# 2015 Physics

# Advanced Higher

# Finalised Marking Instructions

## Part One: General Marking Principles for Physics – Advanced Higher

*This information is provided to help you understand the general principles you must apply when marking candidate responses to questions in this Paper. These principles must be read in conjunction with the specific Marking Instructions for each question.*

**(a)** Marks for each candidate response must always be assigned in line with these general marking principles and the specific Marking Instructions for the relevant question. If a specific candidate response does not seem to be covered by either the principles or detailed Marking Instructions, and you are uncertain how to assess it, you must seek guidance from your Team Leader/Principal Assessor.

### GENERAL MARKING ADVICE: Physics – Advanced Higher

The marking schemes are written to assist in determining the "minimal acceptable answer" rather than listing every possible correct and incorrect answer. The following notes are offered to support Markers in making judgements on candidates' evidence, and apply to marking both end of unit assessments and course assessments.

1. **Numerical Marking**

   (a) The fine divisions of marks shown in the marking scheme may be recorded within the body of the script beside the candidate's answer. If such marks are shown they must total to the mark in the inner margin.

   (b) The number recorded should always be the marks being awarded.
   The number out of which a mark is scored SHOULD NEVER BE SHOWN AS A DENOMINATOR. (½ mark will always mean one half mark and never 1 out of 2.)

   (c) Where square ruled paper is enclosed inside answer books it should be clearly indicated that this item has been considered. Marks awarded should be transferred to the script booklet inner margin and marked G.

   (d) The total for the paper should be rounded up to the nearest whole number.

2. **Other Marking Symbols which may be used**

| | | |
|---|---|---|
| TICK | – | Correct point as detailed in scheme, includes data entry. |
| SCORE THROUGH | – | Any part of answer which is wrong. (For a block of wrong answer indicate zero marks.)<br>Excess significant figures. |
| INVERTED VEE | – | A point omitted which has led to a loss of marks. |
| WAVY LINE | – | Under an answer worth marks which is wrong only because a wrong answer has been carried forward from a previous part. |
| "G" | – | Reference to a graph on separate paper. You MUST show a mark on the graph paper and the SAME mark on the script. |
| "X" | – | Wrong Physics |
| ✳ | – | Wrong order of marks |

**No other annotations are allowed on the scripts.**

3. **General Instructions (Refer to National Qualifications Marking Instructions Booklet)**

(a) No marks are allowed for a description of the wrong experiment or one which would not work.
Full marks should be given for information conveyed correctly by a sketch.

(b) Surplus answers: where a number of reasons, examples etc are asked for and a candidate gives more than the required number then wrong answers may be treated as negative and cancel out part of the previous answer.

(c) Full marks should be given for a correct answer to a numerical problem even if the steps are not shown explicitly. The part marks shown in the scheme are for use in marking partially correct answers.

**However, when the numerical answer is given or a derivation of a formula is required every step must be shown explicitly.**

(d) Where 1 mark is shown for the final answer to a numerical problem ½ mark may be deducted for an incorrect unit.

(e) Where a final answer to a numerical problem is given in the form $3^{-6}$ instead of $3 \times 10^{-6}$ then deduct ½ mark.

(f) Deduct ½ mark if an answer is wrong because of an arithmetic slip.

(g) No marks should be awarded in a part question after the application of a wrong physics principle (wrong formula, wrong substitution) **unless specifically allowed for in the marking scheme – eg marks can be awarded for data retrieval.**

(h) In certain situations, a wrong answer to a part of a question can be carried forward within that part of the question. This would incur no further penalty provided that it is used correctly. Such situations are indicated by a horizontal dotted line in the marking instructions.

Wrong answers can always be carried forward to the next part of a question, over a solid line without penalty.

The exceptions to this are:

- where the numerical answer is given
- where the required equation is given.

(i) ½ mark should be awarded for selecting a formula.

(j) Where a triangle type "relationship" is written down and then not used or used incorrectly then any partial ½ mark for a formula should not be awarded.

