



# Mark Scheme (Results)

June 2019

Pearson Edexcel GCE  
In Physics (9PH0)  
Paper 01 Advanced Physics I

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## General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

## Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- Organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

## Physics Specific Marking Guidance

### Underlying principle

The mark scheme will clearly indicate the concept that is being rewarded, backed up by examples. It is not a set of model answers.

For example:

Horizontal force of hinge on table top

66.3 (N) or 66 (N) **and** correct indication of direction [no ue]

[Some examples of direction: acting from right (to left) / to the left / West / opposite direction to horizontal. May show direction by arrow. Do not accept a minus sign in front of number as direction.]

This has a clear statement of the principle for awarding the mark, supported by some examples illustrating acceptable boundaries.

### Mark scheme format

- Bold lower case will be used for emphasis.
- Round brackets ( ) indicate words that are not essential e.g. “(hence) distance is increased”.
- Square brackets [ ] indicate advice to examiners or examples e.g. [Do not accept gravity] [ecf].

### Unit error penalties

- A separate mark is not usually given for a unit but a missing or incorrect unit will normally cause the final calculation mark to be lost.
- Incorrect use of case e.g. ‘Watt’ or ‘w’ will not be penalised.
- There will be no unit penalty applied in ‘show that’ questions or in any other question where the units to be used have been given.
- The same missing or incorrect unit will not be penalised more than once within one question but may be penalised again in another question.
- Occasionally, it may be decided not to penalise a missing or incorrect unit e.g. the candidate may be calculating the gradient of a graph, resulting in a unit that is not one that should be known and is complex.
- The mark scheme will indicate if no unit error penalty is to be applied by means of [no ue].

### Significant figures

- Use of an inappropriate number of significant figures in the theory papers will normally only be penalised in ‘show that’ questions where use of too few significant figures has resulted in the candidate not demonstrating the validity of the given answer.
- Use of an inappropriate number of significant figures will normally be penalised in the practical examinations or coursework.
- Using  $g = 10 \text{ m s}^{-2}$  **will** be penalised.

### Calculations

- Bald (i.e. no working shown) correct answers score full marks unless in a ‘show that’ question.
- Rounding errors will not be penalised.
- If a ‘show that’ question is worth 2 marks then both marks will be available for a reverse working; if it is worth 3 marks then only 2 will be available.
- use of the formula means that the candidate demonstrates substitution of physically correct values, although there may be conversion errors e.g. power of 10 error.
- recall of the correct formula will be awarded when the formula is seen or implied by substitution.
  - The mark scheme will show a correctly worked answer for illustration only.

| Question Number | Acceptable answers | Additional guidance | Mark |
|-----------------|--------------------|---------------------|------|
| 1               | B                  |                     | 1    |
| 2               | B                  |                     | 1    |
| 3               | B                  |                     | 1    |
| 4               | C                  |                     | 1    |
| 5               | B                  |                     | 1    |
| 6               | C                  |                     | 1    |
| 7               | D                  |                     | 1    |
| 8               | A                  |                     | 1    |
| 9               | C                  |                     | 1    |
| 10              | C                  |                     | 1    |

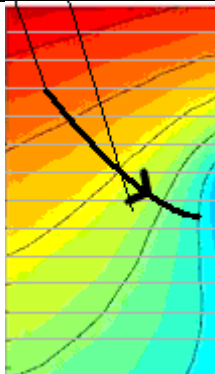
(Total for Multiple Choice Questions = 10 marks)

