Statistics

<table>
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<tr>
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<th>VHA</th>
<th>HA</th>
<th>SA</th>
<th>LA</th>
<th>VLA</th>
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Multiple-choice questions

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<td>Correct response</td>
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<td>B</td>
<td>C</td>
<td>D</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>C</td>
<td>B</td>
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<table>
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<tr>
<th>Question</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
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<tr>
<td>Correct response</td>
<td>A</td>
<td>C</td>
<td>C</td>
<td>B</td>
<td>D</td>
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General comments

Candidates were required to demonstrate ability in all three areas of the syllabus: Knowledge of subject matter (K), Scientific processes (SP) and Complex reasoning processes (CRP).

Successful candidates provided good responses to questions that assessed K and CRP although most did not perform well in questions that assessed SP. Candidates must achieve credit in CRP to be awarded a Sound Level of Achievement or better. It is pleasing to note that all candidates were awarded credit for Paper Two (CRP), which assisted many candidates in trade-offs where they had not achieved so highly in the other criteria. This is due, in part, to the new style of placement of CRP questions in one of two sections (differentiated by their level of difficulty).

Generally, candidates demonstrated a good understanding of basic mathematical skills and used appropriate units. They also displayed a satisfactory level of skill in calculator use. The majority of candidates’ responses were neat, legible and complete.
Characteristics of good responses

Successful candidates produced clear, unambiguous responses that were well set out and easy to follow. Errors were able to be identified, with partial credit awarded where possible. Candidates showed an ability to use correct formulas and, where necessary, demonstrated adequate algebraic processes, e.g. transposing equations. Correct substitutions were generally followed by successful calculations.

Many candidates provided only partial responses to questions in Paper Two (assessing CRP). The application of graphing conventions such as the use of pencil, straight lines and correct scale was evident.

Successful candidates used a combination of sketches, formulas and text to demonstrate “what they were thinking” while trying to “figure out” a solution to a question.

Common weaknesses

Responses to questions assessing SP were generally poorly completed by most candidates, which is disappointing. Several questions referred to common physics experiments that candidates should have completed during their study of the subject.

Some candidates responded to all CRP questions in Paper Two but crossed out poor attempts. Poorly performing candidates often failed to respond clearly, with a few candidates not responding to some questions at all. These types of candidates should use the perusal time provided to identify those questions they think they can respond to, and in what order. They then need to spend their time “recording their thinking” rather than dissipating their energies over every question.

Sample solutions

The following solutions are not necessarily prescriptive model responses and are not necessarily the only way of solving a problem. Other approaches and problem-solving strategies may be just as acceptable.
Paper One Part B

Question 1

\[ \frac{4}{3} \pi \left(3.624 \times 10^{-3}\right)^3 \]

\[ = 1.944 \times 10^{-10} \]

Question 2

\[ u = 58.2 \text{ m/s} \]
\[ t = 5.10 \text{ s} \]
\[ v = 10.5 \text{ m/s} \]
\[ s = ? \]

\[ \frac{s}{t} = \left( \frac{u + v}{2} \right) \]

\[ s = \left( \frac{58.2 + 10.5}{2} \right) \times 5.10 \]

\[ s = 175 \text{ m} \]
The frictional force will oppose the force down the incline.

\[
F = W \sin 30^\circ = mg \sin 30^\circ = 2150 \times 9.8 \times \sin 30^\circ = 10,500 \text{ N}
\]
(a) Total displacement = Area under velocity-time graph
\[ \frac{1}{2} \left( 10 + 4 \right) \times 8 \]
\[ = 56 \text{ m} \] (1 mark)

(b) First 4 seconds, \( a = \frac{8-0}{4} = 2 \text{ m/s}^2 \) (2 marks)
Next 4 seconds, \( a = 0 \text{ m/s}^2 \)
Last 2 seconds, \( a = \frac{0-8}{2} = -4 \text{ m/s}^2 \)
Question 5

(a) If all GPE is converted to KE,

\[ u = mgh = \frac{1}{2}mv^2 \]

\[ \sqrt{2gh} = v \]

\[ \sqrt{2 \times 9.8 \times 28.2} = v \]

\[ 23.5 \text{ m/s} = v \] The velocity upon impact.

(b) No, assuming negligible air resistance and if the 115 kg person steps off the bridge in a similar manner to the 60.0 kg person both will accelerate towards the water at the same rate as they will accelerate under the influence of gravity.