(k) In numerical calculations, if the correct answer is given then converted wrongly in the last line to another multiple/submultiple of the correct unit then deduct ½ mark.

(l) Significant figures.
Data in question is given to 3 significant figures.
Correct final answer is 8·16J.
Final answer 8·2J or 8·158J or 8·1576J – No penalty.
Final answer 8J or 8·15761J – Deduct ½ mark.
Candidates should be penalised for a final answer that includes:

- three or more figures too many
  **or**
- two or more figures too few
  **ie accept two higher and one lower.**

**Max ½ mark deduction per question.**
**Max 2½ deduction from question paper.**

(m) Squaring Error

$E_K = ½ mv^2 = ½ \times 4 \times 2^2 = 4J$ **Award 1½** Arith error

$E_K = ½ mv^2 = ½ \times 4 \times 2 = 4J$ **Award ½ for formula.** Incorrect substitution.

The General Marking Instructions booklet should be brought to the markers' meeting.

**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.

| | Answers | Mark + comment | Issue |
|---|---|---|---|
| 1. | $V=IR$<br>$7\cdot5=1\cdot5R$<br>$R=5\cdot0\Omega$ | (½)<br>(½)<br>(1) | Ideal Answer |
| 2. | $5\cdot0\Omega$ | (2) Correct Answer | GMI 1 |
| 3. | 5·0 | (1½) Unit missing | GMI 2(a) |
| 4. | $4\cdot0\Omega$ | (0) No evidence/Wrong Answer | GMI 1 |
| 5. | ______ Ω | (0) No final answer | GMI 1 |
| 6. | $R=\frac{V}{I}=\frac{7\cdot5}{1\cdot5}=4\cdot0\,\Omega$ | (1½) Arithmetic error | GMI 7 |
| 7. | $R=\frac{V}{I}=4\cdot0\,\Omega$ | (½) Formula only | GMI 4 and 1 |
| 8. | $R=\frac{V}{I}=$ ______ Ω | (½) Formula only | GMI 4 and 1 |
| 9. | $R=\frac{V}{I}=\frac{7\cdot5}{1\cdot5}=$ ______ Ω | (1) Formula + subs/No final answer | GMI 4 and 1 |
| 10. | $R=\frac{V}{I}=\frac{7\cdot5}{1\cdot5}=4\cdot0$ | (1) Formula + substitution | GMI 2(a) and 7 |
| 11. | $R=\frac{V}{I}=\frac{1\cdot5}{7\cdot5}=5\cdot0\,\Omega$ | (½) Formula but wrong substitution | GMI 5 |
| 12. | $R=\frac{V}{I}=\frac{75}{1\cdot5}=5\cdot0\,\Omega$ | (½) Formula but wrong substitution | GMI 5 |
| 13. | $R=\frac{I}{V}=\frac{7\cdot5}{1\cdot5}=5\cdot0\,\Omega$ | (0) Wrong formula | GMI 5 |
| 14. | $V=IR \quad 7\cdot5=1\cdot5\times R$<br>$R=0\cdot2\,\Omega$ | (1½) Arithmetic error | GMI 7 |
| 15. | $V=IR$<br>$R=\frac{I}{V}=\frac{1\cdot5}{7\cdot5}=0\cdot2\,\Omega$ | (½) Formula only | GMI 20 |