| Question Number | Acceptable answers                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                         | Mark |
|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 11(a)           | <ul style="list-style-type: none"> <li>Use of <math>F = \frac{mv^2}{r}</math> (1)</li> <li>States that <math>F = mg</math> only as reaction force is zero (1)</li> </ul>                                                                        | Example of derivation:<br>$mg = \frac{mv^2}{r}$<br>$v = \sqrt{gr}$                                                                                                                                                                          | (2)  |
| 11(b)           | <ul style="list-style-type: none"> <li>Use of energy conservation (1)</li> <li>Substitution of <math>v^2 = rg</math> (1)</li> <li><math>V_{\text{bottom}} = 2.7 \text{ m s}^{-1}</math> (1)</li> </ul>                                          | Example of calculation:<br>$\frac{1}{2}mv^2_{\text{top}} + mgh = \frac{1}{2}mv^2_{\text{bottom}}$<br>$g(\text{ms}^{-2})r(\text{m}) + 2g(\text{ms}^{-2})0.30(\text{m}) = v^2(\text{ms}^{-1})^2$<br>$v^2 = 0.75g$<br>$v = 2.71\text{ms}^{-1}$ | (3)  |
| 11(c)           | <ul style="list-style-type: none"> <li>Use of <math>s = ut + \frac{1}{2}at^2</math> (1)</li> <li>Recognise <math>u = 0</math> (1)</li> <li>Use of <math>v = d/t</math> in horizontal direction (1)</li> <li>Displacement = 1.1 m (1)</li> </ul> | Example of calculation:<br>$0.65 \text{ m} = \frac{1}{2}9.81 \text{ ms}^{-2}t^2$<br>$t = 0.364 \text{ s}$<br>$s = 3.0 \text{ ms}^{-1} \times 0.364 \text{ s}$<br>$s = 1.09 \text{ m}$                                                       | (4)  |

(Total for Question 11 = 9 marks)

| Question Number | Acceptable answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 12(a)           | <ul style="list-style-type: none"> <li>• Alternating current/a.c. (in primary) produces changing/alternating magnetic flux/field (1)</li> <li>• The magnetic flux/field is linked to the secondary coil by the iron core (1)</li> <li>• The changing magnetic flux/field induces an emf in the secondary coil (1)</li> <li>• More turns on the secondary (will increase the rate of change of flux linkage according to Faraday's law). (1)</li> </ul>                                   | <p>alt. to changing magnetic flux is <math>\Delta N\phi</math></p> <p>alt. quote of <math>V_1/V_2 = N_1/N_2</math></p>                                                                                                                                                                                                                                                                                                                                                                                  | (4)  |
| 12(b)           | <ul style="list-style-type: none"> <li>• 270K corresponds to a resistivity of <math>2 \times 10^{-8} (\Omega \text{ m})</math> (1)</li> <li>• Use of <math>P=VI</math> (1)</li> <li>• Use of <math>R=\rho l/A</math> (1)</li> <li>• Use of <math>P=I^2R</math> (1)</li> <li>• Power losses from copper cables 19 kW so more than 7 kW and that the superconductor would save energy. MP5 dependant on MP2,3,4 (1)</li> </ul> <p>(Acceptable range for Power losses: 9.6 kW to 34 kW)</p> | <p>range allow <math>2 \times 10^{-8} \Omega \text{ m}</math> to <math>2.1 \times 10^{-8} \Omega \text{ m}</math></p> <p>Example of calculation:<br/> <math>40 \times 10^6 \text{ W} = 110 \times 10^3 \text{ V} \times I</math><br/> <math>I = 364 \text{ A}</math><br/> <math>R = \frac{2 \times 10^{-8} \Omega \text{ m} \times 1.050 \times 10^3 \text{ m}}{145 \times 10^{-6} \text{ m}^2} = 0.145 \Omega</math><br/> <math>P = 364^2 \text{ A}^2 \times 0.145 \Omega = 19.2 \text{ kW}</math></p> | 5    |

(Total for Question 12 = 9 marks)

| Question Number | Acceptable answers                                                                                                                                                                                                                                                       | Additional guidance                                                                                                                                              | Mark |
|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 13(a)           | <ul style="list-style-type: none"> <li>A region where a charged particle experiences a force/acceleration</li> </ul>                                                                                                                                                     |                                                                                                                                                                  | (1)  |
| 13(b)(i)        | <ul style="list-style-type: none"> <li>States a value of <math>\Delta V</math></li> <li>Uses <math>\Delta V/\Delta d</math> with a difference in distance</li> <li><math>E = 560 \text{ V m}^{-1}</math><br/>allow range 500-560 <math>\text{V m}^{-1}</math></li> </ul> | <p>Example of calculation:<br/> <math>E = \frac{(80-75)\text{V}}{0.009\text{m}} = 556 \text{ V m}^{-1}</math><br/> (Alt: <math>5.6 \text{ V cm}^{-1}</math>)</p> | (3)  |
| 13(b)(ii)       | <ul style="list-style-type: none"> <li>Line perpendicular to a least 2 equipotential lines</li> <li>Arrow pointing towards flower</li> </ul>                                                                                                                             |                                                                              | (2)  |

