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**MATHEMATICS**

**9709/41**

Paper 4

**October/November 2016**

MARK SCHEME

Maximum Mark: 50

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**Published**

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge will not enter into discussions about these mark schemes.

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## Mark Scheme Notes

Marks are of the following three types:

**M** Method mark, awarded for a valid method applied to the problem. Method marks are not lost for numerical errors, algebraic slips or errors in units. However, it is not usually sufficient for a candidate just to indicate an intention of using some method or just to quote a formula; the formula or idea must be applied to the specific problem in hand, e.g. by substituting the relevant quantities into the formula. Correct application of a formula without the formula being quoted obviously earns the M mark and in some cases an M mark can be implied from a correct answer.

**A** Accuracy mark, awarded for a correct answer or intermediate step correctly obtained. Accuracy marks cannot be given unless the associated method mark is earned (or implied).

**B** Mark for a correct result or statement independent of method marks.

- When a part of a question has two or more “method” steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep\*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
- The symbol  $\nabla$  implies that the A or B mark indicated is allowed for work correctly following on from previously incorrect results. Otherwise, A or B marks are given for correct work only. A and B marks are not given for fortuitously “correct” answers or results obtained from incorrect working.
  - Note: B2 or A2 means that the candidate can earn 2 or 0.  
B2/1/0 means that the candidate can earn anything from 0 to 2.

The marks indicated in the scheme may not be subdivided. If there is genuine doubt whether a candidate has earned a mark, allow the candidate the benefit of the doubt. Unless otherwise indicated, marks once gained cannot subsequently be lost, e.g. wrong working following a correct form of answer is ignored.

- Wrong or missing units in an answer should not lead to the loss of a mark unless the scheme specifically indicates otherwise.
- For a numerical answer, allow the A or B mark if a value is obtained which is correct to 3 s.f., or which would be correct to 3 s.f. if rounded (1 d.p. in the case of an angle). As stated above, an A or B mark is not given if a correct numerical answer arises fortuitously from incorrect working. For Mechanics questions, allow A or B marks for correct answers which arise from taking  $g$  equal to 9.8 or 9.81 instead of 10.

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The following abbreviations may be used in a mark scheme or used on the scripts:

AEF/OE Any Equivalent Form (of answer is equally acceptable) / Or Equivalent

AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

CAO Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)

CWO Correct Working Only – often written by a ‘fortuitous’ answer

ISW Ignore Subsequent Working

SOI Seen or implied

SR Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

### **Penalties**

MR –1 A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through  $\frac{1}{2}$ ” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.

PA –1 This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

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|              |   |                                     |     |   |     |  |
|--------------|---|-------------------------------------|-----|---|-----|--|
| <b>1</b>     | $[0.4g - T = 0.4a \quad T = 0.6a$<br>System equation $0.4g = (0.4 + 0.6)a]$   | <b>M1</b>                           | [4] | For applying Newton's 2nd law to either particle or to the system<br><br>For applying Newton's 2nd law to the other particle and attempt to solve for $a$ and $T$ |     |  |
|              | $a = 4 \text{ ms}^{-2}$   | <b>M1</b>                           |     |   |     |  |
|              | $T = 2.4 \text{ N}$   | <b>A1</b>                           |     |   |     |  |
|              |   | <b>A1</b>                           |     |   |     |  |
| <b>2 (i)</b> | $2 = 5a \rightarrow a = 0.4 \text{ ms}^{-2}$<br>$[0.1g \sin 20 - F = 0.1 \times 0.4]$<br>$F = 0.302 \text{ N}$      | <b>B1</b><br><b>M1</b><br><b>A1</b> | [3] | For applying Newton's 2nd law to the particle   |     |  |
|              |   | AG                                  |     |   |     |  |
|              |   |                                     |     |   |     |  |
| <b>(ii)</b>  | $[R = 0.1g \cos 20 (= 0.9397)]$<br>$\mu = 0.3020/0.9397 = 0.321$  | <b>M1</b><br><b>A1</b>              | [2] | For attempting to find $R$ and using $\mu = F/R$  |     |  |
| <b>3 (i)</b> | $[0 = 6^2 - 2g \times s]$<br>$s = 1.8$<br>Total height = 2.3 m  | <b>M1</b><br><b>A1</b><br><b>B1</b> | [3] | For using $v^2 = u^2 + 2as$   |     |  |
|              | <b>Alternative for 3(i)</b>   |                                     |     |   |     |  |
|              | $[6^2 = u^2 - 2g \times 0.5]$<br>$u^2 = 46$<br>$0^2 = 46 - 2gs \rightarrow s = \text{total height} = 2.3 \text{ m}$ | <b>M1</b><br><b>A1</b><br><b>B1</b> |     |   | [3] | For using $v^2 = u^2 + 2as$ to find the initial velocity |
|              |   |                                     |     |   |     |  |
|              |   |                                     |     |   |     |  |

