

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2014 series

9709 MATHEMATICS

9709/41

Paper 4, maximum raw mark 50

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1	$DF - R = 800 \times 1.2$ $DF = 22500/18 [= 1250]$ Resistance is 290 N	M1 A1 B1 A1	4	For using Newton's 2 nd law with three terms
2	For <i>A</i> : right angle between 18 and <i>R</i> and 30° opposite 18 or $W_A \sin 30^\circ = 18$ or For <i>B</i> : right angle between 18 and <i>W</i> and 30° opposite 18 or $W_B \sin 30^\circ = 18 \cos 30^\circ$ For <i>B</i> : right angle between 18 and <i>W</i> and 30° opposite 18 or $W_B \sin 30^\circ = 18 \cos 30^\circ$ or For <i>A</i> : right angle between 18 and <i>R</i> and 30° opposite 18 or $W_A \sin 30^\circ = 18$ Weight of <i>A</i> is 36 N and weight of <i>B</i> is 31.2 N	M1 A1 B1 A1	4	For a triangle of forces with sides 18, <i>R</i> and <i>W</i> for <i>A</i> or for <i>B</i> – or – for resolving forces acting on <i>A</i> or on <i>B</i> parallel to line of greatest slope
3 (i)	$F + W \sin \alpha = 7.2$ $[\mu \times 7.5 \cos \alpha \geq 7.2 - 7.5 \sin \alpha]$ $\mu \geq 17/24$	M1 A1 M1 A1	4	For resolving forces parallel to slope with three terms For using $F \leq \mu R$ AG
(ii)	$[7.2 + 7.5 \times (7/25) - \mu(7.5 \times 24/25) > 0]$ $\mu < 31/24$	M1 A1	2	For using 'resultant force down the plane is > 0 ' and $F = \mu R$ AG
4 (i)	End speed = $1.3 + 0.1 \times 20$ $v_Q(t) = 0.008t^2 + v_Q(0)$ $[3.3 = 0.008 \times 20^2 + v_Q(0)]$ Speed of <i>Q</i> when $t = 0$ is 0.1 ms^{-1}	B1 B1 M1 A1	4	For substituting end speed and $t = 20$

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(iii)	$[v_S^2 = 2 \times 10 \times 5 = 100 \text{ or } v_B^2 = v_T^2 + 2 \times 5.5 \times 4]$	M1		For using $v^2 = u^2 + 2as$ (for either stage)
	$v_S = 10 \text{ ms}^{-1}$ at surface and $v_B = 12 \text{ ms}^{-1}$ at bottom – both shown on sketch	A1		
	$[10 = 0 + 10t_1 \text{ or } 12 = 10 + 5.5(t_2 - t_1)]$	M1		For using $v = u + at$ (for either stage)
	$t_1 = 1 \text{ s}$ at surface and shown on sketch	A1		
	$t_2 = 1.36 \text{ s}$ at bottom and shown on sketch.	A1	5	
7	PE change = $60g \times 17.5$ or KE change = $\frac{1}{2} 60(8.5^2 - 3.5^2)$	M1		To obtain PE change or KE change
		A1		[PE = 10500]
	KE change = $\frac{1}{2} 60(8.5^2 - 3.5^2)$ or PE change = $60g \times 17.5$	B1		[KE = 1800]
	WD against resistance = 6×250	B1		[= 1500]
	WD by pulling force = $50\cos\alpha \times 250$	B1		
		M1		For using ‘WD by the pulling force is a linear combination of PE change, KE change and WD against resistance.’
	WD = $10500 - 1800 + 1500$	A1✓		
	WD by the pulling force is $10200 \text{ J or } 10.2 \text{ kJ}$	A1		
	For using WD = $Fd\cos\alpha$	M1		
	$10200 = 50 \times 250 \cos\alpha$	A1		
	$\alpha = 35.3$	A1	11	

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Alternative solution				
	$(3.5)^2 = (8.5)^2 + 2a(250)$ $a = -3/25 = -0.12$	M1 A1 A1 M2 A4 M1 A1	11	Using $v^2 = u^2 + 2as$ Applying Newton's 2 nd law with 4 relevant terms [Allow M1 with 3 relevant terms] One mark for each correct term Solve for $\cos \alpha$
	$50 \cos \alpha - 6 - 60g(17.5/250) = 60(-0.12)$ $[\cos \alpha = 102/125]$ $\alpha = 35.3$			

