2007 Physics

Standard Grade – Credit

Finalised Marking Instructions

© Scottish Qualifications Authority 2007

The information in this publication may be reproduced to support SQA qualifications only on a non-commercial basis. If it is to be used for any other purposes written permission must be obtained from the Assessment Materials Team, Dalkeith.

Where the publication includes materials from sources other than SQA (secondary copyright), this material should only be reproduced for the purposes of examination or assessment. If it needs to be reproduced for any other purpose it is the centre's responsibility to obtain the necessary copyright clearance. SQA's Assessment Materials Team at Dalkeith may be able to direct you to the secondary sources.

These Marking Instructions have been prepared by Examination Teams for use by SQA Appointed Markers when marking External Course Assessments. This publication must not be reproduced for commercial or trade purposes.
Physics – Marking Issues

The current in a resistor is 1.5 amperes when the potential difference across it is 7.5 volts. Calculate the resistance of the resistor.

<table>
<thead>
<tr>
<th>Answers</th>
<th>Mark + Comment</th>
<th>Issue</th>
</tr>
</thead>
</table>
| 1. \( V=IR \)  
    \[ 7.5 = 1.5R \]  
    \[ R = 5.0 \, \Omega \]  | (½) Ideal answer | |
| 2. 5.0 Ω | (2) Correct answer | GMI 1 |
| 3. 5.0 | (1½) Unit missing | GMI 2 (a) |
| 4. 4.0 Ω | (0) No evidence/wrong answer | GMI 1 |
| 5. _____ Ω | (0) No final answer | GMI 1 |
| 6. \[ R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0 \, \Omega \] | (1½) Arithmetic error | GMI 7 |
| 7. \[ R = \frac{V}{I} = 4.0 \, \Omega \] | (½) Formula only | GMI 4 and 1 |
| 8. \[ R = \frac{V}{I} = _____ \, \Omega \] | (½) Formula only | GMI 4 and 1 |
| 9. \[ R = \frac{V}{I} = \frac{7.5}{1.5} = _____ \, \Omega \] | (1) Formula + subs/No final answer | GMI 4 and 1 |
| 10. \[ R = \frac{V}{I} = \frac{7.5}{1.5} = 4.0 \] | (1) Formula + substitution | GMI 2 (a) and 7 |
| 11. \[ R = \frac{V}{I} = \frac{1.5}{7.5} = 0.5 \, \Omega \] | (½) Formula but wrong substitution | GMI 5 |
| 12. \[ R = \frac{V}{I} = \frac{75}{1.5} = 5.0 \, \Omega \] | (½) Formula but wrong substitution | GMI 5 |
| 13. \[ R = \frac{I}{V} = \frac{7.5}{1.5} = 5.0 \, \Omega \] | (0) Wrong formula | GMI 5 |
| 14. \( V = IR \)  
    \[ 7.5 = 1.5 \times R \]  
    \[ R = 0.2 \, \Omega \] | (1½) Arithmetic error | GMI 7 |
| 15. \( V = IR \)  
    \[ R = \frac{I}{V} = \frac{1.5}{7.5} = 0.2 \, \Omega \] | (½) Formula only | GMI 20 |
### Data Sheet

#### Speed of light in materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Speed in m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>$3.0 \times 10^8$</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>$3.0 \times 10^8$</td>
</tr>
<tr>
<td>Diamond</td>
<td>$1.2 \times 10^8$</td>
</tr>
<tr>
<td>Glass</td>
<td>$2.0 \times 10^8$</td>
</tr>
<tr>
<td>Glycerol</td>
<td>$2.1 \times 10^8$</td>
</tr>
<tr>
<td>Water</td>
<td>$2.3 \times 10^8$</td>
</tr>
</tbody>
</table>