This can also be shown mathematically.

\[ \text{GPE} = KE \]

\[ mgh = \frac{1}{2}mv^2 \]

\[ v = \sqrt{2gh} \]

i.e. velocity is independent of mass.
Question 

\[ m = 2.50 \text{ kg} \]

Initial velocity \[ \frac{5 \text{ cm}}{0.1 \text{ s}} = 50 \text{ cm/s} = 0.5 \text{ m/s} \]

Final velocity \[ \frac{2 \text{ cm}}{0.1 \text{ s}} = 20 \text{ cm/s} = 0.2 \text{ m/s} \]

The change in momentum of the trolley

\[ \Delta p = m \Delta v \]

\[ = m (v - u) \]

\[ = 2.5 \left( 0.2 - 0.5 \right) \]

\[ = 2.5 \left( 0.2 - 0.5 \right) \]

\[ = 0.750 \text{ kg m/s} \]
(a). (i.) \[ V = \frac{s}{t} = \frac{12}{0.5} = 24.0 \text{ cm/s} \] (1 mark)

(ii.) \[ \lambda = \frac{V}{f} = \frac{24}{12} = 2.00 \text{ cm} \] (1 mark)

(b) \[ P \] lies 6\(\lambda\) from \(X\) and 6\(\frac{1}{2}\)\(\lambda\) from \(Y\).

\[ P \] therefore has a path difference of \(\pm\lambda\) from the sources \(X\) and \(Y\).

\[ P \] lies on a NODAL line and destructive interference will occur here. (2 marks)
Question 8.

**Apparatus**
- Ray Box with single slit
- Power Pack
- Sheet of white paper
- Ruler, pens

**Method**

- Place the semi-circular plastic on the white paper and mark its outline.
- Set up the ray box and focus the ray of light coming from the ray box.
- Allow the ray of light to enter the plastic as follows.

```
incident ray           refracted ray
```

- Gradually increase the angle of incidence until the angle of refraction is 90°.

```
incident ray           refracted ray
```

- Mark the rays with the pens/pencils and measure the incident angle. This angle is the critical angle for the plastic.
Question 9

\[ q_1 = 8.0 \text{ mC} \quad F = 3 \times 10^5 \text{ N} \]
\[ q_2 = -6.0 \text{ mC} \]

From Coulomb's law,

\[ F = \frac{Kq_1q_2}{r^2} \]

\[ r^2 = \frac{Kq_1q_2}{F} \]

\[ r = \sqrt{\frac{9 \times 10^{-9} \times 8 \times 10^{-3} \times 6 \times 10^{-3}}{(3 \times 10^5)^2}} \]

\[ = 1.2 \text{ m} \]

The charges are 1.2 m apart.
Current through the lamp

\[ I = \frac{P}{V} = \frac{50}{100} = 0.5 \text{ amps} \]

0.5 amps is the current in the series circuit above.

The resistance of the resistor which will have to be placed in the circuit

\[ R = \frac{V}{I} = \frac{130}{0.5} = 260 \Omega \]
The graph shows a linear relationship between voltage \( V \) and current \( I \). 
\[ V \propto I \quad \text{or} \quad V = kI \]

The slope of the line, which represents the resistance, is 
\[ \frac{44}{10} = 4.4 \Omega \]
(2 marks)
Question 12.

(a) The commutator is a split ring shape that is attached to the coil.

When current flows in the circuit, the split ring allows the current to flow in such a direction that the coil continues to flow in the same direction.

(b) The coil could be made to spin faster by:

- increasing the number of coils and/or the area of the coils,
- increasing the current,
- increasing the magnetic field strength.
Question 13.

\[ n = \frac{1.00 \times 10^3}{1.00 \times 10^3} \]

\[ A = 35.0 \text{ m}^2 = 0.0035 \text{ m}^2 \]

\[ B_i = 0.75 \text{ T} \]

\[ B_f = 0 \text{ T} \]

\[ t = 5.00 \text{ s} \]

The induced voltage from the collapsing field

\[ E = -n \frac{\Delta B A}{\Delta t} \]

\[ = \frac{1.00 \times 10^3 \times 0.75 \times 0.0035}{5} \]

\[ = 0.525 \text{ V} \]
as the magnet falls, Lenz's Law states that a current will be induced in the coil to oppose the motion. The top of the coil becomes a N pole. The RH grip rule shows the current direction.

No current will be induced in the coils, as there is no change in flux.

Lenz's Law shows that the bottom of the coil will become a N-pole to oppose the motion of the falling magnet. The RH grip rule shows the direction of current.

The RH grip rule shows that the top of the coil becomes a N pole, so the magnet on the spring will be attracted to the coil.

Magnet will tend to move back to its equilibrium, the only force acting on it will be the gravitational force.

as the top of the coil becomes a S pole (RH grip rule) the magnet will be repelled by the coil.
15. 

