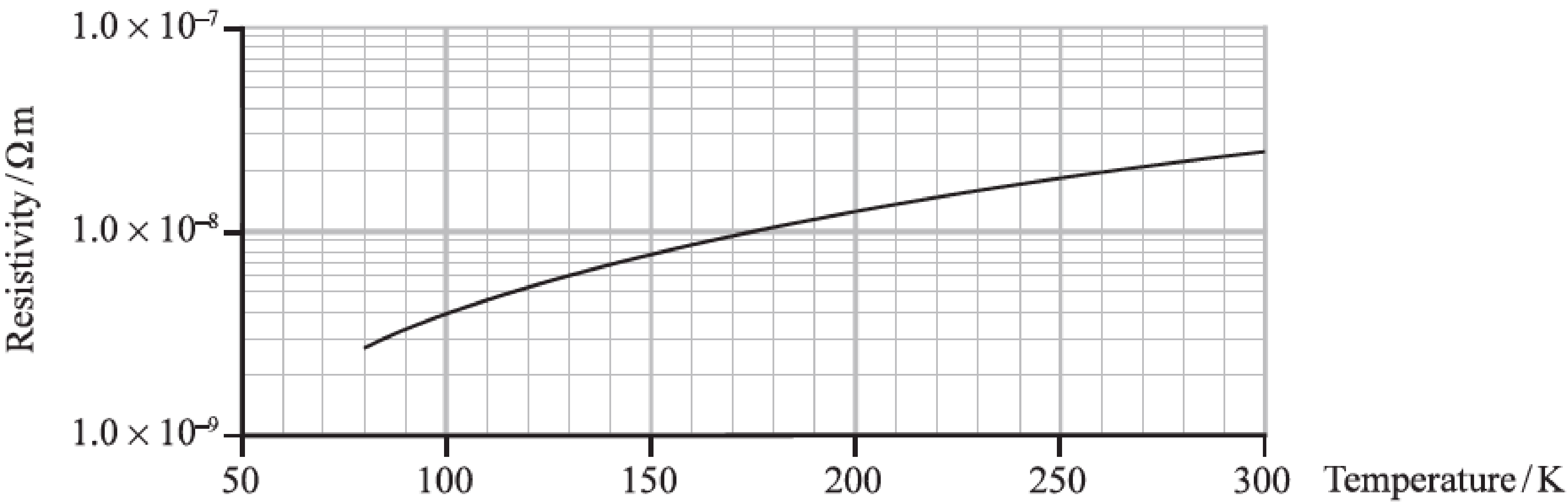
Paper 1, Q12b

Pearson Edexcel

(b) Efficient electrical transmission systems are being developed using superconductors. Superconductors have zero resistance at low temperatures, and therefore no power is wasted by transfer to thermal energy unlike copper cable systems.

In one project a 1.05 km length of copper cable at a temperature of 270 K has been replaced by a superconductor. The superconductor has a cooling system which requires power.

The graph shows the variation of resistivity with temperature for copper.



Deduce whether the power requirement of the superconductor cooling system is less than the power losses in the copper cable.

Paper 1, Q12b – example 1

Pearson Edexcel

(3)

$1.1 \times 10^{-8}\ \Omega m$ at $270K$ $\quad 1mm^2 = 1mm \times 1mm = 1\times10^{-3} \times 1\times10^{-3} = 1\times10^{-6}\ m^2$

$$R = \frac{1.1\times10^{-8} \times 1.05\times10^{3}}{145\times10^{-6}\ m^2} = 0.79655\ \Omega$$

~~P=IV~~ ~~V=~~ ~~V=IR~~

$P = IV \quad V = IR \quad I = \frac{V}{R}$

$$P = \frac{V^2}{R} = \frac{110\times10^{3}}{0.79655} = 138\ kW$$

138 kW lost from resistance on copper cable, Power requirement of Superconductor 7kW,

Superconductor more cost efficient.

Paper 1, Q12b – example 2

When T is 270K, the resistivity ρ is 2.1×10^{-8}

$$\therefore R = \frac{\rho l}{A} = \frac{2.1\times10^{-8} \times 1.05\times10^{3}}{145\times10^{-6}} = 0.152\,\Omega.$$

$P = 40M$. $V = 110k$ $\therefore I = \frac{P}{V} = 363.6A$.

$$\therefore P = I^2 \times R = 20099\ W.$$

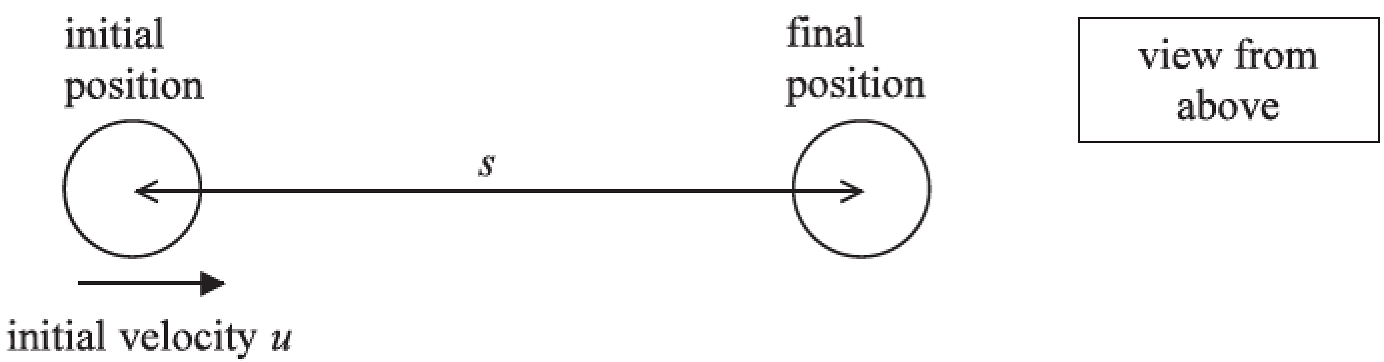
as 20099 is ~~smaller~~ greater than 7000

∴ the power requirement of the superconductor cooling system is less than the power losses in the copper cable.

Paper 1, Q14a

14 A student carried out an experiment with coins.

(a) She gave a 2p coin a sharp tap, so that it slid along a horizontal surface and came to rest as shown.



The student recorded the distance s moved by the coin.

She then replaced the 2p coin with a 1p coin and repeated the process.

The student read that the frictional force between an object and a surface is directly proportional to the mass of the object. She suggested that, in her experiment, u is directly proportional to $\sqrt{s}$ and is independent of the mass of the coin.

Discuss the validity of this suggestion.

(6)

Paper 1, Q14a – example 1

~~Directly proportional friction comes from the~~

Newton's Second law states that the change in momentum of an object is proportional to the force, therefore the decrease in mass will result in an increase in Velocity for the same force.