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		Time after projection is 2.2 seconds	A1	2	
	(ii)	$h = 0 + \frac{1}{2} g \times 2.2^2 = 24.2$	B1✓		
		$V = 0 + g \times 2.2 = 22$	B1✓	2	
2	(i)	$[X = 25 \times 0.96 - 30 \times 0.8 = 0]$	M1		For resolving forces in the x direction
		Component in x -direction is zero	A1	2	AG
	(ii)	$[Y = 25 \times 0.28 - 20 + 30 \times 0.6 = 5]$	M1		For resolving forces in the y direction
		Resultant has magnitude 5 N and acts in the positive y direction	A1	2	
	(iii)	Replacement has magnitude 30 N and acts in the $-ve y$ direction	B1	1	
3	(i)	$[v_B = 1.2 \times 28 \div 0.96]$	M1		For using $P = Fv$ and the factors 1.2 and 0.96 and an equation in v_B only
		Speed of the train at B is 35 ms^{-1}	A1	2	AG
	(ii)	KE increase = $100\,000(35^2 - 28^2)$	B1		
		WD by engine = $44.1 \times 10^6 + 2.3 \times 10^6 \text{ J}$	M1		For using WD by engine = KE increase + WD against resistance
		Work done is 46 400 kJ or $46.4 \times 10^6 \text{ J}$	A1	3	or 46 400 000 J
4	(i)	$[X \cos 30^\circ = 40 \cos 60^\circ]$	M1		For resolving forces horizontally
		$X = 23.1 (= 40 / \sqrt{3})$	A1	2	
	(ii)	$[X \cos 30^\circ - 10 = 40 \cos 60^\circ]$	M1		For resolving forces horizontally
		$X = 60 \div \sqrt{3}$ or 34.6	A1		
		$[R + X \sin 30^\circ + 40 \sin 60^\circ = 15g]$	M1		For resolving forces vertically ($R = 98.038$)
		$[\mu = 10 \div (150 - 30/\sqrt{3} - 20\sqrt{3})]$	M1		For using $F = \mu R$
		Coefficient is 0.102	A1	5	

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5	(i) (a)	$[F = 0.7 \times 3, WD = 2.1 \times 0.9]$ Work done is 1.89 J	M1 A1	2	For using $F = \mu R$ and $WD = Fs$
	(b)	Loss of PE = $3 \times 0.9 = 2.7$ J	B1	1	
	(c)	[KE gain = $2.7 - 1.89$] Gain in KE = 0.81 J	M1 A1	2	For ‘gain in KE = loss in PE – WD by friction’
	(ii)	$\frac{1}{2}(0.3 + 0.3)v_{\text{at break}}^2 = 0.81$ $v_{\text{floor}}^2 = v_{\text{at break}}^2 + 2g \times 0.54$ Speed at the floor is 3.67 ms^{-1}	M1 M1 A1	3	For using $\frac{1}{2}(m_A + m_B)v^2 = \text{gain in KE}$ For using $v^2 = u^2 + 2gs$
	Alternative method for (i) (c) and (ii)				
	(c)	$[T - 2.1 = 0.3a \text{ and } 3 - T = 0.3a]$ $\rightarrow a = 1.5$ $[v^2 = 2 \times 1.5 \times 0.9 = 2.7]$ KE = $0.5 \times (0.3 + 0.3) \times 2.7 = 0.81$ J	M1 A1	2	For applying Newton’s 2 nd law to both particles and finding a and using $v^2 = 0 + 2as$ and attempting KE
	(ii)	$[v_{\text{at break}}^2 = 2.7]$ $v_{\text{floor}}^2 = v_{\text{at break}}^2 + 2g \times 0.54$ Speed at floor = 3.67 ms^{-1} ($= 1.5\sqrt{6}$)	M1 M1 A1	3	For using their v^2 in (i)(c) as $v_{\text{at break}}^2$ For using $v^2 = u^2 + 2gs$
	Alternative method for (ii)				
	(ii)	$[0.3 \times g \times 0.54] \text{ or } [\frac{1}{2} \times 0.3 \times (v^2 - 2.7)]$ $[1.62 = \frac{1}{2} \times 0.3 \times (v^2 - 2.7)]$ Speed at floor = 3.67 ms^{-1} ($= 1.5\sqrt{6}$)	M1 M1 A1	3	For attempting PE loss or KE gain for the falling particle only For using PE loss = KE gain of this particle
6	(i) (a)	(a) Acceleration is 2.8 ms^{-2}	B1		Using acceleration = $g \sin \alpha$
	(b)	$[mg \times 0.28 - 0.5mg \times 0.96 = ma]$ Acceleration is -2 ms^{-2}	M1 A1	3	For using Newton’s 2 nd law