**DATA SHEET**

COMMON PHYSICAL QUANTITIES

| *Quantity* | *Symbol* | *Value* | *Quantity* | *Symbol* | *Value* |
|---|---|---|---|---|---|
| Gravitational acceleration on Earth | $g$ | $9{\cdot}8\ \text{ms}^{-2}$ | Mass of electron | $m_e$ | $9{\cdot}11 \times 10^{-31}\ \text{kg}$ |
| Radius of Earth | $R_E$ | $6{\cdot}4 \times 10^{6}\ \text{m}$ | Charge on electron | $e$ | $-1{\cdot}60 \times 10^{-19}\ \text{C}$ |
| Mass of Earth | $M_E$ | $6{\cdot}0 \times 10^{24}\ \text{kg}$ | Mass of neutron | $m_n$ | $1{\cdot}675 \times 10^{-27}\ \text{kg}$ |
| Mass of Moon | $M_M$ | $7{\cdot}3 \times 10^{22}\ \text{kg}$ | Mass of proton | $m_p$ | $1{\cdot}673 \times 10^{-27}\ \text{kg}$ |
| Radius of Moon | $R_M$ | $1{\cdot}7 \times 10^{6}\ \text{m}$ | Mass of alpha particle | $m_\propto$ | $6{\cdot}645 \times 10^{-27}\ \text{kg}$ |
| Mean Radius of Moon Orbit | | $3{\cdot}84 \times 10^{8}\ \text{m}$ | Charge on alpha particle | | $3{\cdot}20 \times 10^{-19}\ \text{C}$ |
| Universal constant of gravitation | $G$ | $6{\cdot}67 \times 10^{-11}\ \text{m}^3\ \text{kg}^{-1}\text{s}^{-2}$ | Planck's constant | $h$ | $6{\cdot}63 \times 10^{-34}\ \text{Js}$ |
| Speed of light in vacuum | $c$ | $3{\cdot}0 \times 10^{8}\ \text{ms}^{-1}$ | Permittivity of free space | $\varepsilon_0$ | $8{\cdot}85 \times 10^{-12}\ \text{Fm}^{-1}$ |
| Speed of sound in air | $v$ | $3{\cdot}4 \times 10^{2}\ \text{ms}^{-1}$ | Permeability of free space | $\mu_0$ | $4\pi \times 10^{-7}\ \text{Hm}^{-1}$ |

REFRACTIVE INDICIES

The refractive indices refer to sodium light of wavelength 589 nm and to substances at a temperature of 273 K.

| *Substance* | *Refractive index* | *Substance* | *Refractive index* |
|---|---|---|---|
| Diamond | 2·42 | Glycerol | 1·47 |
| Glass | 1·51 | Water | 1·33 |
| Ice | 1·31 | Air | 1·00 |
| Perspex | 1·49 | Magnesium Fluoride | 1·38 |

SPECTRAL LINES

| *Element* | *Wavelength*/nm | *Colour* | *Element* | *Wavelength*/nm | *Colour* |
|---|---|---|---|---|---|
| Hydrogen | 656 | Red | Cadmium | 644 | Red |
| | 486 | Blue-green | | 509 | Green |
| | 434 | Blue-violet | | 480 | Blue |
| | 410 | Violet | *Lasers* | | |
| | 397 | Ultraviolet | *Element* | *Wavelength*/nm | *Colour* |
| | 389 | Ultraviolet | Carbon dioxide | 9550<br>10590 | Infrared |
| Sodium | 589 | Yellow | Helium-neon | 633 | Red |

PROPERTIES OF SELECTED MATERIALS

| *Substance* | *Density*/ kg $m^{-3}$ | *Melting Point*/K | *Boiling Point*/K | *Specific Heat Capacity*/ J $kg^{-1}$ $K^{-1}$ | *Specific Latent Heat of Fusion*/ J $kg^{-1}$ | *Specific Latent Heat of Vaporisation* /J $kg^{-1}$ |
|---|---|---|---|---|---|---|
| Aluminium | $2·70 \times 10^3$ | 933 | 2623 | $9·02 \times 10^2$ | $3·95 \times 10^5$ | …. |
| Copper | $8·96 \times 10^3$ | 1357 | 2853 | $3·86 \times 10^2$ | $2·05 \times 10^5$ | …. |
| Glass | $2·60 \times 10^3$ | 1400 | …. | $6·70 \times 10^2$ | …. | …. |
| Ice | $9·20 \times 10^2$ | 273 | …. | $2·10 \times 10^3$ | $3·34 \times 10^5$ | …. |
| Gylcerol | $1·26 \times 10^3$ | 291 | 563 | $2·43 \times 10^3$ | $1·81 \times 10^5$ | $8·30 \times 10^5$ |
| Methanol | $7·91 \times 10^2$ | 175 | 338 | $2·52 \times 10^3$ | $9·9 \times 10^4$ | $1·12 \times 10^6$ |
| Sea Water | $1·02 \times 10^3$ | 264 | 377 | $3·93 \times 10^3$ | …. | …. |
| Water | $1·00 \times 10^3$ | 273 | 373 | $4·19 \times 10^3$ | $3·34 \times 10^5$ | $2·26 \times 10^6$ |
| Air | 1·29 | …. | …. | …. | .... | …. |
| Hydrogen | $9·0 \times 10^{-2}$ | 14 | 20 | $1·43 \times 10^4$ | .... | $4·50 \times 10^5$ |
| Nitrogen | 1·25 | 63 | 77 | $1·04 \times 10^3$ | …. | $2·00 \times 10^5$ |
| Oxygen | 1·43 | 55 | 90 | $9·18 \times 10^2$ | …. | $2·40 \times 10^5$ |