Paper 1, Q14a – example 2

As the coin comes to rest, its initial kinetic energy is dissipated due to work done against the frictional forces. As a result, $KE_{initial} = W$, so $\frac{1}{2}mu^2 = Fs$ where F is the frictional force. Since the frictional force is directly proportional to mass, we can let $F = km$ where m is mass and k is a constant. Thus, as before, $\frac{1}{2}mu^2 = kms$. Now, the mass cancels out and we obtain $\frac{1}{2}u^2 = ks$. $\therefore u^2 = 2ks$, $u = \sqrt{2k}\sqrt{s}$, and so we see that u is directly proportional to $\sqrt{s}$, since $\sqrt{2k}$ is a constant. Thus the student's suggestion is correct.

(However, the frictional force may also depend on other factors such as the contact area between the surface and coin, which would be different for the 1p and 2p coins.

Paper 1, Q14a – example 3

Coin provided with kinetic energy equal to $\frac{1}{2}mu^2$, which is lost till it reaches zero after a displacement of s.

~~Where frictional force is equal to the mass of object~~

Where work done is equal to frictional force multiplied by displacement.

$$\frac{1}{2}mu^2 \longrightarrow F_{friction} \times s$$

Therefore assuming the only frictional force against motion is by surface, $\frac{1}{2}mu^2 = F_{friction}s$

$$\therefore \; u^2 = \frac{2F_{friction}s}{m}$$

$$u = \sqrt{\frac{2F_{friction}s}{m}}$$

For constant frictional force and mass of object, u is directly proportional to $\sqrt{s}$, however u is not independent of the mass of the coin.

Paper 2, Q11

11 A wet handkerchief is dried in 56 s using a hot iron rated at 2400 W.

Determine whether energy is transferred to the water in the handkerchief at a greater rate than it is transferred to the iron.

initial temperature of wet handkerchief = 18 °C

initial mass of wet handkerchief = 35.9 g

final mass of dry handkerchief = 18.2 g

specific heat capacity of water = 4.19×10^3 J kg^{-1} K^{-1}

specific latent heat of vaporisation of water = 2.26×10^6 J kg^{-1}

(5)

Paper 2, Q11 – example 1

(5)

$P = \frac{E}{t}$ $P = 2400\,W$ $t = 56\,s$ $\Rightarrow$ $E = 134400\,J$

$\Delta E = \Delta E$ $\therefore$ $mc\Delta\theta = \Delta m L$

$\therefore$ $(35.9\times10^{-3})(4.19\times10^{3})(T-18)$

$= (35.9\times10^{-3} - 18.2\times10^{-3})(2.26\times10^{6})$

$\Rightarrow (T-18) = 265.93\ldots$ $\Rightarrow$ $T = 265.9^\circ C$

Paper 2, Q11 – example 2

$E = mc\Delta\theta$

$E = L\Delta m$

0.0359 - 0.0182

$E = 2.26\times10^6 \times (~~35.9 - 18.2~~)$

$= 40,0025$

$E = 35.9 \times 4.19\times10^3 \times 18$

$E = 2707578$

$P = E/T$

~~P =~~ $E = Pt$

$E = 2400 \times 56$

$= 134400$

$E = 2707578 - 40,002$

$E = 2667576$

(Total for Question 11 = 5 marks)

∴ ~~heat~~ transferred to water quicker

Paper 2, Q11 – example 3

Pearson Edexcel

$E_{iron} = Pt = 2400 \times 56 = 134400 \text{ J}$

$\Delta m = 35.9 - 18.2 = 17.7 \text{ g} = 0.0177 \text{ kg}$

$E_{water} = L\Delta m + mc\Delta\theta = 2.26 \times 10^6 \times 0.0177 + 0.0177 \times 4.19 \times 10^3 \times (100 - 18)$

$= 46080 \text{ J}$

$46080 < 134400$

$E_{water} < E_{iron}$ so $P_{water} < P_{iron}$

So the energy is transferred to the watter & is not at a greater rate than it is transferred to the iron.

Paper 3, Q4

4 A student carried out an experiment to determine the focal length of a converging lens.

He placed the lens a distance u from an illuminated object. He placed a screen on the other side of the lens and moved the screen until a sharp image of the object was produced. He measured the corresponding image distance v.

The student repeated the procedure for four more values of u.

In his lab report he wrote:

"I made an initial determination of the focal length of the lens and concluded that it was about 15 cm. When I plotted a graph it confirmed my initial determination of the lens focal length."

The student's graph is shown.

Paper 3, Q4 – example 1

Comment on whether the student's data is consistent with his initial determination of the focal length of the lens.

(5)

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

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

$y = mx + c$

$\therefore \frac{1}{f} = y \text{ intercept} = 0.066$

$\therefore f = \frac{1}{0.066} = 15.2 \text{ cm}$

∴ The student's data is consistent with his initial determination as 15.2cm ≈ 15cm

Paper 3, Q4 – example 2

Comment on whether the student's data is consistent with his initial determination of the focal length of the lens.

(5)

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

$1/v = 0.046$ $1/u = 0.02$

~~$1/v = \frac{1}{0.046}$ ... $1/u = 0.0217$ ... 50 cm~~

(point 2 = 0.03 + 0.035
$1/f = 0.065$
$f = \frac{1}{0.065} = 15.4$ cm)

(point 1 = 0.046 + 0.02 = 0.066 cm = $1/f$
$f = \frac{1}{0.066} = 15.15$ cm)

This is very close to 15 cm so the student's inital determination was correct.

Point 2 is also very close to 15 cm so the students initial determination was correct.

Paper 3, Q5b

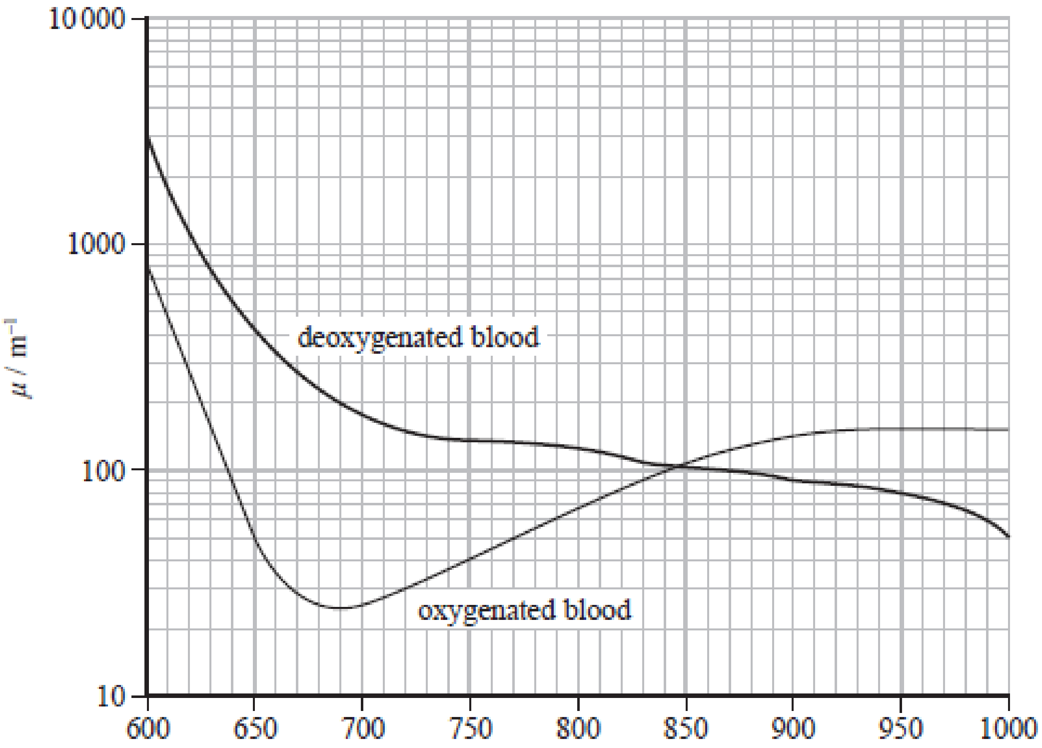
The intensity I of electromagnetic radiation received by the detector, after passing through a thickness x of blood, is given by

$$I = I_0 e^{-\mu x}$$

where I_0 is the intensity that would have been received if the blood were not present and μ is the attenuation coefficient of blood.

