### MARK SCHEME for the June 2004 question papers

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<th>Paper Title and Code</th>
<th>Maximum Raw Mark</th>
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<td>Paper 1 (Pure 1)</td>
<td>75</td>
</tr>
<tr>
<td>9709/02</td>
<td>Paper 2 (Pure 2)</td>
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<tr>
<td>9709/03, 8719/03</td>
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<td>Paper 7 (Probability and Statistics 2)</td>
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These mark schemes are published as an aid to teachers and students, to indicate the requirements of the examination. They show the basis on which Examiners were initially instructed to award marks. They do not indicate the details of the discussions that took place at an Examiners' meeting before marking began. Any substantial changes to the mark scheme that arose from these discussions will be recorded in the published *Report on the Examination*.

All Examiners are instructed that alternative correct answers and unexpected approaches in candidates’ scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes must be read in conjunction with the question papers and the *Report on the Examination*.

- CIE will not enter into discussion or correspondence in connection with these mark schemes.

CIE is publishing the mark schemes for the June 2004 question papers for most IGCSE and GCE Advanced Level syllabuses.
**Grade thresholds** taken for Syllabus 9709 (Mathematics) in the June 2004 examination.

<table>
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<tr>
<th>Component</th>
<th>maximum mark available</th>
<th>minimum mark required for grade:</th>
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<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Component 1</td>
<td>75</td>
<td>63</td>
</tr>
<tr>
<td>Component 2</td>
<td>50</td>
<td>37</td>
</tr>
<tr>
<td>Component 3</td>
<td>75</td>
<td>61</td>
</tr>
<tr>
<td>Component 4</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>Component 5</td>
<td>50</td>
<td>36</td>
</tr>
<tr>
<td>Component 6</td>
<td>50</td>
<td>38</td>
</tr>
<tr>
<td>Component 7</td>
<td>50</td>
<td>42</td>
</tr>
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The thresholds (minimum marks) for Grades C and D are normally set by dividing the mark range between the B and the E thresholds into three. For example, if the difference between the B and the E threshold is 24 marks, the C threshold is set 8 marks below the B threshold and the D threshold is set another 8 marks down. If dividing the interval by three results in a fraction of a mark, then the threshold is normally rounded down.
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 √ 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.
The following abbreviations may be used in a mark scheme or used on the scripts:

- AEF: Any Equivalent Form (of answer is equally acceptable)
- AG: Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)
- BOD: Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
- 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
- MR: Misread
- PA: Premature Approximation (resulting in basically correct work that is insufficiently accurate)
- SOS: See Other Solution (the candidate makes a better attempt at the same question)
- 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 √" 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.
June 2004

GCE A AND AS LEVEL

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MAXIMUM MARK: 75

SYLLABUS/COMPONENT: 9709/01
MATHEMATICS
Paper 1 (Pure 1)
### Mark Scheme

**A AND AS LEVEL – JUNE 2004**

<table>
<thead>
<tr>
<th>Question</th>
<th>Solution</th>
<th>Mark</th>
</tr>
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<tbody>
<tr>
<td>1. (i) ( \frac{a}{1-r} = 256 ) and ( a = 64 )</td>
<td>( r = \frac{3}{4} )</td>
<td>M1 A1</td>
</tr>
<tr>
<td>(ii) ( S_{10} = 64(1 - 0.75^{10}) )</td>
<td>( 1 - 0.75 )</td>
<td>M1 A1</td>
</tr>
<tr>
<td>( S_{10} = 242 )</td>
<td></td>
<td>[2]</td>
</tr>
<tr>
<td>2. ( \int_{0}^{1} \sqrt{3x + 1} , dx = (3x + 1)^{1.5} \div 1.5 )</td>
<td>( 3 )</td>
<td>B1 M1</td>
</tr>
<tr>
<td>then ( \left[ \right] ) at ( 1 - \left[ \right] ) at 0</td>
<td>( 16/9 - 2/9 = 14/9 ) or 1.56</td>
<td>A1</td>
</tr>
<tr>
<td>( \rightarrow S_{10} = 242 )</td>
<td></td>
<td>[3]</td>
</tr>
<tr>
<td>3. (i) ( \sin^2 \theta + 3 \sin \theta \cos \theta = 4 \cos^2 \theta )</td>
<td>( \text{divides by } \cos^2 \theta )</td>
<td>M1 A1</td>
</tr>
<tr>
<td>( \rightarrow \tan^2 \theta + 3 \tan \theta = 4 )</td>
<td>Knowing to divide by ( \cos^2 \theta )</td>
<td>[2]</td>
</tr>
<tr>
<td>(ii) Solution ( \tan \theta = 1 ) or ( \tan \theta = -4 )</td>
<td>( \text{Correct quadratic (not nec } = 0) )</td>
<td>M1 A1</td>
</tr>
<tr>
<td>( \rightarrow \theta = 45^\circ ) or ( 104.0^\circ )</td>
<td>( \text{Correct solution of quadratic } \neq 0 )</td>
<td>[3]</td>
</tr>
<tr>
<td>4. (i) Coeff of ( x^3 ) = 6C3 ( \times 2^3 )</td>
<td>( = 160 )</td>
<td>B1 B1</td>
</tr>
<tr>
<td>( \rightarrow \text{Coeff} = 1 \times (\text{i}) - 3 \times 60 )</td>
<td>B1 for 6C3 B1 for ( 2^3 )</td>
<td>[3]</td>
</tr>
<tr>
<td>( \rightarrow -20 )</td>
<td>B1 for 160</td>
<td></td>
</tr>
<tr>
<td>(ii) Term in ( x^2 ) = 6C2 ( \times 2^2 = 60 )</td>
<td>( \text{Reqd coeff} = 1 \times (\text{i}) - 3 \times 60 )</td>
<td>B1</td>
</tr>
<tr>
<td>( \rightarrow -20 )</td>
<td>B1 for 60 (could be given in (i))</td>
<td>[3]</td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Area of sector = ( \frac{1}{2} \times 6^2 \times 0.8 ) ( = 14.4 )</td>
<td>Use of ( \frac{1}{2}r^2\theta ) with radians</td>
<td>M1</td>
</tr>
<tr>
<td>Area of triangle = ( \frac{1}{2} \times 10 \times 0.8 \times \sin 0.8 ) ( = 35.9 )</td>
<td>Use of ( \frac{1}{2} \text{absinC or } \frac{1}{2} \text{ bh with trig} )</td>
<td>M1 A1</td>
</tr>
<tr>
<td>( \rightarrow \text{Shaded area} = 21.5 )</td>
<td>( \text{Correct only} )</td>
<td>[3]</td>
</tr>
<tr>
<td>(ii) Arc length = 6 ( \times 0.8 ) ( = 4.8 )</td>
<td>Use of ( s=r\theta ) with radians</td>
<td>M1</td>
</tr>
<tr>
<td>CD (by cos rule) or ( 2 \times 10 \times \sin 0.4 ) ( = 7.8 )</td>
<td>( \text{Any correct method – allow if in (i)} )</td>
<td>M1 A1</td>
</tr>
<tr>
<td>( \rightarrow \text{Perimeter} = 8 + 4.8 + 7.8 = 20.6 )</td>
<td>( \text{Correct only} )</td>
<td>[4]</td>
</tr>
</tbody>
</table>
6. (i) eliminates x (or y) completely
   → \(x^2+x-6=0\) or \(y^2-17y+66=0\)
   Solution of quadratic = 0
   → \((2, 6)\) and \((-3, 11)\)
   M1 Needs x or y removed completely
   A1 Correct only (no need for = 0)
   DM1 Equation must = 0.
   A1 Everything ok.

   (ii) Midpoint = \((-\frac{1}{2}, 8\frac{1}{2})\)
   Gradient of line = \(-1\)
   Gradient of perpendicular = \(1\)
   \(\rightarrow y - 8\frac{1}{2} = 1 (x + \frac{1}{2})\) \(\text{(or } y = x + 9\text{)}\)
   B1 \(\sqrt{M1}\) For his two points in (i)
   Use of y-step x-step (beware fortuitous)
   M1 Use of \(m_1m_2 = -1\)

   [4]

7. (i) Differentiate \(y=18/x\) \(\rightarrow\)
   \(-18x^{-2}\)
   Gradient of tangent = \(-\frac{1}{2}\)
   Gradient of normal = 2
   Eqn of normal \(y-3 = 2(x-6)\) \(\text{(y=2x–9)}\)
   M1 Any attempt at differentiation
   A1 For \(-\frac{1}{2}\)
   DM1 Use of \(m_1m_2 = -1\)
   DM1 Correct method for eqn of line
   A1 Ans given – beware fortuitous answers.