The gas densities refer to a temperature of 273 K and pressure of $1·01 \times 10^5$ Pa.

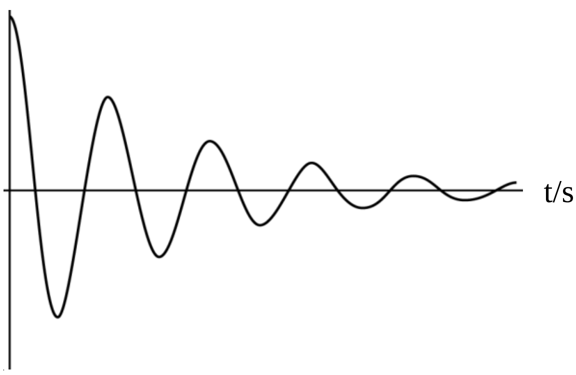
**Part Two: Marking Instructions for each Question**

<table>
<tr><th colspan="3">Question</th><th>Expected Answer/s</th><th>Max Mark</th><th>Additional Guidance</th></tr>
<tr><td>1</td><td>a</td><td></td><td>$m = \frac{m_0}{\sqrt{\left(1-\frac{v^2}{c^2}\right)}}$ (½)<br>$m = \frac{1\cdot673\times10^{-27}}{\sqrt{\left(1-\frac{\left[2\cdot99\times10^{8}\right]^2}{\left[3\cdot0\times10^{8}\right]^2}\right)}}$ (½)<br>$m = \frac{1\cdot673\times10^{-27}}{0\cdot0816}$<br>$m = 2\cdot1 \times 10^{-26}$ kg (1)</td><td>2</td><td></td></tr>
<tr><td>1</td><td>b</td><td></td><td>$E = mc^2$ (½)<br>$= (2\cdot1 \times 10^{-26}) \times (3\cdot0 \times 10^{8})^2$ (½)<br>$= 1\cdot9 \times 10^{-9}$ J (1)</td><td>2<br><br>(4)</td><td></td></tr>
</table>