The red LED emits visible light of wavelength 650 nm and the infrared LED emits infrared of wavelength 950 nm.

The graph shows how μ varies with wavelength λ for oxygenated blood and deoxygenated blood.



Paper 3, Q5b – example 1

Pearson Edexcel

Deduce whether I/I_0 will be smaller for the red or the infrared radiation if the blood is deoxygenated.

(3)

$I_0 = 1.8$ I is smaller ∴ deoxygenated blood as at 950nm deoxygenated blood has a lower [illegible] than oxygenated blood.

Paper 3, Q5b – example 2

Pearson Edexcel

Deduce whether I/I_0 will be smaller for the red or the infrared radiation if the blood is deoxygenated.

(3)

$\mu_{red LED} > \mu_{IR}$ $\quad \frac{I}{I_0} = e^{-\mu x}$ $\quad \mu\uparrow, I\downarrow$

as the value of μ is greater for the red LED, the value of I is smaller, I_0 remains constant so $\frac{I}{I_0}$ for the red is smaller

Paper 3, Q5c – example 1

(c) Deduce whether the light from such a lamp would have a significant effect on the oximeter readings.

(3)

$\lambda T = 2.898 \times 10^{-3}$

$\lambda = \dfrac{2.898 \times 10^{-3}}{3200\ \text{k}} = 905.6\ \text{nm}$

~~Not~~ No, the produced λ is too far away from the ~~wr~~ λ to make ~~a~~ difference in the reading.

(Total for Question 5 = 9 marks)

Paper 3, Q5c – example 2

(c) Deduce whether the light from such a lamp would have a significant effect on the oximeter readings.

(3)

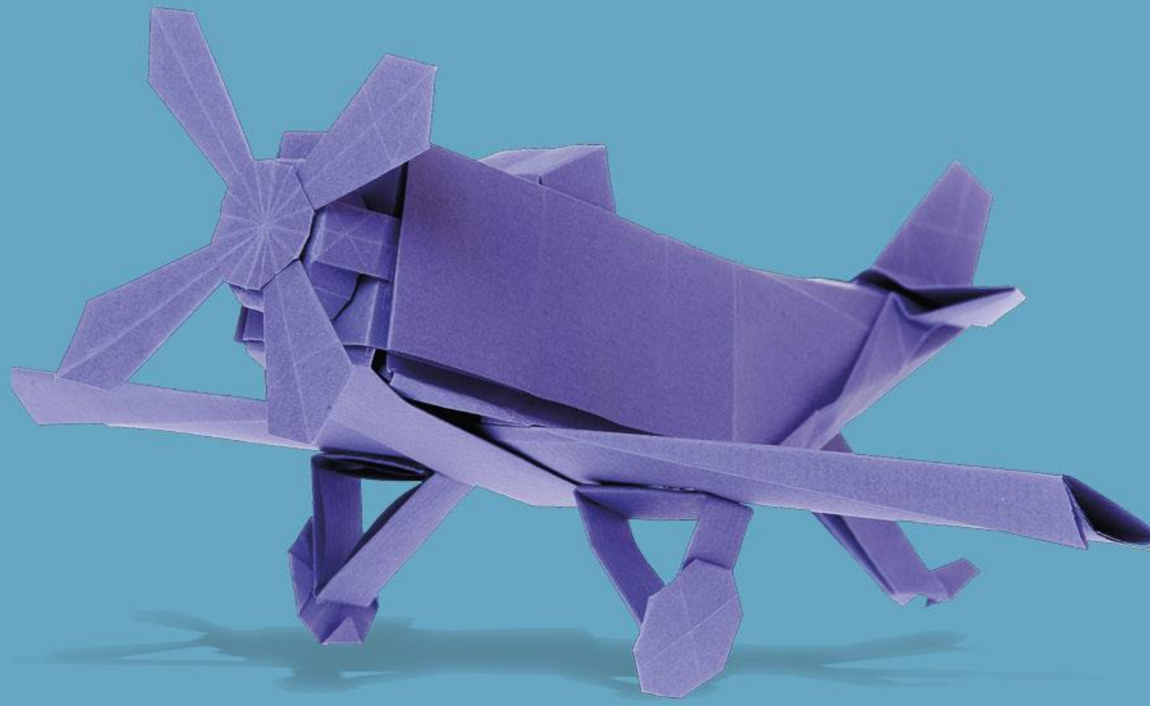
$\lambda_{max} = \frac{2.898 \times 10^{-3}}{T} = \frac{2.898 \times 10^{-3}}{3200} = 9.06 \times 10^{-7} m$

$= 906 nm$

It would have a significant effect as 906 ≈ 950 so it will provide inaccurate results

Examples of Student Responses:

Feedback strand 3: linkage questions



Paper 1 Q16biv (6 marks)

*(iv) The muons are produced at a height of 10 km in the atmosphere. The velocity of the muons is 0.99 c. The average lifetime for muons is normally 2.2 μs and yet muons produced in the upper atmosphere are found in significant numbers at sea level.

Discuss this apparent anomaly.

(6)

Marking Scheme

Pearson Edexcel

<table>
<tr><th>Question Number</th><th>Acceptable answers</th><th>Additional guidance</th><th>Mark</th></tr>
<tr><td>*13</td><td>
This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning.

Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning.

The following table shows how the marks should be awarded for indicative content.

<table>
<tr><th>Number of indicative marking points seen in answer</th><th>Number of marks awarded for indicative marking points</th><th>Max linkage mark available</th><th>Max final mark</th></tr>
<tr><td>6</td><td>4</td><td>2</td><td>6</td></tr>
<tr><td>5</td><td>3</td><td>2</td><td>5</td></tr>
<tr><td>4</td><td>3</td><td>1</td><td>4</td></tr>
<tr><td>3</td><td>2</td><td>1</td><td>3</td></tr>
<tr><td>2</td><td>2</td><td>0</td><td>2</td></tr>
<tr><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
The following table shows how the marks should be awarded for structure and lines of reasoning.
</td><td>Guidance on how the mark scheme should be applied: The mark for indicative content should be added to the mark for lines of reasoning. For example, an answer with five indicative marking points which is partially structured with some linkages and lines of reasoning scores 4 marks (3 marks for indicative content and 1 mark for partial structure and some linkages and lines of reasoning). If there are no linkages between points, the same five indicative marking points would yield an overall score of 3 marks (3 marks for indicative content and no marks for linkages).</td><td>6</td></tr>
</table>

Paper 1, Q16biv – example 1

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(6)

Muons can be found in significant numbers at sea level because even though they have a lifespan of ~ 2.2 μs, they travel at close to the speed of light, meaning they can easily travel 10km before they decay. This can be proven by multiplying the speed of light by the lifespan and determining whether or not the distance they have travelled is greater than 10 km (or 10,000m).