| <b>13(b)(iii)</b> | <ul style="list-style-type: none"> <li>States <math>V \times r = \text{constant}</math> (1)</li> <li>One corresponding pair of values of <math>V</math> and <math>r</math> (1)</li> <li>At least two pairs of values used to show that the product is not constant therefore not radial (1)<br/>(MP3 dependent on MP2)</li> </ul> | <p>Example of calculation:<br/>           Using <math>V = 95</math> and <math>r = 2.0 - 2.2</math>: <math>Vr = 190 - 209</math><br/> <math>V = 90</math> and <math>r = 2.1 - 2.5</math>: <math>Vr = 189 - 225</math><br/> <math>V = 85</math> and <math>r = 2.5 - 2.8</math>: <math>Vr = 212 - 238</math><br/> <math>V = 80</math> and <math>r = 3.5 - 3.8</math>: <math>Vr = 280 - 304</math><br/> <math>V = 75</math> and <math>r = 4.3 - 4.7</math>: <math>Vr = 323 - 353</math><br/> <math>V = 70</math> and <math>r = 5.8 - 6.2</math>: <math>Vr = 406 - 434</math><br/>           Using <math>r = 3</math> and <math>V = 82 - 83</math>: <math>Vr = 246 - 249</math><br/> <math>r = 4</math> and <math>V = 77 - 78</math>: <math>Vr = 308 - 312</math><br/> <math>r = 5</math> and <math>V = 72 - 73</math>: <math>Vr = 360 - 365</math></p> | (3) |
|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>13(c)</b>      | <ul style="list-style-type: none"> <li>Charged particle/hair attracts/repels (1)<br/><br/>Or charged/hair experiences a force</li> </ul>                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | (1) |
| <b>13(d)</b>      | <ul style="list-style-type: none"> <li>Equipotential lines would be further apart (1)</li> </ul>                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | (1) |

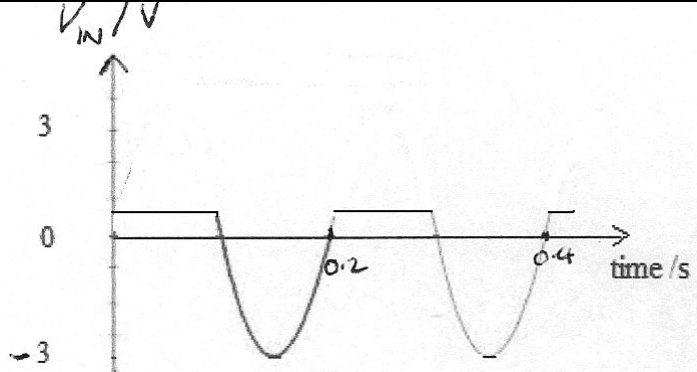
(Total for Question 13 = 11 marks)

| Question Number | Acceptable answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Additional guidance                                                                                                                                                                                                                                                                                                                                                                     | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 14(a)           | <ul style="list-style-type: none"> <li>• Use of <math>v^2 = u^2 + 2as</math> (1)</li> <li>• <math>v = 0</math> so <math>u = \sqrt{-2as}</math> (1)</li> <li>• <math>a</math> is a deceleration caused by friction (with surface) (1)</li> <li>• States <math>F = ma</math> where <math>F</math> is friction (1)</li> <li>• As <math>F = km = ma</math> so <math>a</math> must be constant<br/>Or <math>F = ma</math> if <math>F</math> proportional to <math>m</math> then <math>a</math> must be constant (1)</li> <li>• so acceleration <math>a</math> the same (as 1 p coin) so statement correct (1)</li> </ul> | <p>ignore whether minus sign included or not</p> <p>Alternative:</p> <ul style="list-style-type: none"> <li>• Work done by friction (with surface)</li> <li>• States <math>W = Fs</math></li> <li>• States <math>E_k = \frac{1}{2} mu^2</math></li> <li>• So <math>Fs = \frac{1}{2} mu^2</math></li> <li>• As <math>F = km</math></li> <li>• m's cancel so statement correct</li> </ul> | (6)  |
| 14(b)(i)        | <ul style="list-style-type: none"> <li>• Use of momentum = <math>mv</math> (1)</li> <li>• See component(s) in x direction (1)</li> <li>• Uses momentum conservation (1)</li> <li>• <math>u = 1.6 \text{ (m s}^{-1}\text{)}</math> (1)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                    | <p>Example of calculation:</p> $7.1(\text{g})u = 7.1(\text{g}) \times 0.9(\text{ms}^{-1}) \times \cos 8 + 3.6(\text{g}) \times 1.4(\text{ms}^{-1}) \times \cos 10$ $u = \frac{(6.33 + 4.96)}{7.1}$ $u = 1.59 \text{ms}^{-1}$                                                                                                                                                            | (4)  |