- $\alpha$ radiation: $^4$He
- $\beta$ radiation: $^1$ electrons
- Gamma radiation: Electromagnetic radiation

The $\alpha$ and $\beta$ particles will undergo a circular path. The radius of the $\alpha$ particle path will be larger than that of the $\beta$ particles due to their greater mass. (assuming the velocity of the particles is the same)

The gamma radiation will not be deflected.

16. 

$^{238}U \rightarrow ^{4}He + ^{230}Th$
Paper Two Part A

Part A Question 1

Convert the values given to average speeds.

<table>
<thead>
<tr>
<th>Distance</th>
<th>Time</th>
<th>Av. speed m/s</th>
<th>Av. speed Km/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>9.58</td>
<td>10.4</td>
<td>37.4</td>
</tr>
<tr>
<td>150</td>
<td>14.35</td>
<td>10.5</td>
<td>37.8</td>
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<tr>
<td>200</td>
<td>19.17</td>
<td>10.4</td>
<td>37.4</td>
</tr>
<tr>
<td>160 (last 100 of the 150)</td>
<td>8.70</td>
<td>11.5</td>
<td>41.4</td>
</tr>
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</table>

The question is somewhat open ended. However, students would be expected to have converted the values given to the above values.

Justification in the responses could include:

- The average velocities from a standing start were approximately the same. Some slight differences may occur with enhanced electronic timing.
- The 100m is a straight track versus the 200m which includes a bend.
- The last 100m of Chain Belt's 150m shows that a 40 km/hr speed zone was exceeded.
- Other split times may show similar breaches of speed limits.
Part A Question 2

\[ u = 15.0 \text{ m/s} \]
\[ a = -9.8 \text{ m/s}^2 \]
\[ s = -58.0 \text{ m} \]

\[ s = ut + \frac{1}{2} at^2 \]
\[ -58 = 15t + \frac{1}{2}(-9.8)t^2 \]
\[ 4.9t^2 - 15t - 58 = 0 \]

\[ t = \frac{15 \pm \sqrt{(15)^2 - 4 \times 4.9 \times (-58)}}{2 \times 4.9} \]

\[ t = \frac{15 \pm \sqrt{225 + 1136.8}}{9.8} \]

\[ t = \frac{15 \pm 36.9}{9.8} \]

Disregard the negative value of time.

Time taken for the ball to hit the ground, \( t = 5.30 \text{ s} \)

The velocity upon impact:
\[ v^2 = u^2 + 2as \]
\[ = 225 + 2 \times (-9.8) \times (-58) \]
\[ = 1362 \]
\[ v = \frac{36.9 \text{ m/s}}{} \text{ towards the ground.} \]
Part A Question 3

The light ray will pass straight through and at the fluid-honey interface for TIR to occur, the critical angle

\[
n_f \sin \theta_c = n_h \sin 90^\circ
\]

\[
\theta_c = \sin^{-1} \left( \frac{1.58}{1.62} \right)
\]

for TIR to occur.

\[
= 77.2^\circ
\]

Since the angle of incidence is less than 77°, TIR will not occur.

In this case, TIR will not occur.

The angle of refraction occurs.

\[
n_f \sin \theta_a = n_h \sin \theta_a
\]

\[
\sin \theta_a = \frac{1.62 \sin 45^\circ}{1.58}
\]

\[
\theta_a = 46.5^\circ
\]

The angle of incidence at the honey-air interface will be

\[
\theta_a = 46.5^\circ - 45^\circ
\]

\[
= 1.5^\circ
\]

A ray will emerge from the top at an angle of 2.4° to the normal. Any reflected ray will be out normal to the container.
The power developed by the motor at 75\% efficiency is

\[ P = 0.75 \times VI \]
\[ = 0.75 \times 24 \times 2.5 \]
\[ = 45.0 \text{ W} \]

If the velocity at which the mass is lifted is 1.60 m/s,

Then

\[ P = \frac{mgh}{t} = mgv \]
\[ 450 = m \times 9.8 \times 1.6 \]
\[ 287.6 = m \]

The greatest mass which can be lifted by the motor is 287.6 kg.
Part A  Question 5

(a)  

\[ f = \frac{640}{42} \text{ Hz} \]

When the girl is standing mid-way between the speakers, she will be standing in a place where there is constructive interference if the sound will be maximised.

As the girl moves to her left, the sound gradually decreases due to her moving towards a point where destructive interference occurs (i.e., sound signals cancel each other out).

