

**MARK SCHEME for the May/June 2011 question paper  
for the guidance of teachers**

**9794 MATHEMATICS**

**9794/02**

Paper 2 (Pure Mathematics and Mechanics),  
maximum raw mark 120

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.

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<p><b>1 (i)</b> Substitute <math>x = 4</math> into equation or attempt factorisation of <math>(x - 4)</math> Verify <math>y(4) = 0</math> or that <math>(x - 4)</math> is a factor</p> <p><b>(ii)</b> <i>May be seen in part (i)</i> <math display="block">x^3 - 12x - 16 = (x - 4)(x^2 + 4x + 4)</math><math display="block">= (x - 4)(x + 2)(x + 2)</math></p>	<p>M1 A1 [2]</p> <p>B1 B1 B1 [3]</p>
<p><b>2 (i)</b> Attempt to multiply out brackets Obtain <math>61 - 28\sqrt{3}</math>.</p> <p><i>SC For answer given without working – B1</i></p> <p><b>(ii)</b> <math>\sqrt{125} = 5\sqrt{5}</math> seen Multiply numerator and denominator by <math>2 - \sqrt{5}</math>, and expand. and use of <math>(2 + \sqrt{5})(2 - \sqrt{5}) = -1</math>. Obtain <math>25 - 10\sqrt{5}</math>. AG</p>	<p>M1 A1 [2]</p> <p>B1 M1 A1 A1 [4]</p>
<p><b>3</b> <math>\frac{dv}{dx} = \sin 3x, u = x</math> <math>v = -\frac{1}{3}\cos 3x, \frac{du}{dx} = 1</math> Obtain an expression of the form <math>f(x) \pm \int g(x)dx</math> Obtain <math>-\frac{x}{3}\cos 3x + \int \frac{1}{3}\cos 3x dx</math> <math>= -\frac{x}{3}\cos 3x + \frac{1}{9}\sin 3x + c</math> CAO</p>	<p>M1 A1 M1 A1√ A1 [5]</p>
<p><b>4 (i)</b> Shape of each graph (concavity). Asymptote at <math>\frac{\pi}{2}</math> Max/Min points clearly indicated at <math>x = 0</math> and <math>\pi</math>.</p> <p><b>(ii)</b> Evidence that <math>\sec x = \frac{1}{\cos x}</math> Multiply by <math>\cos x</math>, obtaining a quadratic. Solve quadratic. Solutions <math>x = \pi</math> and <math>x = 0.841</math> <i>SC For either both in degrees or one in degrees and one in radians – A1A0</i></p>	<p>B1 B1 B1 B1 [4] B1 M1 M1 A1 A1 [5]</p>

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5	(i)	Attempt to solve $c = 1$ ( or $c < 1$ ) for at least one drug, and obtain a solution. Obtain 54.9 (hours) for Antiflu; Obtain 23.0 (hours) for Coldcure.	M1 A1 A1	[3]	
	(ii)	Two <i>decaying</i> exponentials in the first quadrant showing correct intercepts on the $c$ -axis and crossing for some $t > 0$ .	M1 A1	[2]	
	(iii)	Assume additive nature of the concentrations: $5e^{-0.07 \times 30} + 5e^{-0.07 \times 10} = 3.10$ .	M1 A1	[2]	
6	(i)	$du = 2x dx$ or equivalent used  Substitute to obtain $\int \frac{1}{2} e^{-\frac{1}{2}u} du$  Obtain $\left[ -e^{-\frac{1}{2}u} \right]$  Evaluate: 0.5      WWW <i>SC For 0.5 without working – B2</i>	M1  A1  A1	[4]	
	(ii)	$\frac{dy}{dx} = 1 \times e^{-\frac{1}{2}x^2} + x \times (-x) \times e^{-\frac{1}{2}x^2}$  Equate to zero and find at least one point Stationary points $(1, e^{-0.5})$ ; $(-1, -e^{-0.5})$	M1 A1  M1 A1	[4]	
7	(i)	(a)	Not invertible Not 1–1 or equivalent	B1 B1	[2]
		(b)	(Minimum value of $-1$ at $x = 1$ ) $-1 \leq f(x)$ [B1 for correct interval; B1 for correct inequality]	B1 B1	[2]
	(ii)	(a)	$gh(x) = \sin^2 x$ .  Obtain $\frac{1}{2}(1 - \cos 2x)$ with some working	B1 AG B1	[2]
		(b)	Sine wave Period of $\pi$ Completely correct	M1 A1 A1	[3]