Eg. $3 \times 10^8 \text{ ms}^{-1} \times 2.2 \times 10^{-3} \text{ s} = 6.6 \times 10^5 \text{ m}$

which is greater than 1×10^4 m.

Paper 1, Q16biv – example 2

This is because of the relativistic ~~to~~ lifetimes ~~of~~ the muons

$0.99(3 \times 10^5) = \frac{10 \times 10^3}{t}$ $t = 3.36 \times 10^{-5}$ s ← this is the time we experience

this time is larger than 2.2 μs. This is because as far as the muon is concerned, it is travelling at its own, fast speed. ~~where its~~ It's lifetime being indeed 2.2μs. But because of ~~time d~~ time dilation, ~~we see~~ time slows down for us meaning ~~we~~ that we are ~~able~~ able to detect muons at sea level, as they haven't decayed completely yet (to us)

Paper 1, Q16biv – example 3

$S =$ ~~[illegible]~~ $\qquad s = ut$

$U = 0{\cdot}99c$ $\qquad S = 0{\cdot}99 \times 3\times10^{8} \times 2{\cdot}2\times10^{-6}$

$V = 0{\cdot}99c$

A $\qquad = 653{\cdot}4\,m$

$T = 2{\cdot}2\times10^{-6}$

$653{\cdot}4\,m < 10{,}000\,m$

The muons should decay well before they reach sea level. However, they are travelling at relativistic speeds which increases their lifetime in relation to time on earth.

Time passes faster on earth than for the muon due to ~~the~~ its relativistic speed.

0·99c is very close to speed of light, this is known as relativistic speed.

Paper 2, Q13

.3 The photograph shows a 'singing bowl'.

When the handles are rubbed with both hands the bowl 'sings', producing a loud note with a frequency of 720 Hz.

A vibration generator is attached to the bowl and connected to a signal generator. The signal generator is adjusted to produce frequencies from 600 Hz to 800 Hz.

At all frequencies in this range the bowl produces a sound at the applied frequency. The sound is quiet for all frequencies except 720 Hz, when it is much louder.

Explain these observations.

Paper 2, Q13 – example 1

Reasonance. When an object has external frequencies the same as its natural frequency, reasonance occurs. The amplitude of the vibrations will increase and hence the sound will be louder. When the vibration generator is at 720Hz this is the same frequency as the singing bowl and so reasonance will take place. This will mean the waves will vibrate more and the amplitude will increase, making the sound louder. When the generator is from 600Hz to 800Hz but not at 720Hz, there will be no reasonance and so the sound will be much quieter because the bowl is experiancing a forced frequency.

(Total for Question 13 = 6 marks)

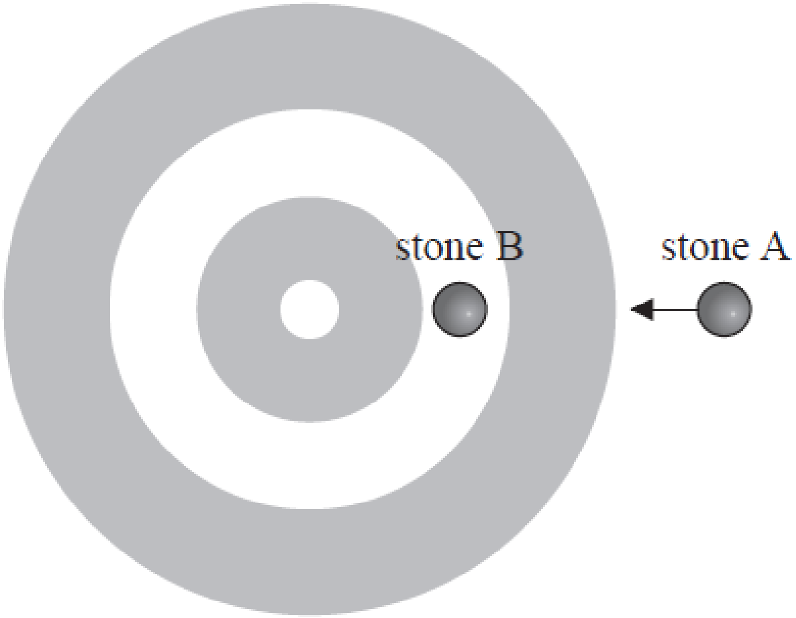
Paper 2, Q13 – example 2

(6)

The bowl is ~~sp~~ designed to undergo resonance, the signal generator provides a driving frequency to the bowl. The water in the bowl causes dampening, causing it to resonate with a wider range of frequencies. When the signal generator applies 720 Hz, the bowl's natural frequency, it will resonate at its peak resonant frequency, causing the sound to be much louder.

Paper 3, Q8b

*(b) Stone B is stationary. Stone A travels towards the target and makes a direct hit on stone B as shown. Both stones have mass m.



The collision is elastic. Just before the collision stone A has a velocity v. After the collision stone B moves off with velocity v.

Discuss how the relevant conservation laws apply to this collision.

(6)

Paper 3, Q8b – example 1

Discuss how the relevant conservation laws apply to this collision.

(6)

Conservation of momentum will apply. This means the total initial momentum of the system, in this case mv, must equal the total momentum of the system after the collision. Therefore, as B moves with velocity v, it has momentum mv, meaning A must stop moving ~~Because the coll~~ The total energy in the system is also conserved, and because it is an elastic collision, total kinetic energy is also conserved. Initially, it is given as $E_k = \frac{1}{2}mv^2$, then because the mass and velocity of B is equal to what A had, the total E_k in the system is exactly the same.