   [5]

   (ii) \(\text{Vol} = \pi \int_{1}^{4} \frac{324}{x^2} dx = \pi \left[-\frac{324}{x}\right]\) \(\text{at } x=6-\text{value at } x=4.5\)
   \(-54 \pi - -72 \pi = 18 \pi\)
   M1 A1 Use of \(\int y^2 dx\) for M. correct (needs \(\pi\)) for A
   DM1 Use of 6 and 4.5
   A1 Beware fortuitous answers (ans given)

   [4]

8. (i) \(2h + 2r + \pi r = 8\)
   \(\rightarrow h = 4 - r - \frac{1}{2} \pi r\)
   M1 Reasonable attempt at linking 4 lengths +
   A1 correct formula for \(\frac{1}{2}C\) or C.
   Co in any form with h subject.

   [2]

   (ii) \(A=2rh+\frac{1}{2}\pi r^2\) \(\rightarrow A = r(8-2r-\pi r) + \frac{1}{2} \pi r^2\)
   \(\rightarrow A = 8r - 2r^2 - \frac{1}{2} \pi r^2\)
   M1 Adds rectangle + \(\frac{1}{2}\)xcircle (eqn on own ok)
   A1 Co beware fortuitous answers (ans given)

   [2]

   (iii) \(\frac{dA}{dr} = 8 - 4r - \pi r\)
   \(= 0 \text{ when } r = 1.12 \text{ (or } 8/(4+ \pi ))\)
   M1 A1 Knowing to differentiate + some attempt
   DM1 A1 Setting his \(dA/dr\) to 0. Decimal or exact ok.

   [4]

   (iv) \(\frac{d^2A}{dr^2} = -4 - \pi\)
   This is negative \(\rightarrow\) Maximum
   M1 Looks at \(2^{\text{nd}}\) differential or other valid complete method.
   A1 Correct deduction but needs \(d^2A/dr^2\)

   [2]
9. \( \overrightarrow{OA} = \begin{pmatrix} 1 \\ 3 \\ -1 \end{pmatrix}, \overrightarrow{OB} = \begin{pmatrix} 3 \\ -1 \\ 3 \end{pmatrix}, \overrightarrow{OC} = \begin{pmatrix} 4 \\ 2 \\ p \end{pmatrix}, \overrightarrow{OD} = \begin{pmatrix} -1 \\ 0 \\ q \end{pmatrix} \)

(i) \( \overrightarrow{AB} = \overrightarrow{b-a} = 2i - 4j + 4k \)
Unit vector = \( \frac{(2i - 4j + 4k)}{\sqrt{2^2 + 4^2 + 4^2}} \)
\( = \pm \frac{2i - 4j + 4k}{6} \)

(ii) \( \overrightarrow{OA}.\overrightarrow{OC} = 4 + 6 - p \)
\( = 0 \) for 90°
\( p = 10 \)

(iii) \((-2)^2 + 3^2 + (q+1)^2 = 7^2 \)
\( \rightarrow (q+1)^2 = 36 \) or \( q^2 + 2q = 35 \)
\( q = 5 \) and \( q = -7 \)

Condone notation throughout.
Allow column vectors or \( i,j,k \) throughout
Use of \( \overrightarrow{b-a} \), rather than \( \overrightarrow{b+a} \) or \( \overrightarrow{a-b} \)
Dividing by the modulus of "his" \( \overrightarrow{AB} \)
Co (allow – for candidates using \( \overrightarrow{a-b} \))
Use of \( x_1x_2 + y_1y_2 + z_1z_2 \)
Setting to 0 + attempt to solve co
Correct method for length with \( \pm \overrightarrow{d-a}, \overrightarrow{d+a} \)
Correct quadratic equation
Correct method of solution. Both correct.
Or B1 for each if \( (q+1)^2 = 36, q = 5 \) only.

10. \( f: x \mapsto x^2 - 2x, \quad g: x \mapsto 2x + 3 \)

(i) \( x^2 - 2x - 15 = 0 \)
End-points –3 and 5
\( \rightarrow x < -3 \) and \( x > 5 \)

(ii) Uses \( \frac{dy}{dx} = 2x - 2 = 0 \) or \( (x-1)^2 - 1 \)
Minimum at \( x = 1 \) or correct form
Range of \( y \) is \( f(x) \geq -1 \)
No inverse since not 1 : 1 (or equivalent)

(iii) \( gf(x) = 2(x^2 - 2x) + 3 \) \((2x^2 - 4x + 3)\)
\( b^2 - 4ac = 16 - 24 = -8 \) → -ve
\( \rightarrow \) No real solutions.

\[ \text{[or } gf(x) = 0 \rightarrow f(x) = -3/2, \text{ Imposs from (ii)]} \]

(iv) \( y = 2x + 3 \) correct line on diagram
Either inverse as mirror image in \( y=x \)
or \( y = g^{-1}(x) = \frac{1}{2} (x-3) \) drawn

Equation set to 0 and solved.
Correct end-points, however used
Co-inequalities – not \( \leq \) or \( \geq \)
Any valid complete method for \( x \) value
Correct only
Correct for his value of "\( x \)" – must be \( \geq \)
Any valid statement.

Must be \( gf \) not \( fg \) – for unsimplified ans.
Used on quadratic=0, even if \( fg \) used.
Must be using \( gf \) and correct assumption
and statement needed.
3 things needed –B1 if one missing.
• \( g \) correct,
• \( g^{-1} \) correct – not parallel to \( g \)
• \( y=x \) drawn or statement re symmetry

DM1 for quadratic equation. Equation must be set to 0.
Formula → must be correct and correctly used – allow for numerical errors though in \( b^2 \) and –4ac.
Factors → attempt to find 2 brackets. Each bracket then solved to 0.
GCE AS LEVEL

MARK SCHEME

MAXIMUM MARK: 50

SYLLABUS/COMPONENT: 9709/02

MATHEMATICS
Paper 2 (Pure 2)
1. Use logarithms to linearise an equation
   \[ \frac{x}{y} = \ln 5 \ln 2 \] or equivalent
   Obtain answer 2.32

2. (i) Use the given iterative formula correctly at least ONCE with \( x_1 = 3 \)
   Obtain final answer 3.142
   Show sufficient iterations to justify its accuracy to 3 d.p.
   (ii) State any suitable equation e.g.
   \[ \frac{1}{5 \left( \frac{4x + 306}{x^2} \right)} \]
   Derive the given answer \( \alpha \) (or \( x \)) = \( \sqrt[3]{306} \)

3. (i) Substitute \( x = 3 \) and equate to zero
   Obtain answer \( \alpha = -1 \)
   (ii) At any stage, state that \( x = 3 \) is a solution
   EITHER: Attempt division by \((x-3)\) reaching a partial quotient of \(2x^2 + kx\)
   Obtain quadratic factor \(2x^2 + 5x + 2\)
   Obtain solutions \( x = -2 \) and \( x = -\frac{1}{2} \)
   OR: Obtain solution \( x = -2 \) by trial and error
   Obtain solution \( x = -\frac{1}{2} \) similarly
   [If an attempt at the quadratic factor is made by inspection, the M1 is earned if it reaches an unknown factor of \(2x^2 + bx + c\) and an equation in \( b \) and/or \( c \).]