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<p><b>8 (i) (a)</b> <math>\frac{dx}{d\theta} = 1 - \cos \theta</math></p> <p><math>\frac{dy}{d\theta} = \sin \theta</math></p> <p><math>\frac{dy}{dx} = \frac{dy}{d\theta} / \frac{dx}{d\theta} = \frac{\sin \theta}{1 - \cos \theta}</math></p> <p><math>= \frac{2 \sin \frac{1}{2} \theta \cos \frac{1}{2} \theta}{2 \sin^2 \frac{1}{2} \theta} = \cot \frac{1}{2} \theta</math></p> <p>At least two of <math>\theta = \dots - 2\pi, 0, 2\pi \dots</math> without any incorrect values</p> <p><b>(b)</b> Rearranging <math>y = x</math> to give</p> <p><math>\theta = 1 + \sin \theta - \cos \theta</math></p> <p><math>= 1 + A \sin(\theta - \alpha)</math></p> <p>where <math>A = \sqrt{2}</math></p> <p>and <math>\alpha = \frac{\pi}{4}</math></p> <p><b>(c)</b> Consider sign of <math>\theta - 1 - \sqrt{2} \sin\left(\theta - \frac{\pi}{4}\right)</math> at <math>\theta = \frac{\pi}{2}, \pi</math></p> <p>Change of sign implies root:</p> <p><math>\left(\frac{\pi}{2} - 2(\text{negative}) \text{ and } \pi - 2(\text{positive})\right)</math></p> <p><b>(ii)</b> <math>\frac{dy}{dx} = \frac{\sin \theta}{2 - \cos \theta}</math></p> <p><math>\frac{d^2 y}{dx^2} = \frac{d}{d\theta} \left( \frac{dy}{dx} \right) \times \frac{d\theta}{dx}</math> or equivalent</p> <p><math>= \frac{2(2 \cos \theta - 1)}{(2 - \cos \theta)^3}</math> AEF, unsimplified</p> <p><math>\frac{d^2 y}{dx^2} = 0 \Rightarrow y = \frac{3}{4}</math></p>	<p>B1</p> <p>B1</p> <p>M1</p> <p>A1 AG</p> <p>B1 [5]</p> <p>M1</p> <p>M1</p> <p>A1</p> <p>A1 [4]</p> <p>M1</p> <p>A1 [2]</p> <p>B1</p> <p>M1</p> <p>A1</p> <p>A1 [4]</p>
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<p>9 (i) <math>P</math> has <math>x</math>-coordinate <math>k</math>.</p>	B1
<p>Region R has area <math>\frac{1}{2}k \times k^2 - \int_0^{(k)} x^2 dx</math> or <math>\int_0^{(k)} kx - x^2 dx</math></p>	M1
<p><math>= \frac{1}{2}k^3 - \frac{1}{3}k^3</math></p>	
<p><math>= \frac{1}{6}k^3</math> AG</p>	A1 [3]
<p>(ii) <math>\int_0^a kx - x^2 dx = \frac{1}{12}k^3</math> or equivalent.</p>	M1
<p><math>= \left[ \frac{1}{2}kx^2 - \frac{1}{3}x^3 \right]_0^a</math></p>	A1
<p><math>\Rightarrow k^3 - 6ka^2 + 4a^3 = 0</math> AG</p>	A1 [3]
<p>(iii) Differentiate the implicit equation wrt <math>t</math>:</p>	M1
<p><math>3k^2 \frac{dk}{dt} - 12a \frac{da}{dt} k - 6a^2 \frac{dk}{dt} + 12a^2 \frac{da}{dt} = 0</math></p>	A1 ( $< 3$ errors)
<p>Make substitutions and obtain <math>\frac{da}{dt} = 1</math>.</p>	A1 CAO
<p><u>OR</u>:</p>	A1 [4]
<p>Differentiate the implicit equation wrt <math>a</math> or <math>k</math></p>	M1
<p><math>3k^2 \frac{dk}{da} - 12ak - 6a^2 \frac{dk}{da} + 12a^2 = 0</math> or <math>3k^2 - 12a \frac{da}{dk} k - 6a^2 + 12a^2 \frac{da}{dk} = 0</math></p>	A1
<p>Relate connected rates of change</p>	M1
<p>Make substitutions and obtain <math>\frac{da}{dt} = 1</math>.</p>	A1
<p>(iv) <math>\left( \text{The formula } \frac{da}{dt} = \frac{k^2 - 2}{2(k-1)} \text{ may appear} \right)</math></p>	
<p>Attempt to factorise <math>k^3 - 6k + 4</math> with linear factor <math>(k - 2)</math></p>	M1
<p>Obtain <math>(k - 2)(k^2 + 2k - 2)</math></p>	A1
<p>Solve quadratic factor and obtain either or both of <math>k = \pm\sqrt{3} - 1</math></p>	A1
<p>Correctly substitute into derivative formula and attempt to simplify</p>	M1
<p>Obtain either or both of <math>\frac{da}{dt} = 1 \pm \sqrt{3}</math>.</p>	A1 [5]