#### Speed of sound in materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Speed in m/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>5200</td>
</tr>
<tr>
<td>Air</td>
<td>340</td>
</tr>
<tr>
<td>Bone</td>
<td>4100</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>270</td>
</tr>
<tr>
<td>Glycerol</td>
<td>1900</td>
</tr>
<tr>
<td>Muscle</td>
<td>1600</td>
</tr>
<tr>
<td>Steel</td>
<td>5200</td>
</tr>
<tr>
<td>Tissue</td>
<td>1500</td>
</tr>
<tr>
<td>Water</td>
<td>1500</td>
</tr>
</tbody>
</table>

#### Gravitational field strengths

<table>
<thead>
<tr>
<th>Material</th>
<th>Gravitational field strength on the surface in N/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earth</td>
<td>10</td>
</tr>
<tr>
<td>Jupiter</td>
<td>26</td>
</tr>
<tr>
<td>Mars</td>
<td>4</td>
</tr>
<tr>
<td>Mercury</td>
<td>4</td>
</tr>
<tr>
<td>Moon</td>
<td>1.6</td>
</tr>
<tr>
<td>Neptune</td>
<td>12</td>
</tr>
<tr>
<td>Saturn</td>
<td>11</td>
</tr>
<tr>
<td>Sun</td>
<td>270</td>
</tr>
<tr>
<td>Venus</td>
<td>9</td>
</tr>
</tbody>
</table>

#### Specific heat capacity of materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific heat capacity in J/kg°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>2350</td>
</tr>
<tr>
<td>Aluminium</td>
<td>902</td>
</tr>
<tr>
<td>Copper</td>
<td>386</td>
</tr>
<tr>
<td>Diamond</td>
<td>530</td>
</tr>
<tr>
<td>Glass</td>
<td>500</td>
</tr>
<tr>
<td>Glycerol</td>
<td>2400</td>
</tr>
<tr>
<td>Ice</td>
<td>2100</td>
</tr>
<tr>
<td>Lead</td>
<td>128</td>
</tr>
<tr>
<td>Water</td>
<td>4180</td>
</tr>
</tbody>
</table>

#### Melting and boiling points of materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Melting point in °C</th>
<th>Boiling point in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>−98</td>
<td>65</td>
</tr>
<tr>
<td>Aluminium</td>
<td>660</td>
<td>2470</td>
</tr>
<tr>
<td>Copper</td>
<td>1077</td>
<td>2567</td>
</tr>
<tr>
<td>Glycerol</td>
<td>18</td>
<td>290</td>
</tr>
<tr>
<td>Lead</td>
<td>328</td>
<td>1737</td>
</tr>
<tr>
<td>Turpentine</td>
<td>−10</td>
<td>156</td>
</tr>
</tbody>
</table>

#### Specific latent heat of fusion of materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific latent heat of fusion in J/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>$0.99 \times 10^5$</td>
</tr>
<tr>
<td>Aluminium</td>
<td>$3.95 \times 10^5$</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>$1.80 \times 10^5$</td>
</tr>
<tr>
<td>Copper</td>
<td>$2.05 \times 10^5$</td>
</tr>
<tr>
<td>Glycerol</td>
<td>$1.81 \times 10^5$</td>
</tr>
<tr>
<td>Lead</td>
<td>$0.25 \times 10^5$</td>
</tr>
<tr>
<td>Water</td>
<td>$3.34 \times 10^5$</td>
</tr>
</tbody>
</table>

#### Specific latent heat of vaporisation of materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Specific latent heat of vaporisation in J/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol</td>
<td>$11.2 \times 10^5$</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>$3.77 \times 10^5$</td>
</tr>
<tr>
<td>Glycerol</td>
<td>$8.30 \times 10^5$</td>
</tr>
<tr>
<td>Turpentine</td>
<td>$2.90 \times 10^5$</td>
</tr>
<tr>
<td>Water</td>
<td>$22.6 \times 10^5$</td>
</tr>
</tbody>
</table>