Paper 3, Q8b – example 2

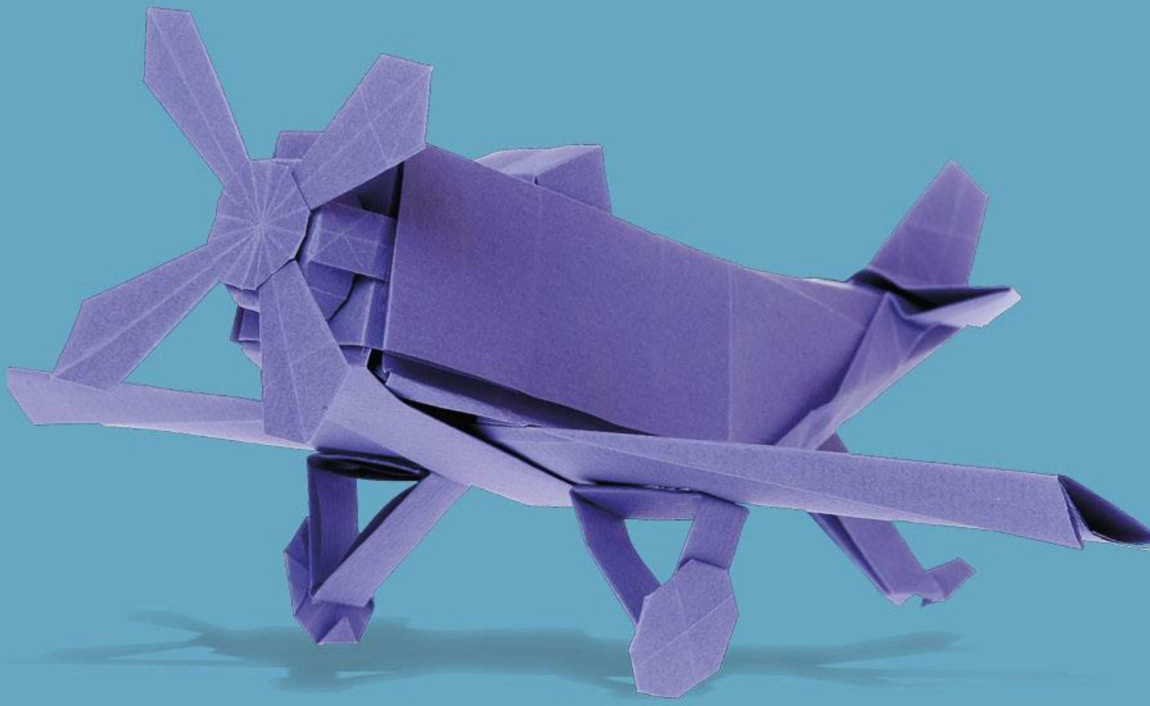
Discuss how the relevant conservation laws apply to this collision.

(6)

Since the collision is elastic, Kinetic Energy is conserved. Momentum is always conserved in a system when no external forces are acting. Since the stones are on ice, friction is negligible so no external forces act. Therefore, momentum is conserved (air resistance is also negligible). Thus mv = mv + 0m, so all the kinetic energy and momentum is transferred from stone A ~~to~~ to stone B ~~and~~, stone B moves with the same velocity of stone ~~AB~~ A before collision and in the same direction and stone A ~~remains~~ ~~station~~ becomes stationary.

Examples of Student Responses:

Feedback strand 4: experimental skills

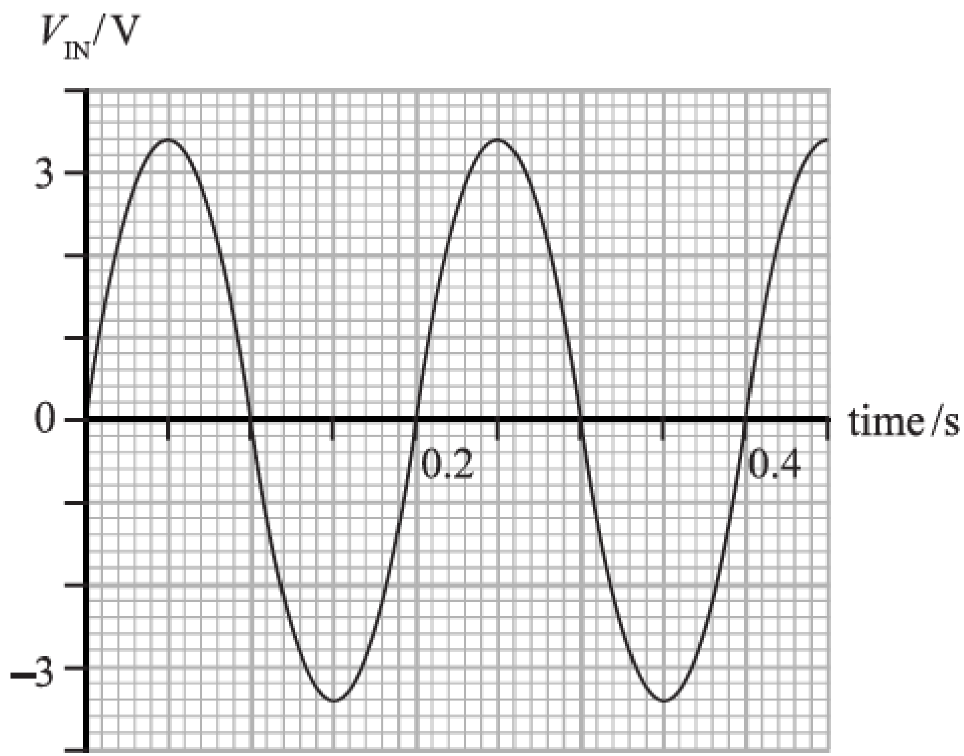


Paper 1, Q15biii

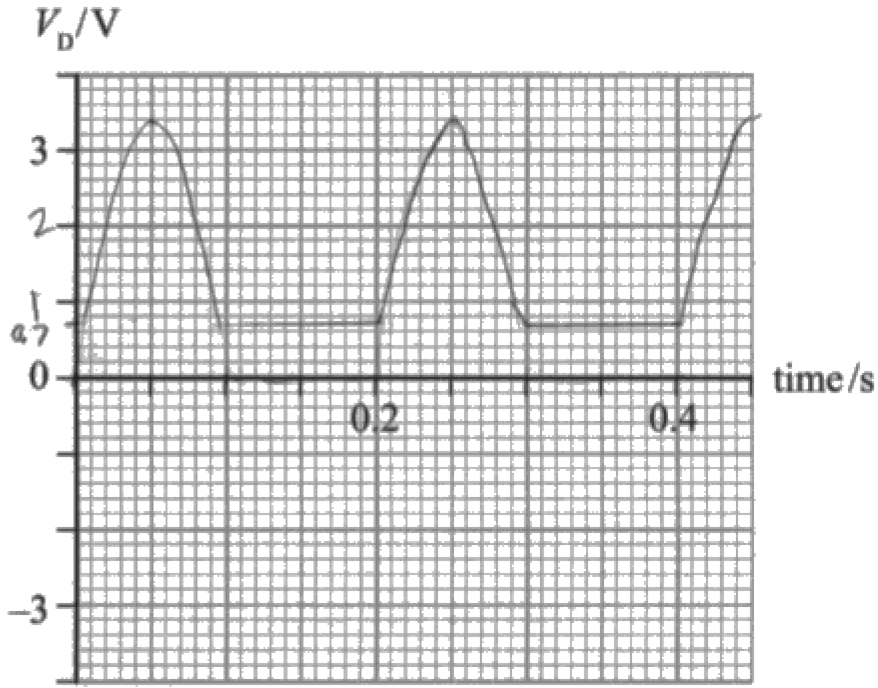
(iii) The graph shows how V_{IN} varies with time.

Sketch a graph of V_D against time using the axes provided below.