|                  |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                     |     |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| <b>14(b)(ii)</b> | <ul style="list-style-type: none"> <li>• Use of <math>E_k = \frac{1}{2}mv^2</math> (1)</li> <li>• Value of Initial <math>E_k = 9.0 \times 10^{-3}</math> (J) and (1)<br/> Final <math>E_k = 6.4 \times 10^{-3}</math> (J)<br/> (Show that value gives Initial <math>E_k = 1.42 \times 10^{-2}</math> (J)<br/> allow ecf from (b)(i))</li> </ul> | Allow ecf from b(i)<br><br>Example of calculation:<br><br>Initial $E_k = \frac{1}{2} \times 7.1 \times 10^{-3} (\text{kg}) \times 1.59^2 (\text{ms}^{-1})^2 = 9.0 \times 10^{-3} \text{ J}$<br>Final $E_k = \frac{1}{2} \times 7.1 \times 10^{-3} \times 0.9^2 + \frac{1}{2} \times 3.6 \times 10^{-3} \times 1.4^2 = 6.4 \times 10^{-3} \text{ J}$ | (2) |
|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|

(Total for Question 14 = 12 marks)

| Question Number | Acceptable answers                                                                                                                                                                                                                                                                      | Additional guidance                                                                                                                                                                                                       | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 15(a)           | <ul style="list-style-type: none"> <li>The diode only conducts (current) when the potential difference across it is (at least +) 0.7V (1)</li> <li>The diode does not conduct current when the p.d. is negative/reversed. (1)</li> </ul>                                                |                                                                                                                                                                                                                           | (2)  |
| 15(b)(i)        | <ul style="list-style-type: none"> <li>Use of <math>V_{rms} = \frac{V_o}{\sqrt{2}}</math> (1)</li> <li><math>V_{rms} = 2.4 \text{ V}</math> (1)</li> </ul>                                                                                                                              | <p>Example of calculation:<br/> <math>V_{rms} = \frac{3.4}{\sqrt{2}} = 2.4 \text{ V}</math></p>                                                                                                                           | (2)  |
| 15(b)(ii)       | <ul style="list-style-type: none"> <li>Energy is conserved<br/> <b>Or</b> Kirchoff's law<br/> <b>Or</b> potential difference is energy per unit charge (1)</li> <li>So the sum of p.d.s in a series circuit must equal the e.m.f. applied (1)<br/> (MP2 is dependent on MP1)</li> </ul> | <p>accept work done for energy</p> <p>accept <math>V_{in}</math> for emf</p> <p>Alternative:<br/> Current is the same in both components (1)</p> <p><math>IV_{IN} = IV_R + IV_D</math> and <math>I</math> cancels (1)</p> | (2)  |

|                   |                                                                                                                                                                                                                                                                                                                                                |                                                                                     |            |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|
| <b>15(b)(iii)</b> | <ul style="list-style-type: none"> <li>• Alternate half cycles of sine curve (with peak about 3 V) (1)</li> <li>• Horizontal line in 1<sup>st</sup> half cycle and negative half cycle of a sine curve in 2<sup>nd</sup> half cycle (1)</li> <li>• horizontal lines/spaces at a value of potential difference of 0.6 V to 0.8 V (1)</li> </ul> |  | <b>(3)</b> |
|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------|