#### SI Prefixes and Multiplication Factors

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Symbol</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>giga</td>
<td>G</td>
<td>$10^9$</td>
</tr>
<tr>
<td>mega</td>
<td>M</td>
<td>$10^6$</td>
</tr>
<tr>
<td>kilo</td>
<td>k</td>
<td>$10^3$</td>
</tr>
<tr>
<td>milli</td>
<td>m</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>micro</td>
<td>µ</td>
<td>$10^{-6}$</td>
</tr>
<tr>
<td>nano</td>
<td>n</td>
<td>$10^{-9}$</td>
</tr>
</tbody>
</table>
Question Nos 1(a), (b) and (c)

(a) What is the speed of radio waves?

\[ v = 3 \times 10^8 \text{ m/s} \]

(b) Calculate the wavelength of the signal.

\[ \lambda = \frac{v}{f} = \frac{3 \times 10^8}{1900 \times 10^6} = 0.16 \text{ m} \]

(c) The pupil sends a video message from the mobile phone. The message travels a total distance of 72 000 km. Calculate the time between the message being transmitted and received.

\[ t = \frac{d}{v} = \frac{72000000}{3 \times 10^8} = 0.24 \text{ s} \]

Notes:

(1) The pupil sends a video message from the mobile phone. The message travels a total distance of 72 000 km.

(2) The pupil sends a video message from the mobile phone. The message travels a total distance of 72 000 km.

1 The pupil sends a video message from the mobile phone. The message travels a total distance of 72 000 km.

2 The pupil sends a video message from the mobile phone. The message travels a total distance of 72 000 km.

3 The pupil sends a video message from the mobile phone. The message travels a total distance of 72 000 km.
Radio waves have a wide range of frequencies. The table gives information about different wavebands.

(a) Coastguards use signals of frequency 500 kHz. What waveband do these signals belong to?

<table>
<thead>
<tr>
<th>Waveband</th>
<th>Frequency Range</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low frequency (LF)</td>
<td>30 kHz – 300 kHz</td>
<td>Radio 4</td>
</tr>
<tr>
<td>Medium frequency (MF)</td>
<td>300 kHz – 3 MHz</td>
<td>Radio Scotland</td>
</tr>
<tr>
<td>High frequency (HF)</td>
<td>3 MHz – 30 MHz</td>
<td>Amateur radio</td>
</tr>
<tr>
<td>Very high frequency (VHF)</td>
<td>30 MHz – 300 MHz</td>
<td>Radio Scotland</td>
</tr>
<tr>
<td>Ultra high frequency (UHF)</td>
<td>300 MHz – 3 GHz</td>
<td>Radio 1 FM</td>
</tr>
<tr>
<td>Super high frequency (SHF)</td>
<td>3 GHz – 30 GHz</td>
<td>BBC 1 and ITV</td>
</tr>
</tbody>
</table>

NOTES

Do not: Radio Scotland
2. (continued)

(b) The diagram shows how radio signals of different wavelengths are sent between a transmitter and a receiver.

(i) Which of the waves in the diagram shows diffraction?
..............................................................................................................

(ii) What does this indicate about the wavelength of the diffracted wave compared to the other two waves?
..............................................................................................................

(iii) The Earth’s ionosphere is shown on the diagram. The ionosphere is a layer of charged particles in the upper atmosphere. High frequency waves are transmitted as sky waves. Explain how the transmitted waves reach the receiver.
..............................................................................................................

(iv) Super high frequency (SHF) signals are shown as space waves on the diagram. Although they can only travel in straight lines they can be used for communications on Earth between a transmitter and receiver. Describe how the SHF signals get to the receiver.
..............................................................................................................

Accept: (radio) waves are reflected by the ionosphere

Do not accept: “bounce (off ionosphere)” “refraction”

Accept: any answer based on frequency

Marks

NOTES
3. A door entry system in an office block allows video and audio information to be sent between two people. (a) A camera at the entrance uses a lens to focus parallel rays of light onto the detector.

---

**NOTES**

- A diagram must be reasonably straight. Rays drawn must meet at mid-point of detector.
- If the answer is given in dyne cm⁻², deduct (½) unit error.