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| 2 | a | | $I = \frac{1}{2}mr^2$ **(½)**<br>$\frac{16\times 0\cdot 30^2}{2}$ **(½)**<br>$= 0\cdot 72$ kg m$^2$ **(1)** | 2 | |
| 2 | b | i | $\omega = \frac{v}{r} = \frac{3\cdot 0}{0\cdot 30} = 10\left(\text{rad s}^{-1}\right)$ **(1)**<br>$\omega^2 = \omega_o{}^2 + 2\alpha\theta$ **(½)**<br>$0 = 10^2 + 2\times\alpha\times(2\pi\times 5)$ **(½)**<br>$\alpha = -1\cdot 6 \text{ rad s}^{-2}$ **(1)** | 3 | Alternative method possible: Calculate linear displacement (9·42 m), use to find acceleration, then convert to angular at end. |
| 2 | b | ii | Torque $= I\alpha$ **(½)**<br>$= 0\cdot 72 \times 1\cdot 6$ **(½)**<br>$= (-)1\cdot 2$ N m **(1)** | 2 | |
| 2 | c | | The speed of the mass will be less (than 3·0m s$^{-1}$) **(1)**<br>Second mark for correct justification. Eg:<br>• Flywheel has greater moment of inertia<br>• Flywheel will be more difficult to start moving<br>• Smaller acceleration of flywheel<br>• More energy required to achieve same angular velocity. **(1)** | 2 | |
| 2 | d | i | $I = ½ \times 6\cdot 0 \times (0\cdot 15^2 + 0\cdot 20^2)$ **(½)**<br>$I = 0\cdot 19$ kg m$^2$ **(½)** | 1 | |
| 2 | d | ii | $\omega = \frac{\theta}{t}$ **(½)**<br>$\omega = \frac{6\cdot 0\times 10^4 \times 2\pi}{60}$<br>$\omega = 2000\pi\,(\text{rad s}^{-1})$ **(½)**<br>$E_{krot} = ½I\omega^2$ **(½)**<br>$= ½ \times 0\cdot 19 \times (2000\pi)^2$ **(½)**<br>$= 3\cdot 8 \times 10^6$ J **(1)** | 3<br>**(13)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **3** | **a** | **i** | $m\omega^2 r = \frac{GMm}{r^2}$<br>**(½)** for both equations and **(½)** for equality<br>$\omega = \frac{2\pi}{T}$ **(½)**<br>$\frac{m4\pi^2 r}{T^2} = \frac{GMm}{r^2}$ **(½)**<br>$M = \frac{4\pi^2 r^3}{GT^2}$ needed. | **2** | |
| **3** | **a** | **ii** | $M = \frac{4\pi^2 r^3}{GT^2}$<br>$= \frac{\left(4\times\pi^2\times\left(1\cdot77\times10^{11}\right)^3\right)}{6\cdot67\times10^{-11}\times\left(525\cdot8\times24\times60\times60\right)^2}$ **(½)** **(½)**<br>$= 1\cdot6\times10^{30}$ kg **(1)** | **2** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **3** | **b** | **i** | $F = \frac{GMm}{r^2}$ **(½)**<br>$= \frac{6 \cdot 67 \times 10^{-11} \times 6 \cdot 0 \times 10^{24} \times 2 \cdot 0}{(3 \cdot 00 \times 10^8)^2}$ **(½)**<br>$= 8 \cdot 89 \times 10^{-3}$ (N) **(½)**<br>$F = \frac{GMm}{r^2}$<br>$= \frac{6 \cdot 67 \times 10^{-11} \times 7 \cdot 3 \times 10^{22} \times 2 \cdot 0}{(0 \cdot 84 \times 10^8)^2}$<br>$= 1 \cdot 38 \times 10^{-3}$ (N) **(½)**<br><br>Then subtraction gives<br>$F = 7 \cdot 5 \times 10^{-3}$ N **(1)** | **3** | |
| **3** | **b** | **ii** | $V = -\frac{GM}{r}$ **(½)**<br>$= -\frac{6 \cdot 67 \times 10^{-11} \times 6 \cdot 0 \times 10^{24}}{3 \cdot 00 \times 10^8}$ **(½)**<br>$= -1 \cdot 3 \times 10^6$ J $kg^{-1}$ **(1)** | **2** | |
| **3** | **b** | **iii** | Potential is work done (per unit mass) moving from infinity to that point.<br>**or**<br>Infinity defined as zero potential. **(1)**<br><br>Work will be done by the field on the mass.<br>**or**<br>A negative amount of work will be done to move an object from infinity to any point.<br>**or**<br>$W_D$ by gravity in moving to that point<br>**or**<br>Force acts in opposite direction to *r*. **(1)**<br><br>Any *valid* alternative explanation gets second mark. | **2**<br><br>**(11)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| 4 | a | i | Force acting on (acceleration of) object is directly proportional to and in the opposite direction to its displacement. (from equilibrium)<br><br>*Mark is 1 or 0.* | 1 | |
| 4 | a | ii | $y = A\sin\omega t$<br>$\frac{dy}{dt} = A\omega\cos\omega t$ **(½)**<br>$\frac{d^2y}{dt^2} = -A\omega^2\sin\omega t$ **(½)**<br>$\frac{d^2y}{dt^2} = -\omega^2 y$ **(1)** | 2 | |