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(ii)	$v_B^2 = 2 \times 2.8(AB)$ and $2^2 = 5.6(AB) - 2 \times 2(5 - AB)$ Distance is 2.5 m	M1 A1 $\frac{1}{4}$ A1	3	For using $v^2 = u^2 + 2as$ for AB and for BC and using $AB + BC = 5$ ft incorrect answers in (i)
Alternative method for (ii)				
	$[mg \times 5 \times 0.28 = \frac{1}{2} m 2^2 + \mu \times mg \times 0.96 \times BC]$ $14 = 2 + 4.8 \times BC$ $BC = 12/4.8 = 2.5 \text{ m}$	M1 A1 A1	3	For using Loss in PE = Gain in KE + WD against Friction for the motion from A to C Correct equation
(iii)	$T = 2 \times 2.5 \div (0 + \sqrt{14}) + 2 \times 2.5 \div (\sqrt{14} + 2)$ Time taken is 2.21 s	M1 A1 A1	3	For using $t = 2s \div (u + v)$ for AB and BC
7 (i)	$v = -4.8$ $[\pm 4.8 = 3a]$ Magnitude of acceleration is 1.6 ms^{-2}	B1 M1 A1	3	For using $v = 0 + at$
(ii)	$[-0.4t + 4 (= 0 \text{ when } t = 10)]$ $v_{\max} = -0.2 \times 100 + 4 \times 10 - 15 \rightarrow$ Maximum velocity is 5 ms^{-1}	M1 M1 A1	3	For finding the value of t when $dv/dt = 0$ For evaluating $v(10)$ as $v_{\max}$ (the graph excludes the possibility of $v(10)$ as $v_{\min}$)
(iii) (a)	Distance 0 to 3 s = $\frac{1}{2} \times 3 \times 4.8 (= 7.2)$ Distance 3 to 5 s = $-\int_3^5 (-0.2t^2 + 4t - 15) dt$ Distance = $\pm 4.5333 \dots \text{m}$ Average speed = $(7.2 + 4.533) \div 5 = 2.35 \text{ ms}^{-1}$	B1 M1 A1 B1		Attempt to integrate and use limits

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	(ii)	$[1080 - 800 = 1400a]$ Acceleration is 0.2 ms^{-2}	M1 A1	2	For using $DF = P \div 25$ and $DF - R = ma$
2		$0.65 \times 10 \times (63/65) - T = 0.65a$ or $T - 0.65 \times 10 \times (16/65) = 0.65a$ $T - 0.65 \times 10 \times (16/65) = 0.65a$ or $0.65 \times 10 \times (63/65) - T = 0.65a$ or $0.65 \times 10 \times (63 - 16)/65 = 2 \times 0.65a$ $[T - 1.6 = 6.3 - T]$ or $[T = 6.3 - 0.65 \times (47/13)]$ or $[T = 1.6 + 0.65 \times (47/13)]$ Tension is 3.95 N	M1 A1 B1 M1 A1	5	For applying Newton's 2nd law to P or to Q For eliminating a
3	(i)	$[W \cos \alpha + 7 \times 0.6 = 8]$ $W \cos \alpha = 3.8$ (cwo) $W \sin \alpha = 5.6$	M1 A1 B1	3	For resolving forces acting at O vertically AG
	(ii)	$W = 6.77$ or $\alpha = 55.8$ $\alpha = 55.8$ or $W = 6.77$	M1 A1 B1	3	For using $W^2 = (W \sin \alpha)^2 + (W \cos \alpha)^2$ or $\tan \alpha = (W \sin \alpha \div W \cos \alpha)$
4	(i)	$v(8) = 0.25 \times 8 = 2$ $2 = -6.4 + 19.2 - k \rightarrow k = 10.8$	B1 B1 ✓	2	ft (12.8 - v)
	(ii)	$[dv/dt = -0.2t + 2.4 (= 0 \text{ when } t = 12)]$ $v_{\max} = -0.1 \times 144 + 2.4 \times 12 - 10.8]$ Maximum speed is 3.6 ms^{-1}	M1 A1 ✓	2	For finding t when $dv/dt = 0$ and substituting into $v(t)$ ft (14.4 - incorrect k)