**Space for Working and Answer**

- Lens used in the camera.
- Line information from the diagram, calculate the power of the lens used.
- Complete the path of the light rays.

(i) Part of the diagram is shown in the diagram below.

(ii) A camera at the entrance uses a lens to focus parallel rays of light onto to be seen between two people.

(iii) Complete the diagram above by:

- (A) drawing the lens used;
- (B) completing the path of the light rays.

(iv) Using information from the diagram, calculate the power of the lens used in the camera.

Space for working and answer.

\[ \frac{f}{d} = \frac{15}{900} \]

\[ f = \frac{1500}{900} \]

\[ f = 1.6 \text{ mm} \]

---

\[ \frac{1}{f} = \frac{1}{P} = \frac{0.0625}{D} \]

\[ P = 0.0625 \text{ D} \]
(b) The door entry system uses a black and white television screen. Describe how a moving picture is seen on the television screen. Your description must include the terms: line build up, image retention, and brightness variation.

- Line build up is when electrons scan across the screen.
- Image retention is when the brain retains each picture while the next is produced (or picture is produced 25 times per second).
- Brightness variation is by changing the number/intensity of electron beam.

Award marks: 2 × (½) for describing line build up, 2 × (½) for describing image retention, and (½) for describing brightness variation with correct explanation.
4. The consumer unit in a house contains a mains switch and circuit breakers. What is the purpose of the mains switch?

(a) (i) to turn on/off all circuits/electrical appliances
(b) (ii) to switch off: electricity supply/power/current to isolate mains
(c) (iii) to switch off: electrically supplied power/current to turn off all circuits/electrical appliances

4(a) (ii) The ring circuit: the lighting circuit?

4(a) (iii) The current ratings for the ring circuit and the lighting circuit are different. State another difference between the ring circuit and the lighting circuit.

- Thicker wire in the ring circuit OR Two paths (for current) in ring circuit
- Thicker wire for lighting circuit
- Wire thickness cheaper/thinner wire for lighting circuit

4(b) Which of the circuits have not been labelled? Shower heater water

4(c) The choices below are incorrect.
- "to switch off mains" to change fuse"
4. (continued)

(b) (i) A 25 W lamp is designed to be used with mains voltage. Calculate the resistance of the lamp.

\[ V = 230 \text{ V} \]

\[ I = \frac{P}{V} = \frac{25}{230} = 0.109 \text{ A} \]

\[ R = \frac{V}{I} = \frac{230}{0.109} = 2110 \Omega \]

(ii) Four of these lamps are connected in parallel. Calculate the total resistance of the lamps.

\[ \frac{1}{R_{\text{total}}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} \]

\[ \frac{1}{R_{\text{total}}} = \frac{1}{2110} + \frac{1}{2110} + \frac{1}{2110} + \frac{1}{2110} \]

\[ R_{\text{total}} = 2116 \Omega \]

OR

If more than 4 lamps are connected in parallel, award 0 marks.

Accept: \[ R = \text{max} (\text{any voltage other than } 230 \text{ V or } 240 \text{ V used}) \]

Accept: \[ R = 2000, 2100, 2120, 2110 \]

Accept if: award 0 marksaccept: OR

(b) (cont.) if any voltage other than 230 V or 240 V used

(1) \[ 0.109 \times 25 = 100 \text{ W} \]
Two groups of pupils are investigating the electrical properties of a lamp.

(a) Group 1 is given the following equipment: ammeter; voltmeter; 12 V d.c. supply; lamp; connecting leads.

Complete the circuit diagram to show how this equipment is used to measure the current through, and the voltage across, the lamp.

(b) Group 2 uses the same lamp and is only given the following equipment: lamp; ohmmeter; connecting leads.

What property of the lamp is measured by the ohmmeter?

(c) The results of both groups are combined and recorded in the table below.

(i) Use these results to complete the last two columns of the table.

(ii) What quantity is represented by the last two columns of the table?

(iii) What is the unit for this quantity?