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<p><b>10 (i)</b> Any valid method, for example  <math>AB \cdot AC = (-4\mathbf{i} + 3\mathbf{k}) \cdot (3\mathbf{i} + 4\mathbf{k})</math>  <math>= -12 + 12 = 0</math> Hence result.</p> <p><b>(ii)</b> Resolving along <math>AB</math>: <math>T_{AB} = 20 \cos\left(\tan^{-1} \frac{4}{3}\right)</math>  Obtain 12N.  Resolving along <math>AC</math>: <math>T_{AC} = 20 \sin\left(\tan^{-1} \frac{4}{3}\right) = 16\text{N}</math>  <i>SC Both answers either unassigned or swapped – B1</i></p> <p><b>(iii)</b> The vector tension is 12 x unit vector in <math>AB</math> direction  <math>= -9.6\mathbf{i} + 7.2\mathbf{j}</math>  Or <math>= -a\mathbf{i} + b\mathbf{j}</math> where <math>\frac{a}{b} = \frac{4}{3}</math> and <math>a^2 + b^2 = (\text{their } T_{AB})^2</math></p>	<p>M1  A1 [2]  M1  A1  A1 [3]  M1  A1√ A1√ [3]</p>
<p><b>11 (i)</b> Use of <math>x = Vt \cos \theta</math> and <math>y = Vt \sin \theta - \frac{1}{2}gt^2</math>  Solving <math>y = 0</math> for <math>t</math> and substitute in <math>x</math> formula  <math display="block">R = \frac{2V^2 \sin \theta \cos \theta}{g} \left( = \frac{V^2 \sin 2\theta}{g} \right)</math></p> <p><b>(ii)</b> (symmetry of the trajectory) implies <math>R = 100\text{m}</math></p> <p><b>(iii)</b> <math>V = \sqrt{1000}</math> (<math>= 10\sqrt{10}</math>) <math>\text{ms}^{-1}</math> (<math>= \sqrt{g \times \text{their } R}</math>)  Solving  <math display="block">30 = 10\sqrt{10}t \sin \frac{\pi}{4}</math>  Obtain <math>t = \frac{3}{\sqrt{5}}</math> or <math>t = \frac{x}{V \cos \theta}</math> and substitute later  Obtain <math>h = 21\text{m}</math></p>	<p>M1 A1  M1  A1 AG [4]  B1 [1]  B1√  M1  A1 M1  A1 [5]</p>

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<p><b>12 (i)</b> All forces shown: Applied, weight and reaction.</p> <p><b>(ii)</b> Net force up the slope <math>20 - 20 \sin 30 = 10(\text{N})</math></p> <p>Use 'Force = mass <math>\times</math> acceleration' <math>\Rightarrow a = 5\text{ms}^{-2}</math></p> <p>Applying 'suva' with <math>u = 0</math> and <math>a = 5</math></p> $v = 5t.$ <p><b>(iii)</b> Let <math>U</math> and <math>V(V &gt; U)</math> be the speeds of the particles up the slope after the collision. An attempt at both of</p> <p>COM: <math>2 \times 15 - 1 \times 5 = 2 \times U + 1 \times V</math></p> <p>NEL: <math>0.2 \times (15 - (-5)) = V - U</math></p> <p>Obtain <math>U = 7\text{ms}^{-1}</math></p> <p>'suva' gives <math>v = 7 - 5T</math>, where <math>T</math> is time after impact.</p>	<p>B1 [1]</p> <p>B1</p> <p>B1</p> <p>M1</p> <p>A1 [4]</p> <p>M1 A1√</p> <p>M1 A1√</p> <p>A1</p> <p>A1√ [6]</p>
<p><b>13 (i)</b> As the system is in equilibrium, the tension in the string is <math>T = mg</math></p> <p>Resolving at right angles to the plane:</p> $R + T \sin \alpha = 2mg \cos \alpha$ <p>giving <math>R = mg(2 \cos \alpha - \sin \alpha)</math>.</p> <p><b>(ii)</b> By implication <math>\alpha \leq 45^\circ</math> (condone boundary case only)</p> $\cos \alpha \geq \frac{1}{\sqrt{2}}; \sin \alpha \leq \frac{1}{\sqrt{2}}$ $R \geq mg \left( \frac{2}{\sqrt{2}} - \frac{1}{\sqrt{2}} \right)$ <p><b>(iii)</b> Resolving up the slope</p> $F = 2mg \sin \alpha - T \cos \alpha = mg(2 \sin \alpha - \cos \alpha)$ <p>For this to be positive</p> <p>and combined with first line of solution of <b>(ii)</b></p> $0.5 < \tan \alpha \leq 1$ <p><b>(iv)</b> Using <math>F = \mu R</math></p> $\mu = \frac{2 \sin \alpha - \cos \alpha}{2 \cos \alpha - \sin \alpha} = \frac{2 \tan \alpha - 1}{2 - \tan \alpha}$ <p>Max value of <math>\mu</math> is 1 when <math>\tan \alpha = 1</math>.</p>	<p>B1</p> <p>M1</p> <p>A1 AG [3]</p> <p>M1</p> <p>A1</p> <p>A1 AG [3]</p> <p>M1</p> <p>A1</p> <p>A1 AG [3]</p> <p>M1</p> <p>A1</p> <p>A1 [3]</p>