4. (i) State answer \( R = 5 \)
   Use trigonometric formulae to find \( \alpha \)
   Obtain answer \( \alpha = 53.13^\circ \)
   (ii) Carry out, or indicate need for, calculation of \( \sin^{-1}(4.5/5) \)
   Obtain answer 11.0°
   Carry out correct method for the second root e.g. \(180^\circ - 64.16^\circ - 53.13^\circ \)
   Obtain answer 62.7° and no others in the range
   [Ignore answers outside the given range.]
   (iii) State least value is 2

5. (i) State derivative of the form \((e^x \pm xe^x)\). Allow \(xe^x \pm e^x\) (via quotient rule)
   Obtain correct derivative of \(e^x \pm xe^x\)
   Equate derivative to zero and solve for \( x \)
   Obtain answer \( x = 1 \)
   (ii) Show or imply correct ordinates 0, 0.367879..., 0.27067...
   Use correct formula, or equivalent, with \( h = 1 \) and three ordinates
   Obtain answer 0.50 with no errors seen
   (iii) Justify statement that the rule gives an under-estimate
6 (i) State that \( \frac{dx}{dt} = 2 + \frac{1}{t} \) or \( \frac{dy}{dt} = \frac{4}{t^2} \), or equivalent B1

Use \( \frac{dy}{dx} = \frac{dy}{dt} \div \frac{dx}{dt} \) M1

Obtain the given answer A1 3

(ii) Substitute \( t = 1 \) in \( \frac{dy}{dx} \) and both parametric equations M1

Obtain \( \frac{dy}{dx} = -1 \) and coordinates (2, 5) A1

State equation of tangent in any correct horizontal form e.g. \( x + y = 7 \) A1√ 3

(iii) Equate \( \frac{dy}{dx} \) to zero and solve for \( t \) M1

Obtain answer \( t = 2 \) A1

Obtain answer \( y = 4 \) A1

Show by any method (but not via \( \frac{d}{dt} (y') \)) that this is a minimum point A1 4

7 (i) Make relevant use of the \( \cos(A + B) \) formula M1*

Make relevant use of \( \cos^2A \) and \( \sin^2A \) formulae M1*

Obtain a correct expression in terms of \( \cos A \) and \( \sin A \) A1

Use \( \sin^2A = 1 - \cos^2A \) to obtain an expression in terms of \( \cos A \) M1(dep*)

Obtain given answer correctly A1 5

(ii) Replace integrand by \( \frac{1}{4} \cos 3x + \frac{3}{4} \cos x \), or equivalent B1

Integrate, obtaining \( \frac{1}{12} \sin 3x + \frac{3}{4} \sin x \), or equivalent B1 + B1√

Use limits correctly M1

Obtain given answer A1 5

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SYLLABUS/COMPONENT: 9709/03, 8719/03

MATHEMATICS AND HIGHER MATHEMATICS
Paper 3 (Pure 3)
1. Show correct sketch for $0 \leq x < \frac{1}{2}\pi$  
   Show correct sketch for $\frac{1}{2}\pi < x < \frac{3}{2}\pi$ or $\frac{3}{2}\pi < x \leq 2\pi$  
   Show completely correct sketch  
   [SR: for a graph with $y = 0$ when $x = 0$, $\pi$, $2\pi$ but otherwise of correct shape, award B1.]

2. **EITHER:** State or imply non-modular inequality $(2x + 1)^2 < x^2$ or corresponding quadratic equation or pair of linear equations $(2x + 1) = \pm x$  
   Expand and make a reasonable solution attempt at a 3-term quadratic, or solve two linear equations  
   Obtain critical values $x = -1$ and $x = -\frac{1}{3}$ only  
   State answer $-1 < x < -\frac{1}{3}$  
   **OR:** Obtain the critical value $x = -1$ from a graphical method, or by inspection, or by solving a linear inequality or equation  
   Obtain the critical value $x = -\frac{1}{3}$ (deduct B1 from B3 if extra values are obtained)  
   State answer $-1 < x < -\frac{1}{3}$  
   [Condone $\leq$ for $<$; accept $-0.33$ for $-\frac{1}{3}$.]

3. **EITHER:** State $6y \frac{dy}{dx}$ as the derivative of $3y^2$  
   State $\pm 4x \frac{dy}{dx} \pm 4y$ as the derivative of $-4xy$  
   Equate attempted derivative of LHS to zero and solve for $\frac{dy}{dx}$  
   Obtain answer 2  
   [The M1 is conditional on at least one of the B marks being obtained. Allow any combination of signs for the second B1.]  
   **OR:** Obtain a correct expression for $y$ in terms of $x$  
   Differentiate using chain rule  
   Obtain derivative in any correct form  
   Substitute $x = 2$ and obtain answer 2 only  
   [The M1 is conditional on a reasonable attempt at solving the quadratic in $y$ being made.]
4  (i)  State or imply \( 2^{-x} = \frac{1}{y} \) \( \quad \text{B1} \)
Obtain 3-term quadratic e.g. \( y^2 - y - 1 = 0 \) \( \quad \text{B1 2} \)

(ii) Solve a 3-term quadratic, obtaining 1 or 2 roots \( \quad \text{M1} \)
Obtain answer \( y = \left(1 + \sqrt{5}\right)/2 \), or equivalent \( \quad \text{A1} \)
Carry out correct method for solving an equation of the form \( 2^x = a \), where \( a > 0 \), reaching a ratio of logarithms \( \quad \text{M1} \)
Obtain answer \( x = 0.694 \) only \( \quad \text{A1 4} \)

5  (i)  Make relevant use of formula for \( \sin 2\theta \) or \( \cos 2\theta \) \( \quad \text{M1} \)
Make relevant use of formula for \( \cos 4\theta \) \( \quad \text{M1} \)
Complete proof of the given result \( \quad \text{A1 3} \)

(ii) Integrate and obtain \( \frac{1}{8}(\theta - \frac{1}{4}\sin 4\theta) \) or equivalent \( \quad \text{B1} \)
Use limits correctly with an integral of the form \( a\theta + b\sin 4\theta \), where \( ab \neq 0 \) \( \quad \text{M1} \)
Obtain answer \( \frac{1}{8}\left(\frac{1}{3}\pi + \frac{\sqrt{3}}{8}\right) \), or exact equivalent \( \quad \text{A1 3} \)

6  Separate variables and attempt to integrate \( \quad \text{M1} \)
Obtain terms \( \frac{1}{3}\ln(y^3 + 1) \) and \( x \), or equivalent \( \quad \text{A1 + A1} \)
Evaluate a constant or use limits \( x = 0, y = 1 \) with a solution containing terms \( k\ln(y^3 + 1) \) and \( x \), or equivalent \( \quad \text{M1} \)
Obtain any correct form of solution e.g. \( \frac{1}{3}\ln(y^3 + 1) = x + \frac{1}{3}\ln 2 \) \( \quad \text{A1} \)
Rearrange and obtain \( y = \left(2e^{3x} - 1\right)^\frac{1}{3}, \) or equivalent \( \quad \text{A1 6} \)
[f.t. is on \( k \neq 0 \).]

7  (i)  Evaluate cubic when \( x = -1 \) and \( x = 0 \) \( \quad \text{M1} \)
Justify given statement correctly \( \quad \text{A1 2} \)
[If calculations are not given but justification uses correct statements about signs, award B1.]

(ii) State \( x = \frac{2x^3 - 1}{3x^2 + 1} \), or equivalent \( \quad \text{B1} \)
Rearrange this in the form \( x^3 + x + 1 = 0 \) (or vice versa) \( \quad \text{B1 2} \)
(iii) Use the iterative formula correctly at least once
Obtain final answer $-0.68$ A1
Show sufficient iterations to justify its accuracy to 2d.p., or show there is a sign change in the interval $(-0.685, -0.675)$ A1 3

8 (i) EITHER: Solve the quadratic and use $\sqrt{-1} = i$ M1
Obtain roots $\frac{1}{2} + i\frac{\sqrt{3}}{2}$ and $\frac{1}{2} - i\frac{\sqrt{3}}{2}$ or equivalent A1
OR: Substitute $x + iy$ and solve for $x$ or $y$ M1
Obtain correct roots A1 2

(ii) State that the modulus of each root is equal to 1 B1√
State that the arguments are $\frac{1}{3}\pi$ and $-\frac{1}{3}\pi$ respectively B1√ + B1√ 3
[Accept degrees and $\frac{5}{4}\pi$ instead of $-\frac{1}{3}\pi$. Accept a modulus in the form $\frac{p}{\sqrt{q}}$ or $\sqrt{n}$, where $p, q, n$ are integers. An answer which only gives roots in modulus-argument form earns B1 for both the implied moduli and B1 for both the implied arguments.]