<table>
<thead>
<tr>
<th>I (A)</th>
<th>V (V)</th>
<th>R (Ω)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

**Space for working**

$I = 2 \times 12 = 24$,

$I^2R = 2^2 \times 6 = 24$

**Power (W)**

$P = IV = 24 \times 24$,

$P = 576$ W

**Resistance / R**

$R = \frac{V}{I} = \frac{24}{2} = 12 \Omega$
6. The thyroid gland, located in the neck, is essential for maintaining good health.

(a) (i) A radioactive source, which is a gamma radiation emitter, is used as a radioactive tracer for the diagnosis of thyroid gland disorders. A small quantity of this tracer, with an activity of 20 MBq, is injected into the patient's body. After 52 hours, the activity of the tracer is measured at 1.25 MBq. Calculate the half-life of the tracer.

(ii) Another radioactive source is used to treat cancer of the thyroid gland. This source emits only beta radiation. Why is this source unsuitable as a tracer?

(iii) The equivalent dose is much higher for the beta emitter than for the gamma emitter. Why is this higher dose necessary?

(b) What are the units of equivalent dose?
A newborn baby is given a hearing test. A small device, containing a loudspeaker and microphone, is placed in the baby’s ear. (a) A pulse of audible sound lasting 10 μs is transmitted through the ear. The sound is played at a level of 80 dB. (i) Give a reason why this pulse of sound does not cause damage to the baby’s hearing.

The duration of the pulse is 10 microseconds, which is very small.

OR

80 dB is threshold level for damage

OR

80 dB is threshold level for damage

OR

Only prolonged exposure at this level will cause damage.

OR

The duration of the pulse, 10 microseconds, is very small.
(a)(ii) The transmitted pulse of sound makes the inner ear vibrate to produce a new sound, which is received by the microphone. Signals from the transmitted and received sounds are viewed on an oscilloscope screen, as shown below.

The average speed of sound inside the ear is 1500 m/s. Calculate the distance between the device and the inner ear.

\[
\text{Distance} = \frac{\text{Speed}}{\text{Time}} = \frac{1500 \text{ m/s}}{30 \times 10^{-6} \text{ s}} = 50000 \text{ m}
\]

(iii) Suggest a frequency that could be used for the hearing test.

Possible answer: any stated value between 20 – 20000 Hz inclusive (unit required)

(b) An ultrasound scan can be used to produce an image of an unborn baby. Explain how the image of an unborn baby is formed by ultrasound.

Ultrasound reflects off the baby in the womb. The reflected ultrasound is detected by the receiver or computer, and an image of the baby is formed on a screen. The image is produced by reflecting ultrasound off different depths of tissue. The ultrasound waves are sent into the body and bounced back by the baby. The reflected ultrasound is detected by the sensor and computer.
A high intensity LED is used as a garden light. The light turns on automatically when it becomes dark.

The light also contains a solar cell which charges a rechargeable battery during daylight hours.

(a) Part of the circuit is shown below.

(i) State the energy transformation in a solar cell.

(ii) At a particular light level, the voltage generated by the solar cell is 1.5V. Calculate the voltage across the rechargeable battery at this light level.

\[
\frac{1}{RT} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{600} + \frac{1}{2400} = \frac{1}{3000} \text{ (Ω)}
\]

Space for working and answer

\[
V = \frac{1.2 \times 1.5}{3000} = 1.2 \text{V}
\]

OR

\[
V = RI = 1.2 \times 0.0005 = 0.006 \text{V}
\]

(b) The light also contains a solar cell which charges a rechargeable battery automatically when it becomes dark.
(b) The LED is switched on using the following circuit.

(i) Name component X.

..................................................................................................

The graph below shows the voltage across the LDR in this circuit for different light levels.

Light level is measured in lux.

(ii) For the LED to be lit, the voltage across the LDR must be at least 0.7 V.

What is the maximum light level for the LED to be lit?

..................................................................................................

(iii) Explain the purpose of resistor R.

..................................................................................................

