

CAMBRIDGE INTERNATIONAL EXAMINATIONS

Cambridge International Advanced Subsidiary and Advanced Level

MARK SCHEME for the October/November 2015 series

9709 MATHEMATICS

9709/41

Paper 4, maximum raw mark 50

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Page 2	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9709	41

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Page 3	Mark Scheme	Syllabus	Paper
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1	(i)	$200g \times 0.7$ Work done = 1400 J	M1 A1	2	For using $WD = mg \times h$
	(ii)	$1400/1.2$ Average Power = 1170 W	M1 A1	2	For using Power = WD/Time
2	(i)	$a = g \sin 30 = 5$ $2.5 = 0 + 5t$ $t = 0.5$ Time = 0.5 s	B1 M1 A1	3	Using $v = u + at$
	(ii)	$v^2 = 0 + 2 \times 5 \times 3 = 30$ $-1 = 0.5a \rightarrow a = -2$ $0 = 30 + 2 \times (-2) \times s$ Distance = 7.5 m	B1 M1 A1	3	For applying Newton's second law to the particle and using $v^2 = u^2 + 2as$
	First alternative method for 2(ii)				
		$v^2 = 0 + 2 \times 5 \times 3 = 30$ $0.5 \times 0.5 \times 30 = 1 \times \text{distance}$ Distance = 7.5 m	B1 M1 A1	3	KE lost = WD against Friction
	Second alternative method for 2(ii)				
		PE lost = $0.5 \times 10 \times 3 \sin 30 = 7.5$ $7.5 = 1 \times \text{distance}$ Distance = 7.5 m	B1 M1 A1	3	Using PE lost = mgh PE lost = WD against Friction
3	(i)	$F - 24000g \sin 3 - 3200 = 24000 \times (0.2)$ Power = $Fv = 20561 \times 25$ Power = 514 kW	M1 A1 M1 A1	4	For applying Newton's second law to the lorry up the hill [$F = 20561$] Using $P = Fv$
	(ii)	DF = $3200 + 24000g \sin 3$ [=15761] $v = 500000/15761 = 31.7 \text{ ms}^{-1}$	M1 A1	2	Using Newton's second law up the hill in the steady case $P = Fv$ so $v = P/F$

Page 5	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9709	41

4	$F = 0.2 \times mg \cos 35$ $5g - mg \sin 35 - 0.2 mg \cos 35 = 0$ $5g - Mg \sin 35 + 0.2 Mg \cos 35 = 0$ $m = 6.78$ or $M = 12.2$ $6.78 \leq \text{mass} \leq 12.2$	B1 M1 A1 A1 M1 A1	6	Maximum value of F For resolving forces along the plane in either case Equilibrium, on the point of moving up the plane Equilibrium, on the point of moving down the plane For solving either
5 (i)	$F \cos 70 + 20 - 10 \cos 30 = R \cos 15$ $10 \sin 30 - F \sin 70 = R \sin 15$ $F = 1.90 \text{ N and } R = 12.4 \text{ N}$	M1 A1 A1 M1 A1	5	For resolving forces either horizontally or vertically For solving simultaneously
Alternative method for 5(i)				
	$[X = 0.342 F + 11.34$ $Y = 0.94 F - 5]$ $(0.342 F + 11.34)^2 + (0.94 F - 5)^2 = R^2$ $\tan 15 = (5 - 0.94 F) / (0.342 F + 11.34)$ $F = 1.90 \text{ N and } R = 12.4 \text{ N}$	M1 A1 A1 M1 A1	5	For finding components of the forces in the x and y directions Solve the $\tan 15$ equation for F and substitute to find R
(ii)	$11.7^2 = 0 + 2a \times 3$ $a = 22.815$ $R \cos 15 = m \times 22.815$ Mass of bead = 0.526 kg	B1 M1 A1	3	Applying Newton's second law to the particle in direction AB