(iii) EITHER: Verify $z^3 = -1$ for each root B1 + B1
OR: State $z^3 + 1 = (z + 1)(z^2 - z + 1)$ B1
Justify the given statement B1
OR: Obtain $z^3 = z^2 - z$ B1
Justify the given statement B1 2

9 (i) State or imply $f(x) = \frac{A}{x-1} + \frac{B}{x-2} + \frac{C}{x+1}$ B1

EITHER: Use any relevant method to obtain a constant M1
Obtain one of the values: $A = -1, B = 4$ and $C = -2$ A1
Obtain the remaining two values A1
OR: Obtain one value by inspection B1
State a second value B1
State the third value B1 4
[Apply the same scheme to the form $\frac{A}{x-2} + \frac{Bx+C}{x^2-1}$ which has $A = 4, B = -3$ and $C = 1$.]
(ii) Use correct method to obtain the first two terms of the expansion of \((x - 1)^{-1}\) or \((x - 2)^{-1}\)

or \((x + 1)^{-1}\)

Obtain any correct unsimplified expansion of the partial fractions up to the terms in \(x^3\)

(deduct A1 for each incorrect expansion)

\[A1 \sqrt{+} A1 \sqrt{+} A1 \sqrt{+} \]

Obtain the given answer correctly

A1

[Binomial coefficients involving \(-1, e.g. \binom{-1}{1},\) are not sufficient for the M1 mark. The f.t. is on \(A, B, C,\)]

Apply a similar scheme to the alternative form of fractions in (i), awarding M1*A1 for the expansions, M1 (dep*) for multiplying by \(Bx + C,\) and A1 for obtaining the given answer correctly.

In the case of an attempt to expand \((x^2 + 7x - 6)(x - 1)^{-1}(x - 2)^{-1}(x + 1)^{-1}\), give M1A1A1A1 for the expansions and A1 for multiplying out and obtaining the given answer correctly.

[Allow attempts to multiply out \((x - 1)(x - 2)(x + 1)(-3 + 2x - \frac{3}{2}x^2 + \frac{11}{4}x^3)\), giving B1 for reduction to a product of two expressions correct up to their terms in \(x^3\), M1 for attempting to multiply out at least as far as terms in \(x^2\), A1 for a correct expansion up to terms in \(x^3\), and A1 for correctly obtaining the answer \(x^2 + 7x - 6\) and also showing there is no term in \(x^3\).

[Allow the use of Maclaurin, giving M1A1 for \(f(0) = -3\) and \(f'(0) = 2, A1\) for \(f''(0) = -3, A1\) for \(f'''(0) = \frac{33}{2},\) and A1 for obtaining the given answer correctly (f.t. is on \(A, B, C,\) if used).]

10 (i) State \(x\)-coordinate of \(A\) is 1

B1

(ii) Use product or quotient rule

Obtain derivative in any correct form e.g.

\[-\frac{2 \ln x}{x^3} + \frac{1}{x} \cdot \frac{1}{x} \cdot \frac{1}{x^2}\]

A1

Equate derivative to zero and solve for \(\ln x\)

M1

Obtain \(x = e^\frac{1}{2}\) or equivalent (accept 1.65)

A1

Obtain \(y = \frac{1}{2e}\) or exact equivalent not involving \(\ln\)

A1

[SR: if the quotient rule is misused, with a ‘reversed’ numerator or \(x^2\) instead of \(x^4\) in the denominator, award M0A0 but allow the following M1A1A1.]

(iii) Attempt integration by parts, going the correct way

Obtain \(-\frac{\ln x}{x} + \int \frac{1}{x} \cdot \frac{1}{x} \cdot dx\) or equivalent

A1

Obtain indefinite integral \(-\frac{\ln x}{x} - \frac{1}{x}\)

A1

Use \(x\)-coordinate of \(A\) and \(e\) as limits, having integrated twice

M1

Obtain exact answer \(1 - \frac{2}{e}\), or equivalent

A1

[If \(u = \ln x\) is used, apply an analogous scheme to the result of the substitution.]
11  (i) **EITHER:** Obtain a vector in the plane e.g. $\overrightarrow{PQ} = -3\mathbf{i} + 4\mathbf{j} + \mathbf{k}$  

Use scalar product to obtain a relevant equation in $a$, $b$, $c$ e.g. $-3a + 4b + c = 0$ or $6a - 2b + c = 0$ or $3a + 2b + 2c = 0$  

State two correct equations in $a$, $b$, $c$  

Solve simultaneous equations to obtain one ratio e.g. $a : b$  

Obtain equation $2x + 3y - 6z = 8$ or equivalent  

[The second M1 is also given if say $c$ is given an arbitrary value and $a$ or $b$ is found. The following A1 is then given for finding the correct values of $a$ and $b$.]

**OR:** Substitute for $P$, $Q$, $R$ in equation of plane and state 3 equations in $a$, $b$, $c$, $d$  

Eliminate one unknown, e.g. $d$, entirely  

Obtain 2 equations in 3 unknowns  

Solve to obtain one ratio e.g. $a : b$  

Obtain equation $2x + 3y - 6z = 8$ or equivalent  

[The first M1 is also given if say $d$ is given an arbitrary value and two equations in two unknowns, e.g. $a$ and $b$, are obtained. The following A1 is for two correct equations. Solving to obtain one unknown earns the second M1 and the following A1 is for finding the correct values of $a$ and $b$.]

**OR:** Obtain a vector in the plane e.g. $\overrightarrow{QR} = 6\mathbf{i} - 2\mathbf{j} + \mathbf{k}$  

Find a second vector in the plane and form correctly a 2-parameter equation for the plane  

Obtain equation in any correct form e.g. $r = \lambda(-3\mathbf{i} + 4\mathbf{j} + \mathbf{k}) + \mu(6\mathbf{i} - 2\mathbf{j} + \mathbf{k}) + \mathbf{i} - \mathbf{k}$  

State 3 equations in $x$, $y$, $z$, $\lambda$, and $\mu$  

Eliminate $\lambda$ and $\mu$  

Obtain equation $2x + 3y - 6z = 8$ or equivalent

**OR:** Obtain a vector in the plane e.g. $\overrightarrow{PR} = 3\mathbf{i} + 2\mathbf{j} + 2\mathbf{k}$  

Obtain a second vector in the plane and calculate the vector product of the two vectors, e.g. $(-3\mathbf{i} + 4\mathbf{j} + \mathbf{k}) \times (3\mathbf{i} + 2\mathbf{j} + 2\mathbf{k})$  

Obtain 2 correct components of the product  

Obtain correct product e.g. $6\mathbf{i} + 9\mathbf{j} - 18\mathbf{k}$ or equivalent  

Substitute in $2x + 3y - 6z = d$ and find $d$ or equivalent  

Obtain equation $2x + 3y - 6z = 8$ or equivalent
(ii) EITHER: State equation of $SN$ is $\mathbf{r} = 3\mathbf{i} + 5\mathbf{j} - 6\mathbf{k} + \lambda(2\mathbf{i} + 3\mathbf{j} - 6\mathbf{k})$ or equivalent $\quad \text{B1√}$
Express $x$, $y$, $z$ in terms of $\lambda$ e.g. $(3 + 2\lambda, 5 + 3\lambda, -6 - 6\lambda) \quad \text{B1√}$
Substitute in the equation of the plane and solve for $\lambda \quad \text{M1}$
Obtain $\overrightarrow{ON} = \mathbf{i} + 2\mathbf{j}$, or equivalent $\quad \text{A1}$
Carry out method for finding $SN \quad \text{M1}$
Show that $SN = 7$ correctly $\quad \text{A1}$

OR: Letting $\overrightarrow{ON} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$, obtain two equations in $x$, $y$, $z$ by equating scalar product of $\overrightarrow{NS}$ with two of $\overrightarrow{PQ}, \overrightarrow{QR}, \overrightarrow{RP}$ to zero $\quad \text{B1√+ B1√}$
Using the plane equation as third equation, solve for $x$, $y$, and $z \quad \text{M1}$
Obtain $\overrightarrow{ON} = \mathbf{i} + 2\mathbf{j}$, or equivalent $\quad \text{A1}$
Carry out method for finding $SN \quad \text{M1}$
Show that $SN = 7$ correctly $\quad \text{A1}$