Switch

transistor (switch)

\[ R \]

[Diagram of circuit with battery, switch, transistor, and diode]

1. Name component X.

..................................................................................................

1. The LED is switched on using the following circuit.

..................................................................................................

Notes:

(ii) (b) Ignore: “pnp”, “npn”, phototransistor, mosfet transistor, switch

(iii) Do not accept: “to reduce voltage” only “to stop LED blowing” “to reduce the voltage across the LED” “to reduce charge/power to the LED”
9. An electronic tuner for a guitar contains a microphone and an amplifier. The output voltage from the amplifier is 9 V.

(a) The voltage gain of the amplifier is 150. Calculate the input voltage to the amplifier.

(b) The tuner is used to measure the frequency of six guitar strings. The number and frequency of each string is given in the table below.

<table>
<thead>
<tr>
<th>Number of string</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>330.0</td>
</tr>
<tr>
<td>2</td>
<td>247.0</td>
</tr>
<tr>
<td>3</td>
<td>196.0</td>
</tr>
<tr>
<td>4</td>
<td>147.0</td>
</tr>
<tr>
<td>5</td>
<td>110.0</td>
</tr>
<tr>
<td>6</td>
<td>82.5</td>
</tr>
</tbody>
</table>

(i) The controls of the oscilloscope are not altered. In Figure 2, draw the trace obtained if string 1 is played louder than string 5.

(ii) String 3 is plucked. What is the frequency of the output signal from the amplifier?

\[
\text{Space for choosing answer} \frac{\text{Frequency}}{10} = 0.9 \%
\]

\[
\text{Space for choosing answer} \frac{\text{Gain}}{10} = 30 \%
\]

The number and frequency of each string is given in the table below.

<table>
<thead>
<tr>
<th>Number of string</th>
<th>Frequency (Hz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>330.0</td>
</tr>
<tr>
<td>2</td>
<td>247.0</td>
</tr>
<tr>
<td>3</td>
<td>196.0</td>
</tr>
<tr>
<td>4</td>
<td>147.0</td>
</tr>
<tr>
<td>5</td>
<td>110.0</td>
</tr>
<tr>
<td>6</td>
<td>82.5</td>
</tr>
</tbody>
</table>

The tuner is used to measure the frequency of six guitar strings.

1. What is the frequency of the output signal from the amplifier?

2. The controls of the oscilloscope are not altered. In Figure 2, draw the trace obtained if string 1 is played louder than string 5.

(a) String 1 is played louder than string 5.

(b) String 5 is played louder than string 1.

\[
\text{Space for choosing answer} \frac{\text{Gain}}{10} = 30 \%
\]

\[
\text{Space for choosing answer} \frac{\text{Frequency}}{10} = 0.9 \%
\]
Question No. 10 (a) and (b)

Cameras placed at 5 km intervals along a stretch of road are used to record the average speed of a car. The car is travelling on a road which has a speed limit of 100 km/h. The car travels a distance of 5 km in 2.5 minutes.

(a) Does the average speed of the car stay within the speed limit?

You must justify your answer with a calculation.

\[ v = \frac{d}{t} \]

\[ = \frac{5 \text{ km}}{2.5 \text{ minutes}} \]

\[ = \frac{5 \text{ km}}{\frac{2.5}{60} \text{ hours}} \]

\[ = 120 \text{ km/h} \]

Therefore, the average speed of the car is 120 km/h, which is not within the speed limit of 100 km/h.

(b) At one point in the journey, the car speedometer records 90 km/h. Explain why the average speed for the entire journey is not always the same as the speed recorded on the car speedometer.

Explain why the average speed for the entire journey is not always the same as the speed recorded on the car speedometer.

The average speed is measured over the entire journey, while the speedometer measures instantaneous speed at each point. The speedometer measures instantaneous speed, which can vary during the journey. The average speed is calculated over the entire journey, taking into account the time taken to travel the distance.

Explain why the average speed for the entire journey is not always the same as the speed recorded on the car speedometer.