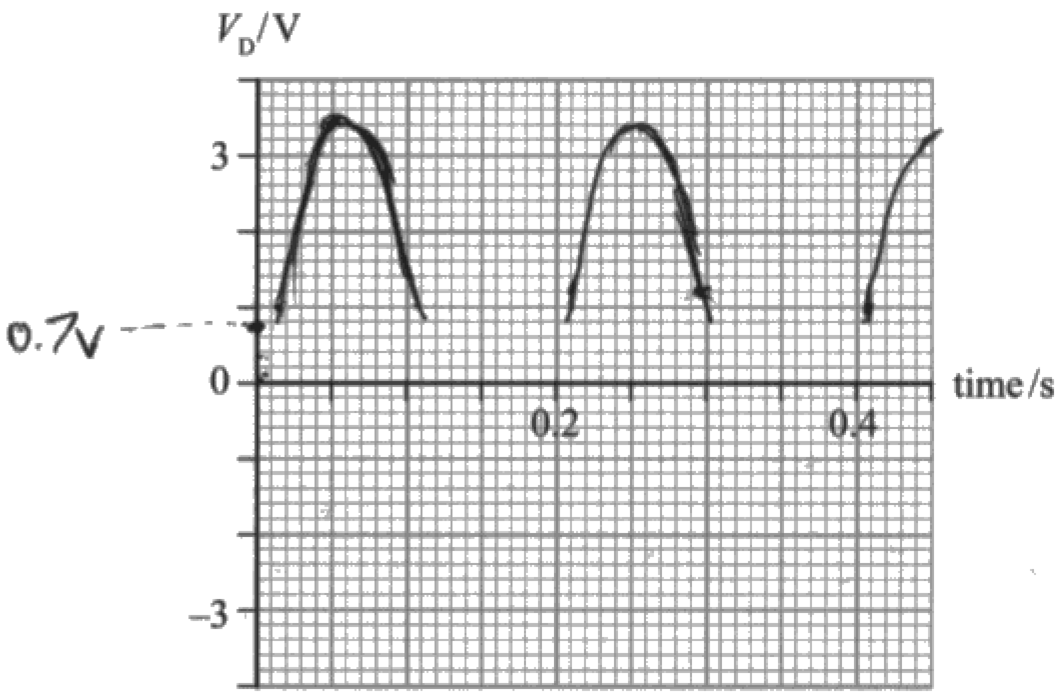
(3)



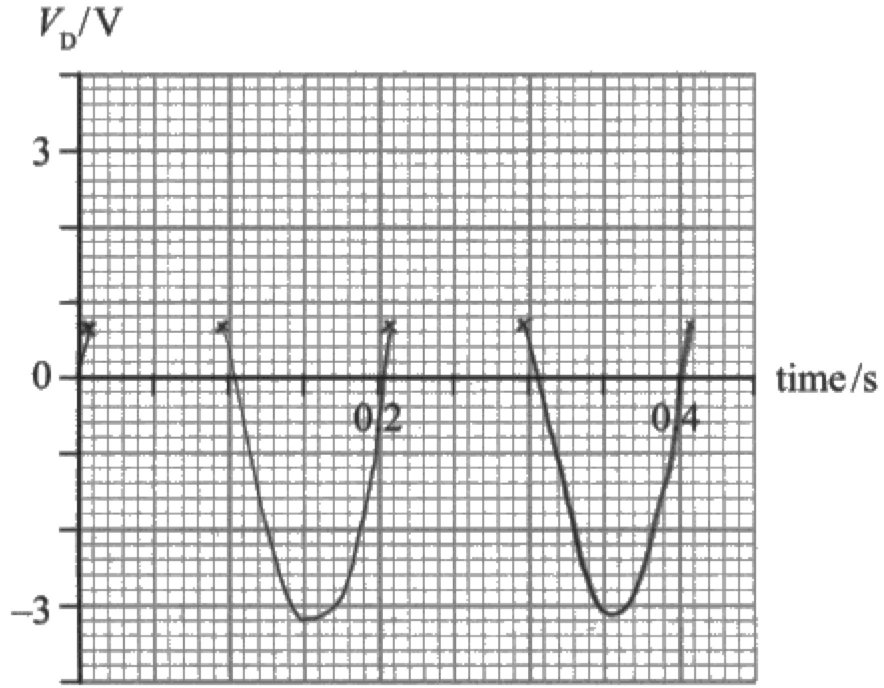
Paper 1, Q15biii – example 1



Paper 1, Q15biii – example 2

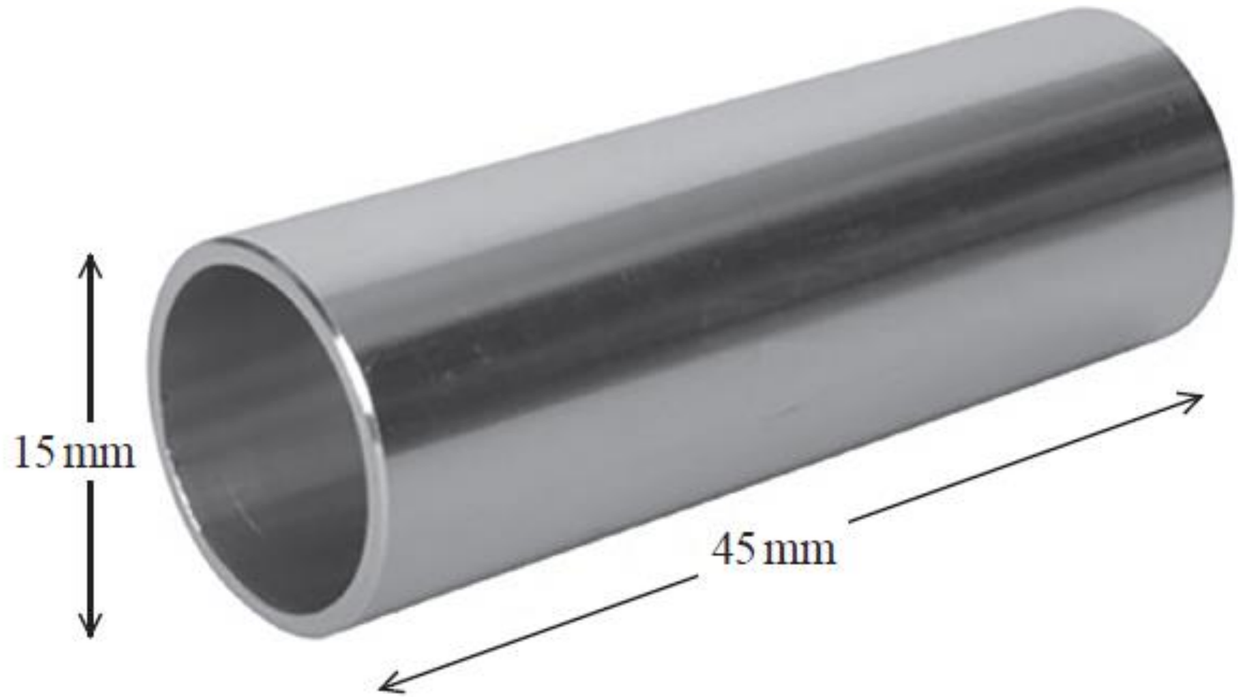


Paper 1, Q15biii – example 3



Paper 3, Q1b – example 1

1 An engineer was checking the dimensions of a steel tube. The tube had a length of about 45 mm and an external diameter of about 15 mm as shown.