OR: Use Cartesian formula or scalar product of $\overrightarrow{PS}$ with a normal vector to find $SN \quad \text{M1}$
Obtain $SN = 7 \quad \text{A1}$
State a unit normal $\hat{n}$ to the plane $\quad \text{B1√}$
Use $\overrightarrow{ON} = \overrightarrow{OS} \pm 7\hat{n} \quad \text{M1}$
Obtain an unsimplified expression e.g. $3\mathbf{i} + 5\mathbf{j} - 6\mathbf{k} \pm \left(\frac{2}{7}\mathbf{i} + \frac{3}{7}\mathbf{j} - \frac{6}{7}\mathbf{k}\right) \quad \text{A1√}$
Obtain $\overrightarrow{ON} = \mathbf{i} + 2\mathbf{j}$, or equivalent, only $\quad \text{A1}$
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<thead>
<tr>
<th>MARK SCHEME</th>
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<tr>
<td>MAXIMUM MARK: 50</td>
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<tr>
<td>SYLLABUS/COMPONENT: 9709/04</td>
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<td>MATHEMATICS</td>
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<td>Paper 4 (Mechanics 1)</td>
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<tbody>
<tr>
<td><strong>1</strong></td>
<td><strong>(i)</strong></td>
<td>( F = 13 \cos \alpha )</td>
<td>M1</td>
<td>2</td>
<td>For resolving forces horizontally</td>
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<td>Frictional component is 12 N</td>
<td>A1</td>
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<td><strong>(ii)</strong></td>
<td>R = 1.1 \times 10 + 13 \sin \alpha</td>
<td>M1</td>
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<td>For resolving forces vertically (3 terms needed)</td>
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<td>Normal component is 16 N</td>
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<td><strong>(iii)</strong></td>
<td>Coefficient of friction is 0.75</td>
<td>B1</td>
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<td><strong>2</strong></td>
<td>X = 100 + 250\cos70^\circ</td>
<td>B1</td>
<td></td>
<td></td>
<td>For using ( R^2 = X^2 + Y^2 )</td>
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<td>Y = 300 – 250\sin70^\circ</td>
<td>B1</td>
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<td>ft only if one B1 is scored or if</td>
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<td>( R^2 = 185.5^2 + 65.1^2 )</td>
<td>M1</td>
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<td>A1 ft</td>
<td>the expressions for the</td>
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<td>R = 197</td>
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<td>candidate’s X and Y are those</td>
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<td>tan( \alpha ) = 65.1/185.5</td>
<td>M1</td>
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<td>A1 ft 6</td>
<td>of the equilibrant</td>
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<td>( \alpha = 19.3^\circ )</td>
<td>A1</td>
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<td><strong>3</strong></td>
<td><strong>(i)</strong></td>
<td>Distance AC is 70 m</td>
<td>B1</td>
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<td>For using</td>
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<td>7 \times 10 - 4 \times 15</td>
<td>M1</td>
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<td>Distance AB is 10 m</td>
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<td><strong>(ii)</strong></td>
<td>x(m)</td>
<td>M1</td>
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<td>Graph consists of 3 connected</td>
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<td>negative slopes. ( x(t) ) is single</td>
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<td>steeper than the ( 3^{rd} ) and the ( 3^{rd}</td>
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<td>line segment does not terminate</td>
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<td>( Values ) of ( t ) (10, 15 and 30) and</td>
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<td>( x ) (70, 70, 10) shown, or can be</td>
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<td>For first 2 segments correct B1</td>
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<td>Mark Scheme</td>
<td>Syllabus</td>
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<td><strong>A AND AS LEVEL – JUNE 2004</strong></td>
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<tr>
<td>(i)</td>
<td>KE = 0.2g(0.7)</td>
<td>M1</td>
<td>For using KE = PE lost and PE lost = mgh</td>
<td></td>
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<tr>
<td></td>
<td>Kinetic energy is 1.4 J</td>
<td>A1</td>
<td>2</td>
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<tr>
<td>(ii)</td>
<td>( R = 0.2\times10\times\cos 16.3^\circ )</td>
<td>B1</td>
<td>1.92</td>
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<tr>
<td></td>
<td>( F = 0.288 \text{ N} )</td>
<td>B1 ft</td>
<td>From 0.15R (may be implied by subsequent exact value 0.72, 1.36 or 0.68)</td>
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<tr>
<td></td>
<td>WD = 0.72 J or ( a = 1.36 )</td>
<td>B1 ft</td>
<td>From 2.5F or from 0.2a = 0.2\times10\times \left(\frac{7}{25}\right) – F (may be implied by subsequent exact value 0.68)</td>
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<td>or resultant downward force</td>
<td>M1</td>
<td>For using KE = PE lost – WD</td>
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<td>= 0.272 N</td>
<td>A1 ft</td>
<td>KE = resultant downward force \times 2.5</td>
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<td></td>
<td>KE = 1.4 – 0.72 ( \text{ or } )</td>
<td>KE = ( \frac{1}{2} \times 0.2 \times (2 \times 1.36 \times 2.5) )</td>
<td>0.272 \times 2.5</td>
<td>M1</td>
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<tr>
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<td>KE = ( \frac{1}{2} \times 0.2 \times (2 \times 1.36 \times 2.5) )</td>
<td></td>
<td>For using KE = PE lost – WD</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>or resultant downward force</td>
<td>A1 ft</td>
<td>KE = resultant downward force \times 2.5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>KE = 0.68 J</td>
<td>A1 ft</td>
<td>5</td>
<td></td>
<td></td>
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<td><strong>5</strong></td>
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</tr>
<tr>
<td>(i)</td>
<td>( 10t^2 - 0.25t^4 ) ( (+C) )</td>
<td>M1</td>
<td>For integrating ( v )</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expression is ( 10t^2 - 0.25t^4 - 36 )</td>
<td>DM1</td>
<td>For including constant of integration and attempting to evaluate it</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>A1</td>
<td>3</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>(ii)</td>
<td>Displacement is 60 m</td>
<td>A1 ft</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Dependent on both M marks in (i); ft if there is not more than one error in ( s(t) )</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(iii)</td>
<td>((t^2 - 36)(1 - 0.25t^2) = 0 )</td>
<td>M1</td>
<td>For attempting to solve ( s = 0 ) (depends on both method marks in (i)) or ( \int_v^t ) ( v \text{d}t ) =36 (but not –36) for ( \dot{t} ) by factors or formula method</td>
<td></td>
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<td></td>
<td></td>
<td>A1</td>
<td>3</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Roots of quadratic are 4, 36</td>
<td>A1 ft</td>
<td>ft only from 3 term quadratic in ( t^2 )</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>( t = 2, 6 )</td>
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<td><strong>6</strong></td>
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<td></td>
</tr>
<tr>
<td>(i)</td>
<td>( \Delta P = 400 = 1200 \times 0.5 )</td>
<td>M1</td>
<td>For using Newton’s 2nd law (3 terms needed)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>20000 = 1000v ( )</td>
<td>A1</td>
<td>For using ( P = Fv )</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Speed is 20 ms(^{-1} )</td>
<td>M1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>A1</td>
<td>4</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(ii)</td>
<td>( 20000/v - 400 = 0 )</td>
<td>M1</td>
<td>For using ( P = Fv ) and Newton’s 2nd law with ( a = 0 ) and ( F = 400 )</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>( v_{\text{max}} = 50 \text{ ms}^{-1} )</td>
<td>A1</td>
<td>AG</td>
<td></td>
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</tr>
<tr>
<td>(iii)</td>
<td>( 20000 = \frac{1500000}{\Delta T} ) ( \text{ or } )</td>
<td>M1</td>
<td>For using ( P = \frac{\Delta W}{\Delta T} ) or for using ‘distance = work done/400’ and ‘time =distance/50’</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>distance = 1500 000/400 = 3750 ( )</td>
<td>A1</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>and time = 3750/50</td>
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<td></td>
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<tr>
<td></td>
<td>Time taken is 75 s</td>
<td></td>
<td></td>
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</tbody>
</table>
### Question 7