The average speed is measured over the entire journey, while the speedometer measures instantaneous speed at each point. The speedometer measures instantaneous speed, which can vary during the journey. The average speed is calculated over the entire journey, taking into account the time taken to travel the distance.

Explain why the average speed for the entire journey is not always the same as the speed recorded on the car speedometer.

The average speed is measured over the entire journey, while the speedometer measures instantaneous speed at each point. The speedometer measures instantaneous speed, which can vary during the journey. The average speed is calculated over the entire journey, taking into account the time taken to travel the distance.
11. An aeroplane on an aircraft carrier must reach a minimum speed of 70 m/s to safely take off. The mass of the aeroplane is 28 000 kg.

(a) The aeroplane accelerates from rest to its minimum take-off speed in 2 s.

(i) Calculate the acceleration of the aeroplane.

(ii) Calculate the force required to produce this acceleration.

(iii) The aeroplane's engines provide a total thrust of 240 kN. An additional force is supplied by a catapult to produce the acceleration required. Calculate the force supplied by the catapult.

\[
\frac{1}{a} = \frac{1}{v} - \frac{1}{u} = \frac{1}{70} - \frac{1}{0} = \frac{1}{70} \\
\frac{1}{a} = \frac{1}{v} - \frac{1}{u} = \frac{1}{70} - \frac{1}{0} = \frac{1}{70} \\
\]

\[
\frac{1}{a} = \frac{1}{70} \Rightarrow a = \frac{70}{1} = 70 \text{ m/s}^2 \\
\]

\[
\begin{align*}
F &= ma \\
F &= 28000 \times 70 \\
F &= 1960000 \text{ N}
\end{align*}
\]

Additional force required = total force - aircraft thrust

\[
\begin{align*}
\text{Additional force required} &= 1960000 - 240000 \\
\text{Additional force required} &= 1720000 \text{ N}
\end{align*}
\]
11. (continued)

(b) Later, the same aeroplane travelling at a speed of 65 m/s, touches down on the carrier.

(i) Calculate the kinetic energy of the aeroplane at this speed.

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

\[ = \frac{1}{2} \times 28000 \times 65^2 \]

\[ = 59.15 \text{ MJ} \]

(ii) The graph shows the motion of the aeroplane from the point when it touches down on the carrier until it stops.

Calculate the distance travelled by the aeroplane on the carrier.

Distance = area under speed-time graph

\[ \text{Distance} = \text{area under speed-time graph} \]

\[ \text{Distance} = 128.75 \text{ m} \]
The advertisement below is for a new torch.

No batteries needed – magnet powered!

Bright white LED won’t burn out!

30-40 seconds of gentle shaking produces 10-15 minutes of light!

(a) (i) Explain how a voltage is induced in the coil.

(ii) What is the effect of shaking the torch faster?

(iii) Draw the circuit symbol for a capacitor.

(b) When lit, the current in the LED is 20 mA.

Calculate how much charge flows through the LED in 12 minutes.

\[ Q = I \times t = 0.02 \times 12 \times 60 = 14.4 \, \text{C} \]

(a) (i) answer should indicate movement

eg magnet is moved (1) in/out of coils/wires (1)

(a) (ii) accept: "(induced) current will increase"

"will charge more quickly" "produce more electrical energy/power"

do not accept: "lamp will shine brighter"

"more charge in the capacitor"

"will charge more quickly"

"(induced) current will increase"

(b) if no conversion into amperes and/or seconds then unit error (–½)

must show connecting wires
12. (continued) (c) The torch produces a beam of light.

The diagram shows the LED positioned at the focus of the torch reflector. Complete the diagram by drawing light rays to show how the beam of light is produced.