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| <b>(ii)</b>  | $[2.3 = 0 + 0.5gt^2]$<br><br>$t = 0.678$<br><br>Total time = $2 \times 0.678 = 1.36$ s  | <b>M1</b><br><br><b>A1</b><br><br><b>B1</b>                                | [3] | For using $s = ut + 0.5gt^2$ to find time to reach the ground  |
|              | <b>Alternative for 3(ii)</b>  |  |     |  |
|              | $[0 = \sqrt{46} - gt]$<br><br>$t = \frac{\sqrt{46}}{10} = 0.678$<br><br>Total time = $2 \times 0.678 = 1.36$ s  | <b>M1</b><br><br><b>A1</b><br><br><b>B1</b>                                | [3] | Using $v = u - gt$ to find time taken to the highest point   |
| <b>4</b>     | $2F + F\cos 60 = 15\cos\alpha$<br><br>$F\sin 60 = 15\sin\alpha$<br><br>$F = 5.67$ and $\alpha = 19.1$   | <b>M1</b><br><b>A1</b><br><b>M1</b><br><b>A1</b><br><b>M1</b><br><b>A1</b> | [6] | For resolving forces horizontally<br><br>For resolving forces vertically<br><br>For using Pythagoras or for using $\tan \alpha$ to find <b>F and <math>\alpha</math></b><br><br>Allow $F = 15\sqrt{7}/7$ |
| <b>5 (i)</b> | $a = 0.5 \text{ m s}^{-2}$  | <b>B1</b>  | [1] |  |
| <b>(ii)</b>  | [Distance<br>= $25 + 100 + 5(5 + V) + 30V + 10V]$<br><br>$150 + 45V$<br><br>$150 + 45V = 465 \rightarrow V = 7 \text{ m s}^{-1}$  | <b>M1</b><br><b>AG</b><br><b>A1</b><br><b>B1</b>                           | [3] | For attempting to find the distance travelled  |
| <b>(iii)</b> | $\frac{1}{2} \times 80 \times 7^2 - \frac{1}{2} \times 80 \times 5^2 [= 960]$<br><br>$20 \times (5 + 7)/2 \times 10 [= 1200]$<br><br>$[80gh = 960 + 1200]$<br><br>$h = 2.7$ m | <b>M1</b><br><br><b>M1</b><br><br><b>M1</b><br><br><b>A1</b>               | [4] | For change in KE<br><br>For work done against friction using $F \times d$<br><br>For using PE loss = KE gain + WD against Res.   |