(b)  

At the point of lowest sound intensity, the path difference between sound waves will be half a wavelength at the first nodal point.

\[ \frac{d \times \lambda}{\lambda} = (n - \frac{1}{2}) \lambda \]

\[ d = 1 \text{ m} \]

\[ \lambda = \frac{v}{f} = \frac{320}{640} = 0.500 \text{ m} \]

At the first node,

\[ \lambda = \frac{2 \times 1.60}{2} = 1.25 \text{ m} \]

She will have to move 1.25 m to her left.
Paper Two Part B

The vector diagram below shows the motion of the soccer ball.

\[ V = 30 \text{ m/s} \]

The change in velocity \( \Delta V = V - u \)

\[ \Delta V = 3 \text{ m/s} \]

The components of velocity can be resolved as:
- Horizontal: \( 20 + 30 \cos 45 = 41.2 \text{ m/s} \)
- Vertical: \( 30 \sin 45 = 21.2 \text{ m/s} \)

The change in velocity using horizontal and vertical components:

\[ \Delta V = 21.2 \text{ m/s} \]

Using Pythagoras:

\[ \Delta V = \sqrt{(41.2)^2 + (21.2)^2} \]

\[ = 46.3 \text{ m/s} \]

\[ \theta = \tan^{-1} \left( \frac{21.2}{41.2} \right) \]

\[ = 62.8^\circ \]

By using the direction conventions:

the impulse of the net force:

\[ P = F \Delta t = m \Delta V \]

\[ = 0.40 \times 46.3 \]

\[ = 18.5 \text{ Ns in the direction N} 62.8^\circ \text{W} \]
Part B  Question 2

Cross-sectional area,

\[ A = 2.00 \text{ cm}^2 = 2 \times 10^{-4} \text{ m}^2 \]

Since the water has a flow rate of

\[ 1 \text{ L/s} = 0.001 \text{ m}^3/\text{s} = AV \]

\[ \therefore \text{the water velocity}, \quad V = \frac{0.001}{2.00 \times 10^{-4}} \]

\[ = 5.00 \text{ m/s}. \]

The water is moving vertically upwards, and at maximum height, \( V = 0 \).

Using \( V^2 = u^2 + 2as \)

\[ 0 = (5.00)^2 + 2 \times 9.8s \]

\[ 19.6s = 2.5 \]

\[ s = 1.28 \text{ m}. \]

The power of the pump = \( \frac{1}{2}mv^2 \)

\[ = \frac{1}{2} \times 1 \times 5^2 \]

\[ = 12.5 \text{ W}. \]

If frictional forces are ignored and the power of the pump doubles to 25.0 W, assume the KE of the water also doubles.

\[ \text{GPE} = mgh = 25.0 \text{ W} \]

\[ \Rightarrow h = \frac{25.0}{9.8} \]

\[ = 2.56 \text{ m}. \]
For the 60W globe, \[ I = \frac{V}{I} = \frac{60}{240} = 0.250 \text{ amps}. \]

Heating element, \[ I = \frac{V}{I} = \frac{480}{240} = 2.00 \text{ amps}. \]

The total current being drawn by the circuit, \[ I_{\text{tot}} = 0.25 + 0.80 + 2.0 = 3.05 \text{ amps}. \]

The power being delivered to the circuit, \[ P_{\text{tot}} = VI = 3.05 \times 240 = 730 \text{ W}. \]

If the test ran for \( \frac{1}{2} \) hr.

Energy used \[ = 730 \times \frac{1}{2} \div 1000 \]

\[ = 0.365 \text{ kWh}. \]

Cost of energy \[ = 0.365 \times 18.5 \]

\[ = 6.8 \text{ cents}. \]
Convert the values given in the table below to those of Li. The work function for Na metal, the work function for Li based on these results 2.55 eV.

\[ W = \frac{3.5 \times 10^{-19}}{-1.6 \times 10^{-19}} = 2.19 \]

\[ f = \frac{C}{\lambda} = \frac{3 \times 10^8}{\lambda} \]

<table>
<thead>
<tr>
<th>( \frac{\lambda}{nm} )</th>
<th>( f \times 10^{14} )</th>
<th>( V ) (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.75</td>
<td>8.00</td>
<td>0.841</td>
</tr>
<tr>
<td>3.33</td>
<td>9.01</td>
<td>1.25</td>
</tr>
<tr>
<td>3.01</td>
<td>9.97</td>
<td>1.65</td>
</tr>
<tr>
<td>2.73</td>
<td>11.00</td>
<td>2.08</td>
</tr>
<tr>
<td>2.50</td>
<td>12.00</td>
<td>2.52</td>
</tr>
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</table>

Based on these results, Na would be the more reactive metal as it has the lower value of the work function i.e., electrons are easier to remove.