| 4 | a | iii | (Cos used when at $t = 0$) displacement is a maximum ($A$). | 1 | |
| 4 | b | i | $\omega = \frac{2\pi}{T}$ **or** $\omega = 2\pi f$ **(½)**<br>$\omega = \left(\frac{2\pi}{0\cdot50} =\right) 4\pi$ (= 12·6) (rad $s^{-1}$) **(½)**<br>$v = (\pm)\omega\sqrt{A^2 - y^2}$ **(½)**<br>$v = (\pm)4\pi\sqrt{0\cdot05^2 - 0^2}$ **(½)**<br>$v = 0\cdot63$ m $s^{-1}$ **(1)** | 3 | Alternative : differentiate<br>$y = A\sin\omega t$<br>$v = A\omega\cos\omega t$ **(½)**<br>$= 0\cdot05 \times 4\pi \times \cos(0\cdot5 \times 4\pi)$ **(½)**<br>$= 0\cdot63$ m $s^{-1}$ **(1)**<br><br>$v_{max} = A\omega$ **(½)**<br>$= 0\cdot05 \times 4\pi$ **(½)**<br>$= 0\cdot63$ m $s^{-1}$ **(1)** |
| 4 | b | ii | $a = (\pm)\omega^2 y$ **or** $(\pm)\omega^2 A$ **(½)**<br>$= (4\pi)^2 \times 0\cdot050$ **(½)**<br>$= (\pm)7\cdot9$ m $s^{-2}$ **(1)** | 2 | |
| 4 | c | |  | 1<br><br>**(10)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **5** | **a** | **i** | $V_y = V_p + V_q$ **(½)**<br>$V = \frac{Q}{4\pi\varepsilon_o r}$ **(½)**<br><br>**OR** $V_y = \frac{Q_p}{4\pi\varepsilon_o r_1} + \frac{Q_q}{4\pi\varepsilon_o r_2}$ **(1)**<br>(this statement combines both available formula ½ marks)<br><br>$= \frac{-3\cdot0\times10^{-9}}{4\pi\times8\cdot85\times10^{-12}\times0\cdot15} + \frac{8\cdot0\times10^{-9}}{4\pi\times8\cdot85\times10^{-12}\times0\cdot15}$<br>**(½) for both substitutions.**<br><br>$= -180 + 480$ **(½)**<br>(cannot award this ½ mark unless $V_y = V_p + V_q$ has been indicated)<br>$(= -179\cdot8 + 479\cdot6)$<br>$= 300$ V | **2** | |
| **5** | **a** | **ii** | Potential will reduce (to zero) **(1)**<br>and (then) become negative **(1)** | **2** | |
| **5** | **b** | | one more up quark (in daughter element) **(1)**<br>one less down quark (in daughter element) **(1)** | **2**<br><br>**(6)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **6** | **a** | **i** | Force exerted per (unit) charge is constant at any point in the field. | **1** | |
| **6** | **a** | **ii** | E = gradient of line<br>**or**<br>$= \frac{y_2 - y_1}{x_2 - x_1}$ **(½)**<br>$= \frac{3000 - 1000}{0{\cdot}124 - 0{\cdot}044}$ **(½)**<br>$= 25000\ V\ m^{-1}$ **(1)** | **2** | |
| **6** | **a** | **iii** | $E = \frac{V}{d}$ **(½)**<br>$25000 = \frac{5000}{d}$ **(½)**<br>d = 0·20 m (200 mm) **(1)** | **2** | |
| **6** | **a** | **iv** | Any suitable answer eg<br>• Systematic uncertainty in measuring *d/V*<br>• Alignment of metre stick<br>• The flame has a finite thickness so cannot get exactly to the zero point.<br>• Factors causing field to be non-uniform.<br>• A p.d. across the resistor for all readings.<br>• Poor calibration of instruments measuring *V/d*. | **1** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| 6 | b | i | $F = QE$ **(½)**<br>$= 3{\cdot}20 \times 10^{-19} \times 2{\cdot}5 \times 10^{5}$ **(½)**<br>$( = 8 \times 10^{-14}$ (N) )<br>$a = \frac{F}{m}$<br>$= \frac{8\times10^{-14}}{6\cdot645\times10^{-27}}$ **or** $\frac{3\cdot2\times10^{-19}\times2\cdot5\times10^{5}}{6\cdot645\times10^{-27}}$<br>**(½)**<br>$= 1{\cdot}2 \times 10^{13}$ (m s$^{-2}$) **(½)**<br>------------------------------------------------<br>$s = ut + \frac{1}{2}at^{2}$ **(½)**<br>$= ½ \times 1{\cdot}2 \times 10^{13} \times (9{\cdot}4 \times 10^{-9})^{2}$ **(½)**<br>$= 5{\cdot}3 \times 10^{-4}$ m **(1)** | **4** | |
| 6 | b | ii | Deflection is less **(1)**<br>E is less **(½)**<br>Force/acceleration is less **(½)** | **2**<br><br>**(12)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| 7 | a | i | Force acts on particle at right angles to the direction of its velocity/motion<br>**or**<br>a central force on particle. | 1 | |