(Total for Question 15 = 9 marks)

| Question Number | Acceptable answers                                                                                                                                                                          | Additional guidance                                                                                                                                                                | Mark |
|-----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 16(a)           | <ul style="list-style-type: none"> <li>converts eV to J (1)</li> <li>use of <math>\Delta m = \Delta E / c^2</math> (1)</li> <li>mass = <math>1.9 \times 10^{-28}</math> (kg) (1)</li> </ul> | Example of calculation:<br>$m = \frac{106 \text{ V} \times 1.6 \times 10^{-19} \text{ C} \times 10^6}{(3 \times 10^8)^2 (\text{ms}^{-1})^2}$ $m = 1.88 \times 10^{-28} \text{ kg}$ | (3)  |
| 16(b)(i)        | <ul style="list-style-type: none"> <li>Charge: -1 = -1 + 0 (1)</li> <li>Baryon number: needs to be stated as 0 (1)</li> <li>Lepton number: 0 = +1 + (-1) (1)</li> </ul>                     |                                                                                                                                                                                    | (3)  |
| 16(b)(ii)       | <ul style="list-style-type: none"> <li>Mass difference = 34 (MeV/c<sup>2</sup>) (1)</li> <li><math>E = \Delta mc^2</math> so <math>E = 34 \text{ MeV}</math> (1)</li> </ul>                 | alt to $E = \Delta mc^2$ to show unit $\frac{\text{MeV}}{c^2} \times c^2$                                                                                                          | (2)  |
| 16(b)(iii)      | <ul style="list-style-type: none"> <li>Mass - energy (1)</li> <li>Momentum (1)</li> </ul>                                                                                                   |                                                                                                                                                                                    | (2)  |

**\*16(b)(iv)**

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.

Indicative content:

- Uses velocity = distance/time
  - Calculates a time =  $3 \times 10^{-5}$ s
  - Compares with  $2.2 \times 10^{-6}$ s which is (15 times) smaller
  - Identifies relativistic speed/effects (as velocity close to  $c$ )
  - Time (between events is much) slower/longer
- Or** mentions time dilation
- So increase in muon lifetime

| IC points | IC mark  | Max linkage mark | Max final mark |
|-----------|----------|------------------|----------------|
| <b>6</b>  | <b>4</b> | <b>2</b>         | <b>6</b>       |
| <b>5</b>  | <b>3</b> | <b>2</b>         | <b>5</b>       |
| <b>4</b>  | <b>3</b> | <b>1</b>         | <b>4</b>       |
| <b>3</b>  | <b>2</b> | <b>1</b>         | <b>3</b>       |
| <b>2</b>  | <b>2</b> | <b>0</b>         | <b>2</b>       |
| <b>1</b>  | <b>1</b> | <b>0</b>         | <b>1</b>       |
| <b>0</b>  | <b>0</b> | <b>0</b>         | <b>0</b>       |

Alternative for ic 2 and 3

Calculates height of atmosphere = 653 m

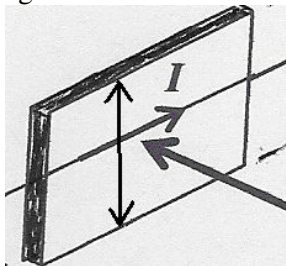
Compares with 10 km which is larger

Example of calculation:

$$\text{Time} = 10000(\text{m})/0.99 \times 3 \times 10^8(\text{ms}^{-1})$$

(6)

**(Total for Question 16 = 16 marks)**

| Question Number | Acceptable answers                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Additional guidance                                                                                                                                                                                                                 | Mark |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 17(a)           | <ul style="list-style-type: none"> <li>The current and magnetic field are perpendicular (1)</li> <li>By (Flemings) left hand rule the force on the electrons is upwards (1)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                          | alt. force results from current not parallel to a magnetic field                                                                                                                                                                    | (2)  |
| 17(b)           | <ul style="list-style-type: none"> <li>indication at top and bottom of conductor (1)</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | eg<br>                                                                                                                                           | (1)  |
| 17(c)           | <ul style="list-style-type: none"> <li>Equates <math>F = Bev</math> and <math>F = eE</math> (1)</li> <li>Substitutes <math>E = V/d</math> (1)</li> <li>Or <math>F = eV/d</math> seen</li> <li>Replaces <math>v</math> with <math>I/neA</math> (1)</li> <li>Substitute <math>A = d \times t</math> and leads to given equation (1)</li> </ul> <p>Alternative:</p> <ul style="list-style-type: none"> <li>Equates <math>F = BIl</math> and <math>F = QE</math> with <math>Q</math> identified as total charge (1)</li> <li>Substitutes <math>E = V/d</math> (1)</li> <li>Or <math>F = QV/d</math> seen</li> </ul> | <p>Example of derivation:</p> $Bev = eE$ $Bev = eV/d$ $\frac{BI}{neA} = \frac{V_H}{d}$ $V_H = \frac{BI}{net}$ <p>Alternative:</p> $BIl = QE$ <p>Total charge <math>Q = neAl</math></p> $BIl = neAlE$ $BI = neAV_H/d$ $V_H = BI/net$ | (4)  |