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(iii)	Displacement $s_1 = \frac{1}{2} 0.25 \times 8^2$ (= 8) [Displacement $s_2 = [-0.1t^3/3 + 1.2t^2 - 10.8t]_8^{18}$ (=26.7)] Displacement is 34.7 m	B1 M1 A1	3	For using displacement $s_2 = \int_8^{18} (-0.1t^2 + 2.4t - 10.8) dt$
5	$[P - 8g\sin 5^\circ - F = 8a]$ $7X - 8g\sin 5^\circ - F = 8 \times 0.15$ and $8X - 8g\sin 5^\circ - F = 8 \times 1.15$ $X = 8$ $F = 56 - 8g\sin 5^\circ - 8 \times 0.15$ or $F = 64 - 8g\sin 5^\circ - 8 \times 1.15$ or $F = 56 \times 1.15 - 64 \times 0.15 - 8g\sin 5^\circ$ or $F = 47.8(275\dots)$ $R = 8g\cos 5^\circ$ (= 79.695...) $[\mu = 47.8 \div 79.7]$ Coefficient is 0.600 (accept 0.6)	M1 A1 A1 M1 A1 ^{1/2} B1 M1 A1	8	For using Newton's 2 nd law (either case) For obtaining a numerical expression for F fit X either from error for one term in X/F equation or from error in solution of correct X/F equations For using $\mu = \frac{F}{R}$
6 (i)	Acceleration is 4 ms^{-2} For $T - mg = 4m$ and $(1 - m)g - T = 4(1 - m)$ or $4 = (1 - m - m)g$ P has mass 0.3 kg and Q has mass 0.7 kg	M1 A1 M1 A1 A1	5	For using the gradient property for acceleration For applying Newton's 2 nd law to both particles or using the formula $(M + m)a = (M - m)g$ and for using $m + M = 1$

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	(ii) For using the area property of the graph or $h = \frac{1}{2} at^2$ to obtain $h = 2$	B1	1	
	(iii) Distance travelled upwards by $P = \frac{1}{2} 1.4 \times 4$ Height is 4.8 m	B1 B1	 2	
7	(i) $4^2 = 0^2 + 2a \times 12.5 \rightarrow a = 0.64$ [$35 \times 0.96 - 3g \times 0.6 - F = 3 \times 0.64$] $F = 13.68$ WD against $F = 13.68 \times 12.5 = 171 \text{ J}$	B1 M1 A1 B1	 4	For using Newton's 2 nd law to find F
	(ii) $R_{\text{from O to A}} = 3g \times 0.8 - 35 \times 0.28$ [$\mu = 13.68 \div 14.2 (= 0.96338)$] Coefficient is 0.963 (accept 0.96)	B1 M1 A1	 3	For using $\mu = F \div R$
	(iii) [$-3g \times 0.6 - 0.96338 \times (3g \times 0.8) = 3a$] Acceleration is -13.7 ms^{-2} [$0 = 16 + 2(-13.7)s$] Distance travelled is 0.584 m	M1 A1 M1 A1	 4	For applying Newton's 2 nd law to the block to find a For using $v^2 = u^2 + 2as$ to find s
Alternative for part (i)				
	(i) Gain in KE = $\frac{1}{2} 3 \times 4^2 (= 24 \text{ J})$ Gain in PE = $3g \times 12.5 \times 0.6 (= 225 \text{ J})$ [WD = $35 \times 12.5 \times 0.96 - \frac{1}{2} 3 \times 4^2 - 3g \times 12.5 \times 0.6$] WD against F is 171 J	B1 B1 M1 A1	 4	For using WD against F = WD by applied force – KE gain – PE gain
Alternative for part (iii)				
	WD against $F = 0.96(338..) \times 3g \times 0.8s$ $\frac{1}{2} 3 \times 4^2 = 3gs(0.6) + 0.96(338..) \times 3g \times 0.8s$ Distance travelled is 0.584 m	B1 M1 A1 A1	 4	For using KE loss = PE gain + WD against friction