| 7 | a | ii | $\frac{mv^2}{r} = Bqv$<br>**(½)** for both equations and **(½)** for equality<br>$r = \frac{mv}{Bq}$ **(½)**<br>$r = \frac{1\cdot673\times10^{-27}\times v}{B\times1\cdot6\times10^{-19}}$ **(½)**<br>$r = \frac{1\cdot05\times10^{-8}v}{B}$ | 2 | |
| 7 | b | | (Component of) velocity at right angles to field/ $v$ sin θ, results in circular motion/central force. **(1)**<br>(Component of) velocity parallel to field/ $v$ cosθ is constant/no unbalance force (in this direction). **(1)** | 2 | |
| 7 | c | i | $f$ = 4·0 Hz, $T$ = 1/$f$ = 0·25 s **(½)**<br>time between mirror points = 0·125 s **(½)**<br>- - - - - - - - - - - - - - - - - - - -<br>$d = vt$ **(½)**<br>= 1·2 × $10^7$ × 0·125 **(½)**<br>= 1·5 × $10^6$ m **(1)** | 3 | |
| 7 | c | ii | Magnetic field strength has decreased. | 1 | |
| 7 | c | iii | $r = \frac{1\cdot05\times10^{-8}v}{B}$ **(½)**<br>$1\cdot0\times10^4 = \frac{1\cdot05\times10^{-8}\times1\cdot2\times10^7}{B}$ **(½)**<br>B = 1·3 × $10^{-5}$ T **(1)** | 2<br><br>**(11)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **8** | **a** | **i** | **Circuit must be able to make required measurements as shown or zero marks**.<br><br>**Variable frequency supply, inductor, ammeter in series.**<br>**Voltmeter in parallel with supply to monitor constant voltage** | **2** | |
| **8** | **a** | **ii** | k values are 5·9 6·1 6·1 5·8 6·0<br>All k values correct **(1½)**<br>I inversely proportional to f **(½)** | **2** | |
| **8** | **b** | i | $V_s$ = 20 (V) **(½)**<br>$V_R = 20 - 9$ **(½)**<br>= 11 V **(1)** | **2** | |
| **8** | **b** | **ii** | $E = -L\, dI/dt$ **(½)**<br>$-4{\cdot}2 = -3 \times dI/dt$ **(½)**<br>$dI/dt = 1{\cdot}4$ A s$^{-1}$ **(1)** | **2** | |
| **8** | **b** | **iii** | Rate of change of current/magnetic field is at its maximum | **1** | |
| **8** | **c** | | Same maximum back emf **(1)**<br>Time for back emf to reach zero is greater **(1)** | **2**<br><br>**(11)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **9** | **a** | | $B = \frac{\mu_0 I}{2\pi r}$ **(½)**<br><br>$= \frac{4\times\pi\times10^{-7}\times0\cdot60}{2\times\pi\times0\cdot30}$ **(½)**<br><br>$= 4\cdot0 \times 10^{-7}$ T **(1)** | **2** | |
| **9** | **b** | **i** | Magnetic fields/induction are equal in magnitude **(½)**<br>and opposite in direction **(½)** | **1** | |
| **9** | **b** | **ii** | $B = \frac{\mu_0 I}{2\pi r}$<br><br>$4\cdot0\times10^{-7} = \frac{4\times\pi\times10^{-7}\times1\cdot8}{2\times\pi\times r}$ **(½)**<br><br>$r = 0\cdot90$ m **(½)**<br><br>Distance from AB = 0·90 + 0·30 = 1·2 m **(1)** | **2**<br><br>**(5)** | Ratio method – ok<br><br>$\frac{1\cdot80}{0\cdot60} = 3$<br><br>$r = 3\times0\cdot30 = 0\cdot90$m |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| **10** | **a** | **i** | The sound will change from a higher to a lower pitch/frequency as the car passes. | **1** | |
| **10** | **a** | **ii** | $f_o = f_s\left(\frac{v}{v+v_s}\right)$ **(½)**<br>$480 = 500\left(\frac{3\cdot4\times10^2}{3\cdot4\times10^2+v_s}\right)$ **(½)**<br>$480v_s = 20 \times 3\cdot4 \times 10^2$<br>$v_s = 14\ \text{m s}^{-1}$ **(1)** | **2** | |
| **10** | **a** | **iii** | **(A**) The frequency heard will be decreas**<u>ing</u>**.<br>**or**<br>Has decreased/decreases gradually **(1).** | **1** | |
| | | | **(B)** The frequency heard will be decreas**<u>ing</u>**.<br>**or**<br>Has decreased/decreases gradually **(1).** | **1** | |
| **10** | **b** | **i** | The speed of light is **much greater** than the speed of the car. | **1** | |
| **10** | **b** | **ii** | $\Delta f = \frac{2vf_T}{c}$<br>$880 = \frac{2\times v\times10\cdot5\times10^9}{3\cdot0\times10^8}$ **(1)**<br>$v = 13\ \text{ms}^{-1}$ **(1)** | **2**<br><br>**(8)** | |