#### (i)

25 = 30t - 5t^2 \Rightarrow t^2 - 6t + 5 = 0 \Rightarrow (t-1)(t-5) = 0

- or -

\( v^2 = 30^2 - 500; \ t_{up} = (20 - 0)/10 \)

- t = 1 or t = 5
- Time = 5 - 1 = 4 s or
- Time = 2 x 2 = 4 s or
- 1 < t < 5

\( M1 \) For using \( 25 = ut - \frac{1}{2}gt^2 \) and attempting to solve for \( t \) or for using \( v^2 = u^2 - 2g(25) \) and \( t_{up} = (v - 0)/g \)

\( M1 \) For using \( t_{up} = (20 - 0)/10 \)

\( A1 \)

\( A1 \ 3 \)

#### (ii)

\( s_1 = 30t - 5t^2 \) and \( s_2 = 10t - 5t^2 \)

- \( 30t - 10t = 25 \)
- \( t = 1.25 \)
- \( v_1 = 30 - 10 \times 1.25 \) or
- \( v_2 = 10 - 10 \times 1.25 \)
- or -

\( v_1^2 = 30^2 - 2 \times 10(29.6875) \) or

\( v_2^2 = 10^2 - 2 \times 10(4.6875) \)

- Velocities 17.5ms\(^{-1}\) and \(-2.5ms\(^{-1}\) \( A1 \ 5 \)

OR

\( v_1 = 30 - 10t, \ v_2 = 10 - 10t \)

\( \Rightarrow v_1 - v_2 = 20 \)

\( (30^2 - v_1^2) \div 20 = (10^2 - v_2^2) \div 20 + 25 \)

\( v_1 - v_2 = 20, \ v_1^2 - v_2^2 = 300 \)

- Velocities are 17.5 ms\(^{-1}\) and \(-2.5 ms\(^{-1}\) \( A1 \ 5 \)

OR

#### (iii)

\( t_{up} = 3 \)

- \( 3 - 1.25 \)
- Time is 1.75 s or 1.25 < t < 3

\( M1 \)

\( M1 \)

\( A1 \)

\( A1 \ 3 \)

SR (max 1 out of 3 marks)

#### (iii)

0 = 17.5 - 10t

- Time is 1.75 s or 1.25 < t < 3

\( M2 \)

\( A1 \)

\( B1 \)

\( A1 \ 3 \)

For using \( 0 = u - gt \) with \( u \) equal to the answer found for \( v_1 \) in (ii)

\( B1 \)

SR (max 1 out of 3 marks)

\( 0 = 17.5 + 10t \)
Mechanics 2

1 For taking moments about the edge of the platform \( M1 \)
\[(75g \times 0.9 = 25g \times x + 10g \times 1.1) \text{ (3 term equation)}\]
Two terms correct (unsimplified) \( A1 \)
Completely correct (unsimplified) \( A1 \)
Distance \( MC = 3.16 \text{m} \) \( A1 \)

**NB:** If moments taken about other points, the force of the platform on the plank must be present at the edge of the platform for \( M1 \)

2 (i) Evaluates \( \frac{2r \sin \alpha \times \cos \frac{\pi}{4}}{3\alpha} \) \( M1 \)
Obtains given answer correctly \( A1 \)

(ii) For taking moments about \( AB \) \( M1 \)
\[(5 \times 10 + \frac{1}{4} \sqrt{\pi} \times 5^2) \times x = (5 \times 10) \times 5 + \frac{1}{4} \sqrt{\pi} \times 5^2(10 + \frac{20}{3\pi})\]
For the total area correct and the moment of the rectangle correct (unsimplified) \( A1 \)
For the moment of \( CDE \) correct (unsimplified) \( A1 \)
Distance is 7.01 cm \( A1 \)

3 For applying Newton’s 2nd law and using \( a = \frac{dv}{dx} \) \( M1 \)
\[
0.6 \frac{dv}{dx} = -\frac{3}{x^4}
\]
For separating the variables and integrating \( M1 \)
\[
0.3v^2 = -\frac{3x^{-2}}{(-2)} \quad (+C)
\]
(ft omission of minus sign in line 2 only)
For using \( = 0 \) when \( x = 10 \) \( M1 \)
\[
v^2 = \frac{5}{x^2} - \frac{1}{20}
\]
(aef) \( A1 \)
(ft wrong sign in line 4 only)
Speed is \( \frac{\sqrt{3}}{2} \text{ms}^{-1} \) (=0.866) \( A1 \)
4 (i) Distance of the rod from the hinge is $\frac{2.4}{2.5}$ or $0.7\cos16.26^\circ (=0.672)$ B1

[May be implied in moment equation]

For taking moments about the hinge (3 term equation) M1

$0.672F = 68 \times 1.2 + 750 \times 2.4$ A1 ft

Force is 2800 N A1

(ii) $X = 784$ (ft for 0.28$F$) B1 ft

For resolving vertically (4 term equation) M1

$Y = 1870$ (ft for 0.96$F - 818$) A1 ft

SR: For use of 680 N for weight of the beam: (i) B1, M1, A0. In (ii) ft 680, so 3/3 possible.

5 (i) For using $EPE = \frac{\lambda x^2}{2L}$ M1

EPE gain = $2 \left( \frac{200x^2}{2 \times 4} \right)$ (=50$x^2$) A1

GPE loss = $10g (4 + x)$ B1

For using the principle of conservation of energy to form an equation M1

containing EPE, GPE and KE terms

$[\frac{1}{2}10^2 + 50x^2 = 10g (4 + x)]$

Given answer obtained correctly A1

ALTERNATIVE METHOD:

$T = \frac{200x}{4}$ B1

$100 - 2\left( \frac{200x}{4} \right) = 10v \frac{dv}{dx}$ M1

$\frac{1}{2}v^2 = 10x - 5x^2$ (+C) A1

Use $x = 0, v^2 = 8g$ M1

$x^2 = 10(8 + 2x - x^2)$ A1

(ii) For using $= 0$ and factorizing or using formula method for solving M1

$x = 4$ (only) A1
6 (i) \[ 2 = VT\sin35° - 5T^2 \] or \[ 2 = 25\tan35° - \frac{25^2 \times 10}{2V^2 \cos^235°} \]

\[ 25 = VT\cos35° \]

For obtaining \(V^2\) or \(T^2\) in \(AV^2 = B\) or \(CT^2 = D\) form where \(A,B,C,D\) are numerical

\[ [(25\tan35° - 2)\cos^235°]V^2 = 3125 \text{ (aef)} \quad \text{or} \]

\[ 5T^2 = 25\tan35° - 2 \quad \text{(aef)} \]

\[ V = 17.3 \quad \text{or} \quad T = 1.76 \quad \text{A1} \]

\[ T = 1.76 \quad \text{or} \quad V = 17.3 \quad \text{(ft} \quad VT = 30.519365) \quad \text{B1 ft 5} \]

(ii) For using \(\dot{y} = V\sin35° - gT\) (must be component of \(V\) for M1)

\[ \dot{y}_m = (9.94 - 17.61 = -7.67) < 0 \quad \text{→ moving downwards} \quad \text{A1 ft} \]

(ft on \(V\) and \(T\))

For using \(m^2 = (V\cos35°)^2 + \dot{y}_m^2 \)

\[ (m^2 = ((14.20)^2 + (-7.67)^2) \quad \text{or} \]

For using the principle of conservation of energy

\[ (\frac{1}{2}m(v_m^2 - 17.3^2) = -mg \times 2) \]

\[ m = 16.1 \text{ ms}^{-1} \quad \text{A1 4} \]

LINES 1 AND 2 ALTERNATIVE METHODS

EITHER Compare 25 with \(\frac{1}{2}R\left(\frac{1}{2} \frac{v^2\sin70°}{g}\right)\)

\[ 25 > 14.1 \quad \text{→ moving downwards} \quad \text{A1} \]

OR Compare 1.76 with time to greatest height \(\left(\frac{V\sin35°}{g}\right)\)

\[ 1.76 > 0.994 \quad \text{→ moving downwards} \quad \text{A1} \]

OR \(\frac{dy}{dx} = \tan35° - \frac{g \times 10}{V^2 \cos^235°}(-0.54) \text{ used} \)