Reasonably straight/parallel minimum of 2 rays drawn

Independent marks

(1) for direction
(1) for length/ray paths

LED reflector

T. The diagram shows the LED positioned at the focus of the torch. T. The torch produces a beam of light.
An electric kettle is used to heat 0.4 kg of water. (a) The initial temperature of the water is 15 °C. Calculate how much heat energy is required to bring this water to its boiling point of 100 °C. (b) The automatic switch on the kettle is not working. The kettle is switched off 5 minutes after it had been switched on. The power rating of the kettle is 2000 W. (i) Calculate how much electrical energy is converted into heat energy in this time. (ii) Calculate the mass of water changed into steam in this time.

\[ E = mc \Delta T \]
\[ E = 4180 \times 0.4 \times 85 \]
\[ E = 142120 \text{ J} \]

\[ E = P \times t \]
\[ E = 2000 \times 5 \times 60 \]
\[ E = 600000 \text{ J} \]
\[ E = 600000 - 142120 = 457880 \text{ J} \]

\[ H = m \times V \]
\[ 457880 = m \times 22.6 \times 10^5 \]
\[ m = 0.2 \text{ kg} \]

(a) If wrong value of \( c \) selected from specific heat capacity of materials data then can get 2 marks max if \( c = 4200 \) or any other value then (½) mark max significant figure range: 100 000 140 000 142 000

(b) (i) If \( E = 100000 \text{ J} \) (no conversion into seconds then deduct (½) unit error) (ii) If wrong value of \( V \) selected from \( V \) data table then can get 2 marks max any other value of \( V \) then (½) mark max

13. An electric kettle is used to heat 0.4 kg of water.
Question Nos 14(a) and (b)

The diagram represents the electromagnetic spectrum in order of increasing wavelength. Some of the radiations have not been named.

(a) (i) Name radiation:
- \( P \) ..............................................................
- \( Q \) ..............................................................
- \( R \) ..............................................................

(a) (ii) Which radiation in the electromagnetic spectrum has the highest frequency?

(b) Stars emit ultraviolet and infrared radiation. Name a detector for each of these two radiations.

- Infrared: ...........................................................
- Ultraviolet: .......................................................

(½) for each name
(½) for correct order

- If any entries are blank, you lose one order mark.

- In any radiation, do not accept:
  - Q — spectrum/ROYGBIV/laser radiation/visible radiation
  - R — “micro” or “\( \mu \)“ if any entries are blank/wrong then lose “order” (½) mark

- Accept:
  - IR — thermofilm/thermistor/thermopile/thermographic film/heat sensitive paper/IR film
  - UV — photographic film

- Do not accept:
  - IR — skin/photographic film
  - IR — camera
  - UV — photographic film

NOTES

Electromagnetic Spectrum

Increasing wavelength
In June 2005, a space vehicle called Mars Lander was sent to the planet Mars.

(a) The graph shows the gravitational field strength data table.

(i) The Mars Lander orbited Mars at a height of 200 km above the planet's surface. What is the value of the gravitational field strength at this height?

(ii) The Mars Lander, of mass 530 kg, then landed. Calculate the weight of the Mars Lander on the surface.

\[ W = mg \]

\[ W = 530 \times 4 \text{ N/kg} \]

\[ W = 2120 \text{ N} \]

Maximum mark: 1

Space for working and answer

\[ \text{Height above Mars surface in km} \]

\[ \text{Gravitational field strength in N/kg} \]

The graph shows the gravitational field strength at different heights.

(a) The graph shows the gravitational field strength at different heights.

(i) The Mars Lander orbited Mars at a height of 200 km above the planet's surface.

(ii) The Mars Lander, of mass 530 kg, then landed.
(b) The Mars Lander released a rover exploration vehicle on to the surface of Mars. To collect data from the bottom of a large crater, the rover launched a probe horizontally at 30 m/s. The probe took 6 s to reach the bottom of the crater.

(i) Calculate the horizontal distance travelled by the probe.

\[ d = v \times t \]
\[ = 30 \times 6 \]
\[ = 180 \text{ m} \]

(ii) Calculate the vertical speed of the probe as it reached the bottom of the crater.

\[ v = u + at \]
\[ = 0 + \frac{9}{t} \]
\[ = 9 \times \frac{6}{6} \]
\[ = 9 \times 1 \]
\[ = 9 \text{ m/s} \]