| Question | | | Expected Answer/s | Max Mark | Additional Guidance |
|---|---|---|---|---|---|
| 11 | a | i | Two sets of coherent waves are necessary (for an interference pattern)<br>**or**<br>(Interference patterns can be produced by) Division of wavefront. | **1** | |
| 11 | a | ii | $\left(\Delta x = \frac{L}{6}\right) = 0\cdot011(\text{m})$ **(1)**<br>----------------------------------------<br>$\Delta x = \frac{\lambda D}{d}$ **(½)**<br>$0\cdot011 = \frac{\lambda \times 4\cdot250}{0\cdot25 \times 10^{-3}}$ **(½)**<br>$\lambda = 6\cdot5 \times 10^{-7}$ m **(1)** | **3** | |
| 11 | a | iii | % unc in $D = \frac{0\cdot005}{4\cdot250} \times 100 = 0\cdot12\%$ **(½)**<br>% unc in $L = \frac{2}{67} \times 100 = 3\cdot0\%$ **(½)**<br>% unc in $d = \frac{0\cdot01}{0\cdot25} \times 100 = 4\cdot0\%$ **(½)**<br>Total % unc = $(3\cdot0^2 + 4\cdot0^2)^{½}$<br>$= 5\cdot0\%$ **(½)**<br>Absolute unc = $0\cdot05 \times 6\cdot5 \times 10^{-7}$<br>$= 3 \times 10^{-8}$ m **(1)** | **3** | |
| 11 | b | | % uncertainty in λ is greater **(1)**<br>*L* (or Δ*x*) will be less<br>**or** **(1)**<br>% uncertainty in *L* (or Δ*x*) will be greater | **2**<br><br>**(9)** | |

[END OF MARKING INSTRUCTIONS]