As \(\tan\phi\) is negative \(\rightarrow \text{moving downwards} \quad \text{A1} \)
7 (i) \[ T \cos 60^\circ = 0.5g \] 
\[ (T = 10) \]
For applying Newton’s 2nd law horizontally and using \[ a = \frac{v^2}{r} \]
(must be a component of \( T \) for M1)
\[ T \sin 60^\circ = \frac{0.5v^2}{0.15 \sin 60^\circ} \] (for an equation in \( V^2 \))
For substituting for \( T \)
\[ = 1.5 \]
A1

ALTERNATIVELY:
\[ a = \frac{v^2}{0.15 \sin 60^\circ} \]
For applying Newton’s 2nd law perpendicular to the string M1
\[ 0.5g \cos 30^\circ = 0.5(\cos 60^\circ) \]
For substituting for \( a \)
\[ (5 \cos 30^\circ = 0.5 \times 0.15 \tan 60^\circ) \] (for an equation in \( V^2 \))
\[ = 1.5 \]
A1

(ii) (a) \[ T \sin 45^\circ = \frac{0.5(0.9)^2}{0.15 \sin 45^\circ} \]
Tension is 5.4 N

(b) For resolving forces vertically M1
\[ 5.4 \cos 45^\circ + R = 0.5g \]
Force is 1.18 N

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<table>
<thead>
<tr>
<th>MARK SCHEME</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAXIMUM MARK: 50</td>
</tr>
<tr>
<td>SYLLABUS/COMPONENT: 9709/06, 0390/06</td>
</tr>
<tr>
<td>MATHEMATICS</td>
</tr>
<tr>
<td>Paper 6 (Probability and Statistics 1)</td>
</tr>
</tbody>
</table>
### 1 (i)
\[ \bar{x}_A = 139 \quad (138.75) \]
\[ \sigma_A = 83.1 \]

**B1**
- For the mean

**B1**
- For the sd

(ii) team B smaller standard deviation

**B1**
- Independent mark
- Need the idea of spread
- SR If team A has a smaller sd then award B1 only for 'team A, smaller sd'

### 2 (i)
- axes and labels
- points

\[ (3,0) \quad (15,160) \quad (20,320) \quad (35,480) \quad (60,640) \]

**B1**
- For correct uniform scales and labels on both axes, accept Frequency, %CF, Number of people, allow axes reversed, allow halves
- For 3 correct points
- All points correct and reasonable graph incl straight lines

(ii) accept 60 – 70 for straight lines
- 40 – 70 for curve

**M1**
- For subtracting from 640 can be implied

**A1**
- For correct answer, reasonably compatible with graph

### 3 (i)

<table>
<thead>
<tr>
<th>x</th>
<th>P(X = x)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>( \frac{11}{36} )</td>
<td>( \frac{9}{36} )</td>
<td>( \frac{7}{36} )</td>
<td>( \frac{5}{36} )</td>
<td>( \frac{3}{36} )</td>
<td>( \frac{1}{36} )</td>
<td></td>
</tr>
</tbody>
</table>

**M1**
- For 36 in the uncancelled denominator somewhere, accept decimals eg 0.305 recurring or 0.306 etc
- For 3 correct probabilities
- All correct

**A1**

(ii) \[ E(X) = 1 \times \frac{11}{36} + 2 \times \frac{9}{36} + 3 \times \frac{7}{36} + 4 \times \frac{5}{36} + 5 \times \frac{3}{36} + 6 \times \frac{1}{36} = \frac{91}{36} \]

**M1**
- For calculation of \( \sum xP(x) \) where all probs < 1

**A1**

### 4 (i)
\[ z = \frac{350 - 450}{120} = -0.833 \]
\% small = \( 1 - 0.7975 = 0.2025 \) or 20.25%

**M1**
- For standardising accept 120 or \( \sqrt{120} \), no cc
- For correct z value, + or -, accept 0.83
- For answer rounding to 0.202 or 0.203

**A1**

(ii) \[ \Phi z_2 = 0.60125 \]
\[ z_2 = 0.257 \]
\[ x = 120 \times 0.257 + 450 = 481 \]

**M1**
- For dividing their remainder by 2
- For adding their above two probs together or subt from 1
- For finding the z corresponding to their probability
- For converting to x from a z value
- For answer, rounding to 481

**M1 dep**

**M1 dep**

**A1**
5 (a) (i) \(3 \times 5 \times 3 \times 2\) or \(3C_1 \times 5C_1 \times 3C_1 \times 2\) \(= 90\)  
M1 For multiplying \(3 \times 5 \times 3\)  
A1 For correct answer  
2

(ii) \((3 \times 5 \times 2) + (3 \times 3) + (5 \times 2 \times 3)\) \(= 69\)  
M1 For summing options that show S&M, S&D, M&D  
M1 \(3 \times 5 \times a + 3 \times 3 \times b + 5 \times 3 \times c\) seen for integers a, b, c  
A1 For correct answer  
3

(b) \(\binom{14}{5} \binom{9}{5} \binom{4}{4}\) or equivalent \(= 252252\)  
M1 For using combinations not all \(\binom{14}{5}\)…  
M1 For multiplying choices for two or three groups  
A1 For correct answer  
NB 14!/5!5!4! scores M2 and A1 if correct answer  
3

6 (i)  

\[0.9 \times \text{Win} \]
\[0.1 \times \text{Lose} \]
\[0.65 \times \text{1st in} \]
\[0.35 \times \text{1st out}\]
\[0.6 \times \text{Win} \]
\[0.8 \times \text{2nd in} \]
\[0.4 \times \text{Lose} \]
\[0.2 \times \text{2nd out} \]
\[1 \times \text{Lose} \]

B1 For top branches correct (0.65, 0.9, 0.1)  
B1 For bottom branches correct (0.35, 0.8, 0.2)  
B1 For win/lose option after 2nd in (0.6, 0.4)  
B1 For all labels including final lose at end of bottom branch  
4

(ii) \(0.65 \times 0.1 + 0.35 \times 0.8 \times 0.4 + 0.35 \times 2\) \(= 0.247\)  
M1 For evaluating 1st in and lose seen  
M1 For 1st out 2nd in lose, or 1st out 2nd out lose  
A1 For correct answer  
3

(iii) \(\frac{0.65 \times 0.1}{0.247}\) \(= 0.263\) (= 5/19)  
M1 For dividing their 1st in and lose by their answer to (ii)  
A1 For correct answer, ft only on \(0.65 \times 0.1/\text{their (ii)}\)  
2
7 (i) \( P(0) = (0.8)^{15} = 0.03518 \)
\( P(1) = \binom{15}{1} \times (0.2) \times (0.8)^{14} = 0.1319 \)
\( P(2) = \binom{15}{2} \times (0.2)^2 \times (0.8)^{13} = 0.2309 \)
\( P(X \leq 2) = 0.398 \)

(ii) \( 1 - (0.8)^n \geq 0.85 \)
\( 0.15 \geq (0.8)^n \)
\( n = 9 \)

(iii) \( \mu = 1600 \times 0.2 = 320 \)
\( \sigma^2 = 1600 \times 0.2 \times 0.8 = 256 \)
\( P(X \geq 290) \) or \( P(X < 350) \)
\( = 1 - \Phi \left( \frac{289.5 - 320}{\sqrt{256}} \right) = 1 - \Phi(-1.906) \)
\( = \Phi(1.906) = 0.972 \)
June 2004

GCE A AND AS LEVEL

MARK SCHEME

MAXIMUM MARK: 50

SYLLABUS/COMPONENT: 9709/07, 8719/07

MATHEMATICS AND HIGHER MATHEMATICS
Paper 7 (Probability and Statistics 2)
### 1 (i)
- **$H_0$: $\mu = 15$ or $p = 0.25$**
- **$H_1$: $\mu > 15$ or $p > 0.25$**

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>For $H_0$ and $H_1$ correct</td>
</tr>
</tbody>
</table>

(ii) **Test statistic**

\[ z = \pm \frac{21.5 - 15}{\sqrt{60 \times 0.25 \times 0.75}} = 1.938 \]

**OR test statistic**

\[ z = \pm \frac{22}{\sqrt{0.25 \times 0.75}} = 1.938 \]