She used a digital micrometer to measure the diameter of the tube. Before taking the reading she closed the jaws of the micrometer to check for a zero error.

Paper 3, Q1b – example 1

(3)

She should repeat her measurements multiple times to avoid random errors, and also measure the diameter at multiple points along the tube to make sure the tube has the same diameter all the way along it.

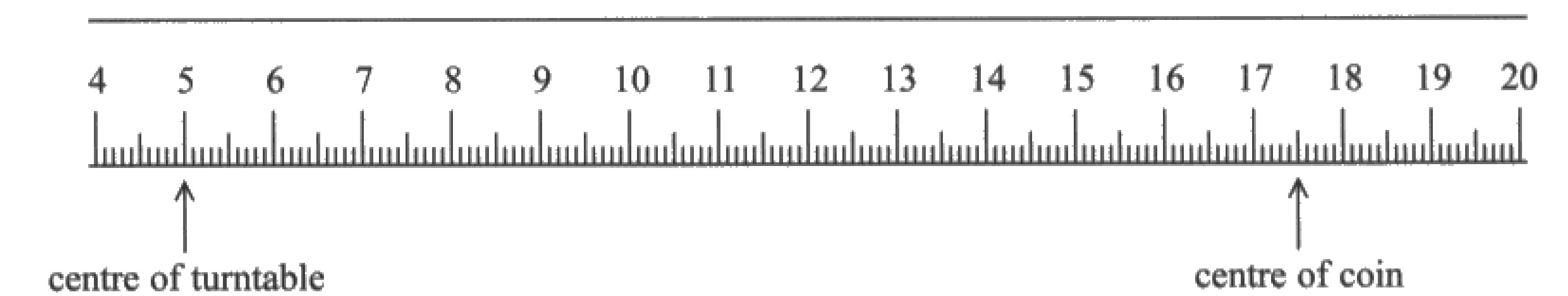
Paper 3, Q1b – examples 2 & 3

Use the micrometer to measure the external diameter of the tube, take multiple readings at different points along the tube, ~~[illegible]~~ measure the diameter at atleast ~~the~~ 3 points and calculate the mean diameter of the tube.

(3)

She should measure the diameter in several places along the tube and at different~~s~~ angles. e.g  . Then taken away any zero error and find the mean average (reducing effect of ~~zero~~ random error).

Paper 3, Q3a – example 1



Explain why the percentage uncertainty in the value of *r* is about 1%.
Your answer should include a calculation.

(3)

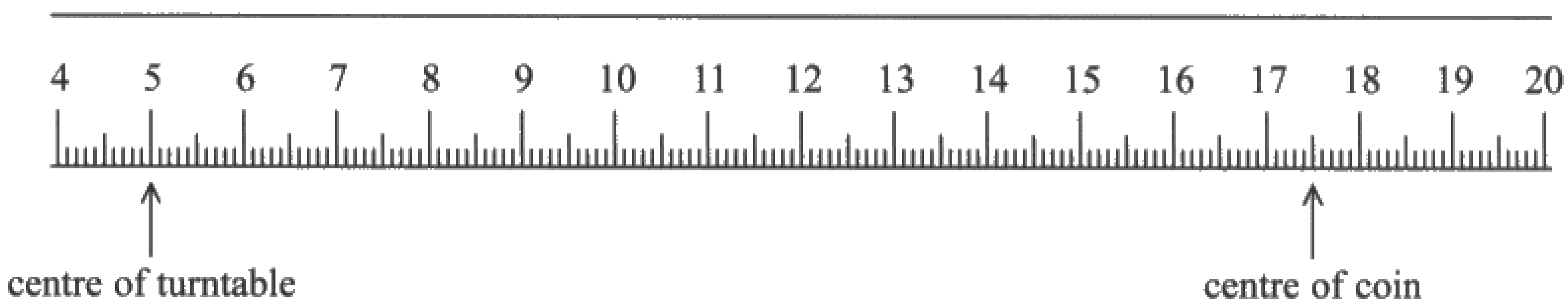
ruler uncertainty = ± 0.5mm

17.5 − 5 = 12.5

$\frac{0.5}{12.5} \times 100$

= 0.4% ≈ 1%

Paper 3, Q3a – example 2



Explain why the percentage uncertainty in the value of r is about 1%.
Your answer should include a calculation.

(3)

$r = 0.175 - 0.05 = 0.125$ metres $= 125$ mm

1 mm is the resolution in the metre rule therefore the uncertainty is ± 0.5mm $= \pm 5 \times 10^{-4}$ m. However, the uncertainty is at both ends therefore the total uncertainty is $\pm 1 \times 10^{-3}$ m.

Therefore $\frac{1 \times 10^{-3}}{0.125} \times 100 = 0.8\% \approx 1\%$

Paper 3, Q3bii&iii – example 1

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(ii) Calculate the percentage uncertainty in the mean value of ω.

(3)

$\frac{Range}{Mean} \times 100 = \%U$

Mean $= \frac{0.125 + 0.112 + 0.118 + 0.123 + 0.116}{5}$

$= 0.1188$

$= 0.119$

$\%U = \frac{(0.125 - 0.112)}{0.119} \times 100 = 10.9 = 11\%$

Percentage uncertainty = 11%

(iii) The student used ω and r to calculate the centripetal acceleration of the coin at the instant it started to slide.

Calculate the percentage uncertainty in this centripetal acceleration.

(3)

$a = r\omega^2$

$\%U = (\%U_r) + (2 \times \%U_\omega)$

$= 1 + 2 \times 11$

$= 23\%$

Percentage uncertainty = 23%

Paper 3, Q3bii&iii – example 2

(ii) Calculate the percentage uncertainty in the mean value of ω.

(3)

uncertainty = $\frac{\text{range}}{2}$ = $\frac{0.013}{2}$ = 0.0065

mean = 0.1188 $\frac{0.0065}{0.1188}$ × 100 = 5.47138

= 5.5%

Percentage uncertainty = 5.5%

(iii) The student used ω and r to calculate the centripetal acceleration of the coin at the instant it started to slide.

Calculate the percentage uncertainty in this centripetal acceleration.