|       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                           |     |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
|       | <ul style="list-style-type: none"> <li>Substitutes <math>Q = neAl</math> and cancels <math>l</math></li> <li>Substitute <math>A = d \times t</math> and leads to given equation</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                                                                                                                                           |     |
| 17(d) | <ul style="list-style-type: none"> <li>Uses <math>V = J/C</math> (1)<br/> <b>Or</b> <math>V = Nm/C</math><br/> <b>Or</b> <math>V = Wb\ s^{-1}</math></li> <li>Use of <math>T = N/Cms^{-1}</math> (1)<br/> <b>Or</b> <math>T = N/Am</math><br/> <b>Or</b> <math>T = Wb\ m^{-2}</math><br/> <b>Or</b> Sub of <math>B = F/IL</math> and cancels <math>I</math>'s</li> <li>Uses units of <math>n = m^{-3}</math> and completes agreement (1)</li> </ul> <p>Alternative with base units:</p> <ul style="list-style-type: none"> <li>Uses base unit of force = <math>kg\ m\ s^{-2}</math> (1)<br/> <b>Or</b> base unit of energy = <math>kg\ m^2\ s^{-2}</math></li> <li>Uses base unit of charge = <math>A\ s</math> (1)<br/> <b>Or</b> uses <math>A = Cs^{-1}</math><br/> <b>Or</b> Sub of <math>B = F/IL</math> and cancel <math>I</math>'s or <math>A</math>'s</li> <li>Uses base units of <math>n = m^{-3}</math> and completes agreement (1)</li> </ul> | <p>Example of unit simplification:<br/> <math>J/C</math> should equal <math>\frac{N}{Am} \times A \div m^{-3}Cm</math><br/> <math>= \frac{Nm}{C} = \frac{J}{C}</math></p> | (3) |

|       |                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |     |
|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----|
| 17(e) | <ul style="list-style-type: none"> <li>Calculates a product <math>nt</math> for at least one sample (1)</li> <li>(Largest value of <math>V_H</math>) smallest value of <math>nt</math> which is silicon (1)</li> </ul> <p><b>Or</b></p> <ul style="list-style-type: none"> <li>Calculates <math>1/nt</math> for at least one sample (1)</li> <li>(Largest value of <math>V_H</math>) largest value of <math>1/nt</math> which is silicon (1)</li> </ul> | <p>Example of calculation of <math>nt</math>:</p> <p>Copper = <math>8.47 \times 10^{28} \times 110 \times 10^{-6} = 9.31 \times 10^{24}</math></p> <p>Germanium = <math>2.25 \times 10^{19} \times 1.10 \times 10^{-6} = 2.48 \times 10^{13}</math></p> <p>Silicon = <math>1.44 \times 10^{16} \times 120 \times 10^{-6} = 1.73 \times 10^{12}</math></p> <p>Example of calculation of <math>1/nt</math>:</p> <p>Copper = <math>1.07 \times 10^{-25}</math></p> <p>Germanium = <math>4.03 \times 10^{-14}</math></p> <p>Silicon = <math>5.79 \times 10^{-13}</math></p> | (2) |
| 17(f) | <ul style="list-style-type: none"> <li>Uses <math>\tan \theta = B_V \div B_H</math> (1)</li> </ul> <p><b>Or</b> uses <math>\tan \theta = B_H \div B_V</math></p> <ul style="list-style-type: none"> <li>Angle = <math>69^\circ</math> (1)</li> </ul>                                                                                                                                                                                                    | <p>Example of calculation:</p> <p><math>\tan \theta = 49/19</math></p> <p><math>\theta = 68.8^\circ</math></p> <p>Accept use of vector triangle as alternative to calculation</p>                                                                                                                                                                                                                                                                                                                                                                                       | (2) |

(Total for Question 17 = 14 marks)