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| 6 | (i)  | [Work done = $50 \cos 10 \times 20$ ]  | M1 | [2] | Using WD = $Fd \cos \theta$  |
|   |  | = 984.8 J  | A1 |     |  |
|   | (ii)   | [ $984.8 = \frac{1}{2} \times 25v^2 + 30 \times 20$ ]  | M1 | [2] | Using WD by DF =<br>KE gain + WD against Res.  |
|   |  | $v = 5.55 \text{ m s}^{-1}$  | A1 |     |  |
|   | (iii)  |  | M1 | [2] | For using Power = $Fv$<br>Greatest power is at $v_{\max}$  |
|   |  | Max power = $50 \cos 10 \times 5.55 = 273 \text{ W}$   | A1 |     |  |
|   | (iv)   | [ $50 \cos 10 - 30 - 25g \sin 5 = 25a$ ]   | M1 | [4] | For using Newton's 2nd law up<br>the plane<br><br>For using $v = u + at$   |
|   |  | $a = -0.102 \text{ m s}^{-2}$  | A1 |     |  |
|   |  | [ $0 = 5.55 - 0.102t$ ]  | M1 |     |  |
|   |  | Time $t = 54.4 \text{ s}$  | A1 |     |  |
|   |  | <b>Alternative for 6(iv)</b>   |    |     |  |
|   |  |  | M1 | [4] | For using<br>WD by DF + KE loss =<br>PE gain + WD against Res to<br>find distance $s$ up plane<br><br>$s = 151 \text{ m}$<br><br>For using $s = \frac{1}{2}(u + v)t$ |
|   | $50 \cos 10 \times s + \frac{1}{2} \times 25 \times 5.55^2 =$<br>$25g \times s \sin 5 + 30 \times s$ | A1   |    |     |  |
|   |  | M1   |    |     |  |
|   | $t = 302/5.55 = 54.4 \text{ s}$  | A1   |    |     |  |
| 7 | (i)  | [ $15 - 6t = 0$ ]  | M1 | [3] | For differentiation<br><br>May be stated from an $a-t$<br>diagram  |
|   |  | Max acceleration when $t = 2.5 \text{ s}$<br><br>Max acceleration = $18.75 \text{ m s}^{-2}$ | A1 |     |  |
|   | (ii)   | [Speed = $7.5t^2 - t^3 (+ c)$ ]  | M1 | [3] | For using integration to obtain<br>speed<br><br>For using integration to obtain<br>distance<br><br>Allow distance = $625/4$  |
|   |  | [Distance = $2.5t^3 - 0.25t^4 (+ ct + d)$ ]  | M1 |     |  |
|   |  | = $2.5 \times 125 - 0.25 \times 625 = 156.25 \text{ m}$                                      | A1 |     |  |

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| <b>(iii)</b>                  | $v(5) = 7.5 \times 25 - 125 = 62.5 \text{ ms}^{-1}$<br>$\int_5^k -\frac{625}{t^2} dt = \left[ \frac{625}{t} \right]_5^k$<br>$= \frac{625}{k} - \frac{625}{5} = \frac{625}{k} - 125$<br>$\frac{625}{k} - 125 = v(k) - v(5) = -62.5$<br>$k = 10$ | <b>B1</b> |     | Allow $v(5) = 125/2$                                       |
|                               |  | <b>M1</b> |     | Integral with correct limits                               |
|                               |  | <b>A1</b> |     |  |
|                               |  | <b>M1</b> |     | Use of $v(5) = 62.5$ and $v(k) = 0$                        |
|                               |  | <b>A1</b> | [5] |  |
| <b>Alternative for 7(iii)</b> |  |           |     |  |
|                               | $v(5) = 7.5 \times 25 - 125 = 62.5 \text{ ms}^{-1}$<br>$v(t) = \int -\frac{625}{t^2} dt = \frac{625}{t} + c$<br>$[c = -62.5]$<br>$v(t) = \frac{625}{t} - 62.5$<br>$v(k) = \frac{625}{k} - 62.5 = 0$<br>$k = 10$                                | <b>B1</b> |     |  |
|                               |  | <b>M1</b> |     | Using indefinite integration                               |
|                               |  | <b>A1</b> |     | For using $v(5) = 62.5$ to find $c$ and setting $v(k) = 0$ |
|                               |  | <b>M1</b> |     |  |
|                               |  | <b>A1</b> | [5] |  |