(3)

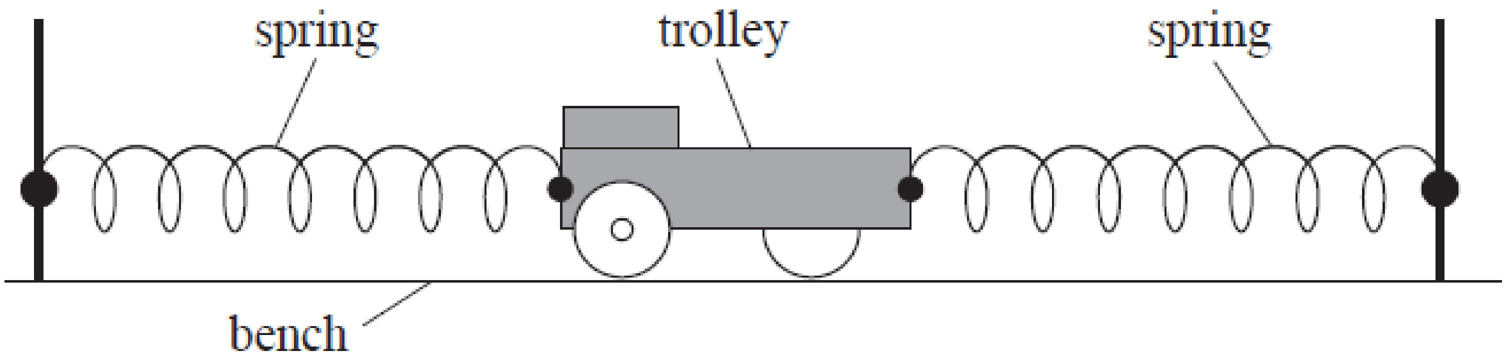
$a = r\omega^2$

= 0.4% + 5.5% + 5.5% = 11.4%

Percentage uncertainty = 11.4%

Paper 3 Q7ai (6 marks)

7 A trolley is attached to the ends of two springs as shown. When displaced from its equilibrium position, the trolley moves with simple harmonic motion.



(a) A student has a stopwatch and metre rule available.

(i) Explain the procedure that the student should follow to make an accurate determination of the time period *T* of the trolley.

Paper 3, Q7ai – example 1

(i) Explain the procedure that the student should follow to make an accurate determination of the time period T of the trolley.

(6)

The student should note the position of equillibrium of the trolley as the center of the bench using the rule and then displace the trolley to one side of the bench.
Then let the spring go and measure the time it takes for the trolley to pass over the center. They shouldn't measure the first oscillation as the force initially applied may skew the data. After this measure the next ~~3~~ 4 oscillations an take an average for their time. Then multiply this average by 2 to get the period T of the trolley.

Paper 3, Q7ai – example 2

(6)

Use the stopwatch to record the time taken for 10 complete oscillation, divide this value by 10 to produce a value for the Time period. This procedure is used so that the percentage uncertainty caused by human reaction time is decreased due to the larger initial time for which the stopwatch was used. Place the ruler close to the moving trolley and record the equilibrium position. This allows the ruler to act as a marker for when the trolley crosses the equilibrium and completes an oscillation.

Stand over the oscillating system to reduce parallax error in judging when the trolley has completed the full 10 oscillations.

Take repeats of the procedure to allow the calculation of a mean which allows the effect of random error to be reduced and anomalies can be spotted and removed

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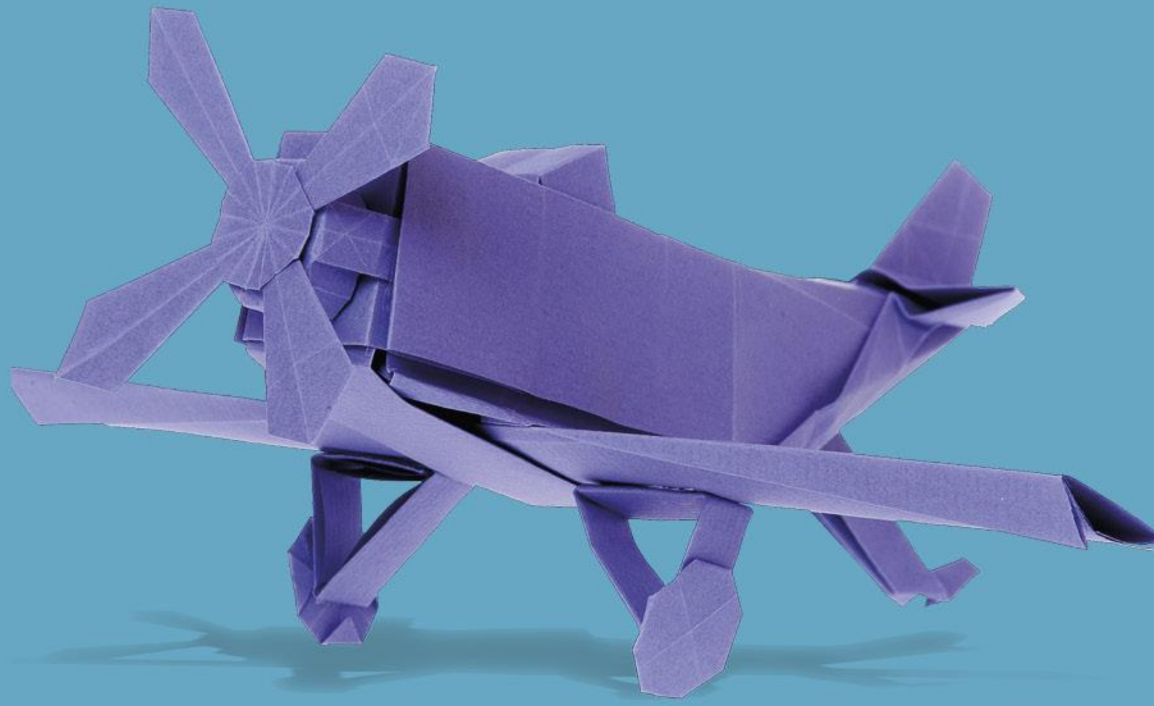
Common features of the responses seen across all three papers



Stronger Responses: Summary

1. Candidates were well prepared for topics on the specification that have been previously examined, suggesting that centres are making good use of past question papers and mark schemes.
2. The most successful candidates completed calculations faultlessly and responded with explanatory points that were ordered logically and were relevant to the question context.
3. Questions that involved straightforward calculations produced significantly better marks than questions requiring discussion or explanation.
4. Questions requiring the evaluation of scientific information leading to a deduction or judgement along with a justified conclusion were often answered well, showing some ingenuity in the variety of approaches.

Weaker Responses: Summary

1. Less successful candidates could not always tackle calculations involving several steps or other complications, such as converting years to seconds.
2. In some calculation questions requiring a judgement to be made conclusions were not always made sufficiently explicit.
3. There is evidence that candidates are not paying sufficient attention to the command words used in the question. For example, in some questions, the word 'explain' did not elicit the level of detail expected.
4. Some of the language and processes of quantifying uncertainties in practical work is poorly understood by candidates. In particular candidates’ use of the terms accuracy, error, precision, resolution and uncertainty.

Common Issues

1. When candidates cannot fit their answers into the answer space they do not always indicate where the rest of the answer is.
2. In a “linkage” question candidates do not always show how statements link together logically to form a complete explanation.
3. When answering a “judgement” question candidates sometimes forget that the final conclusion must include a comparison of data using the calculated answer.

Support

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- **Subject Advisor:** Irine Muhiuddin
- Contact through web form on on 0330 058 9493

- https://qualifications.pearson.com/en/qualifications/edexcel-a-levels/physics-2015.html

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   Results statistics summarise the overall grade outcomes of candidates sitting Edexcel examinations.

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