**CV $z = 1.645$**

In CR Claim justified

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>For attempt at standardising with or without cc, must have $\sqrt{\text{something with } 60 \text{ in on the denom}}$</td>
</tr>
<tr>
<td>A1</td>
<td>For $1.94 \ (1.938)$</td>
</tr>
<tr>
<td>A1ft</td>
<td>For comparing with $1.645$ or $1.96$ if 2-tailed, signs consistent, or comparing areas to 5% For correct answer (ft only for correct one-tail test)</td>
</tr>
</tbody>
</table>

### 2 (i)
- **Mean** = $3.5 + 2.9 + 3.1 = 9.5$
- **Var** = $0.3^2 + 0.25^2 + 0.35^2 \ (0.275)$
- **St dev** = $0.524$

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>9.5 as final answer</td>
</tr>
<tr>
<td>M1</td>
<td>For summing three squared deviations</td>
</tr>
<tr>
<td>A1</td>
<td>For correct answer</td>
</tr>
</tbody>
</table>

(ii) **$z = \frac{9 - 9.5}{\sqrt{\text{their var}}}$**

\[ \text{or } z = \frac{36 - 38}{\sqrt{4 \times \text{their var}}} = -1.907 \]

**$\Phi(1.907) = 0.972$**

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>For standardising, no cc</td>
</tr>
<tr>
<td>M1</td>
<td>For $\sqrt{\text{their var}}$ or $\sqrt{4 \times \text{their var}}$ in denom - no 'mixed' methods.</td>
</tr>
<tr>
<td>A1</td>
<td>For correct answer</td>
</tr>
</tbody>
</table>

### 3 (i)
- **$E(2X-3Y) = 2E(X) - 3E(Y)$**
  
  \[ = 16 - 18 = -2 \]

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>For multiplying by 2 and 3 resp and subt</td>
</tr>
<tr>
<td>A1</td>
<td>For correct answer</td>
</tr>
</tbody>
</table>

(ii) **$\text{Var} \ (2X-3Y) = 4\text{Var} \ (X) +9\text{Var} \ (Y)$**

\[ = 19.2 + 54 = 73.2 \]

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>For use of $\text{Var} \ (Y) = 6$</td>
</tr>
<tr>
<td>M1</td>
<td>For squaring 3 and 2</td>
</tr>
<tr>
<td>M1</td>
<td>For adding variances (and nothing else)</td>
</tr>
<tr>
<td>A1</td>
<td>For correct final answer</td>
</tr>
</tbody>
</table>

### 4 (i)
- **$\bar{x} = 375.3$**
- **$\sigma^2_{n-1} = 8.29$**

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>For correct mean (3.s.f)</td>
</tr>
<tr>
<td>M1</td>
<td>For legit method involving $n-1$, can be implied</td>
</tr>
<tr>
<td>A1</td>
<td>For correct answer</td>
</tr>
</tbody>
</table>

(ii) **$p = 0.19$ or equiv.**

\[ 0.19 \pm 2.055 \times \sqrt{\frac{0.19 \times 0.81}{200}} \]

\[ 0.133 < p < 0.247 \]

<table>
<thead>
<tr>
<th>Mark</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>For correct $p$</td>
</tr>
<tr>
<td>M1</td>
<td>For correct form $p \pm z \times \sqrt{pq/n}$ either/both sides</td>
</tr>
<tr>
<td>B1</td>
<td>For $z = 2.054$ or 2.055</td>
</tr>
<tr>
<td>A1</td>
<td>For correct answer</td>
</tr>
<tr>
<td>Question</td>
<td>Mark Scheme</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>5 (i)</td>
<td>$c = \frac{54 - 1.282 \times 3.1}{\sqrt{10}} = 52.74$</td>
</tr>
<tr>
<td></td>
<td>A1 4</td>
</tr>
<tr>
<td></td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>M1</td>
</tr>
<tr>
<td></td>
<td>For correct expression (c can be numerical, but signs must be consistent)</td>
</tr>
<tr>
<td></td>
<td>For correct GIVEN answer. No errors seen.</td>
</tr>
<tr>
<td></td>
<td>For + or – 1.282 seen</td>
</tr>
<tr>
<td>(ii)</td>
<td>$P(x &gt; 52.74) = 1 - \Phi \left(\frac{52.74 - 51.5}{3.1/\sqrt{10}}\right) = 1 - \Phi(1.265) = 1 - 0.8971 = 0.103$ or 0.102</td>
</tr>
<tr>
<td></td>
<td>M1</td>
</tr>
<tr>
<td></td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>For identifying the outcome for a type II error</td>
</tr>
<tr>
<td></td>
<td>For standardising, no $\sqrt{10}$ needed</td>
</tr>
<tr>
<td></td>
<td>For $\pm 1.265$ (accept 1.26-1.27)</td>
</tr>
<tr>
<td>6 (i)</td>
<td>$P(5) = e^{-6} \times \frac{6^5}{5!} = 0.161$</td>
</tr>
<tr>
<td></td>
<td>A1 2</td>
</tr>
<tr>
<td></td>
<td>B1</td>
</tr>
<tr>
<td></td>
<td>For an attempted Poisson P(5) calculation, any mean</td>
</tr>
<tr>
<td></td>
<td>For correct answer</td>
</tr>
<tr>
<td>(ii)</td>
<td>$P(x \geq 2) = 1 - {P(0) + P(1)} = 1 - e^{-1.6}(1 + 1.6) = 0.475$</td>
</tr>
<tr>
<td></td>
<td>M1</td>
</tr>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>For $\mu = 1.6$, evaluated in a Poisson prob</td>
</tr>
<tr>
<td></td>
<td>For $1 - P(0) - P(1)$ or $1 - P(0) - P(1) - P(2)$</td>
</tr>
<tr>
<td></td>
<td>For correct answer</td>
</tr>
<tr>
<td>(iii)</td>
<td>$P(1 \text{ then } 4 \mid 5) = \left(\frac{e^{-3} \times 3}{5!}\right) \times \left(\frac{e^{-3} \times 3}{4!}\right) = e^{-6} \times \frac{6^5}{5!} = 0.156$ or 5/32</td>
</tr>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>For multiplying P(1) by P(4) any (consistent) mean</td>
</tr>
<tr>
<td></td>
<td>For dividing by P(5) any mean</td>
</tr>
<tr>
<td></td>
<td>For correct answer</td>
</tr>
<tr>
<td>7 (i)</td>
<td>$\int_0^{25} t(25 - t^2)dt = 1$</td>
</tr>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>For equating to 1 and a sensible attempt to integrate</td>
</tr>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>For correct integration and correct limits</td>
</tr>
<tr>
<td></td>
<td>A1 3</td>
</tr>
<tr>
<td></td>
<td>For given answer correctly obtained</td>
</tr>
<tr>
<td>(ii)</td>
<td>$\int_2^4 t(25 - t^2)dt = \left[\frac{25t^2}{2} - \frac{t^4}{4}\right]_2^4 = e[136] - c[46]$</td>
</tr>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>M1*dep</td>
</tr>
<tr>
<td></td>
<td>For attempting to integrate $f(t)$ between 2 and 4 (or attempt 2 and 4)</td>
</tr>
<tr>
<td></td>
<td>For subtracting their value when $t = 2$ from their value when $t = 4$</td>
</tr>
<tr>
<td></td>
<td>A1 3</td>
</tr>
<tr>
<td></td>
<td>For correct answer</td>
</tr>
<tr>
<td>(iii)</td>
<td>$\int_0^5 t(25 - t^2)dt = \left[\frac{25t^3}{3} - \frac{t^5}{5}\right]_0^5 = \frac{8}{3}$</td>
</tr>
<tr>
<td></td>
<td>A1</td>
</tr>
<tr>
<td></td>
<td>M1*dep</td>
</tr>
<tr>
<td></td>
<td>For attempting to integrate $f(t)$, no limits needed</td>
</tr>
<tr>
<td></td>
<td>For correct integrand can have c (or their c)</td>
</tr>
<tr>
<td></td>
<td>For subtracting their value when $t=0$ from their value when $t=5$</td>
</tr>
<tr>
<td></td>
<td>A1 4</td>
</tr>
<tr>
<td></td>
<td>For correct answer</td>
</tr>
</tbody>
</table>