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6	(i)	$s = 0.3t^2 - 0.01t^3$ $s(5) = 0.3 \times 5^2 - 0.01 \times 5^3 = 6.25$ $a = 0.6 - 0.06t$ $a(5) = 0.6 - 0.0 \times 5 = 0.3 \text{ ms}^{-2}$	M1 A1 M1 A1	4	For integration For differentiation
	(ii)	Maximum velocity is when $0.6 - 0.06t = 0$ $[t = 10]$ Max velocity = 3 ms^{-1} $0.6t - 0.03t^2 = 1.5$ $[t^2 - 20t + 50 = 0]$ Times are 2.93 s and 17.07 s	M1 M1 A1 M1 A1 A1	6	For setting $a = 0$ For solving $a = 0$ Setting velocity = half its maximum and attempting to solve a three term quadratic

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	(ii)	$[G = F(\sin 30^\circ + \sin 60^\circ)]$ $G = 56.0$	M1 A1	2	For resolving forces in the y direction Allow $15(2 + \sqrt{3})$
2	(i)	$[V^2 = (V - 10)^2 + 2g \times 35]$ $20V = 100 + 70g$ $V = 40$	M1 A1 A1	3	For using $v^2 = u^2 + 2gs$ to obtain an equation in V only or to obtain two equations in V and H and attempting to eliminate H
Alternative for 2(i)					
	(i)	$V = V - 10 + 10t \rightarrow t = 1$ and $35 = (V - 10) \times 1 + \frac{1}{2} \times 10 \times 1^2$ or $35 = (V - 10 + V)/2 \times 1$ $V = 40$	M1 A1 A1	3	A complete method to find V by considering the final 35 m using $v = u + at$ and either $s = ut + \frac{1}{2}at^2$ or $s = (u + v)/2 \times t$
	(ii)	$[40^2 = 0^2 + 20H]$ $H = 80$	M1 A1	2	For using $v^2 = u^2 + 2gs$
3	(i)	$[a(t) = 0.00012t^2 - 0.012t + 0.288]$ $[a(t) = 0.00012(t^2 - 100t + 2400) = 0.00012(t - 40)(t - 60) = 0]$ $a(t) = 0$ when $t = 40$ and $t = 60$	M1* dM1* A1	3	For attempting to differentiate $v(t)$ For setting $a(t) = 0$ and attempting to solve a three term quadratic
	(ii)	$[0.00001t^4 - 0.002t^3 + 0.144t^2]$ $[0.00001(100)^4 - 0.002(100)^3 + 0.144(100)^2]$ Displacement is 440 m	M1† dM1† A1	3	For attempting to integrate $v(t)$ Integration attempted using correct limits $t = 0$ to $t = 100$

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4	Frictional force $= 0.4 \times 2 \cos 45$ $= 0.4\sqrt{2}$ KE gain $= \frac{1}{2} \times 0.2 \times V_C^2$ and PE loss $= 0.2 \times g \times (2.5 + 2\sqrt{2})$ 0.1 $V_C^2 = (5 + 4\sqrt{2}) - 0.4\sqrt{2} \times 4$ Speed at C is 9.16 ms^{-1}	M1 A1 B1 M1 A1 A1	6	For using $R = 2\cos 45^\circ$ and $F = \mu R$ For using KE gain from A to C = PE loss from A to C – Work done by frictional force
First alternative for the last four marks				
	$\frac{1}{2} \times 0.2 \times V_B^2 = 0.2 \times g \times 2.5 \rightarrow$ $V_B^2 = 50$ 0.1 $(V_C^2 - V_B^2)$ $= 0.2 \times g \times (4 \div \sqrt{2}) -$ $0.4\sqrt{2} \times 4$ Speed at C is 9.16 ms^{-1}	B1 M1 A1 A1		For using KE gain from B to C = PE loss from B to C – Work done by frictional force
Second alternative for the last four marks				
	$\frac{1}{2} \times 0.2 \times V_B^2 = 0.2 \times g \times 2.5 \rightarrow$ $V_B^2 = 50$ $\sqrt{2} - 0.4\sqrt{2} = 0.2a \rightarrow a$ $= 3\sqrt{2} \text{ ms}^{-2}$ and $V_C^2 = V_B^2 + 2 \times 3\sqrt{2} \times 4$ Speed at C is 9.16 ms^{-1}	B1 M1 A1 A1		For using Newton's 2nd law to find acceleration along BC and using $v^2 = u^2 +$ $2as$ to find V_C

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5	(i)	$0.5g \times \frac{7}{25} - T = 0.5a$ $T - 0.1g = 0.1a$ $1.4 - 1 = 0.6a$ For eliminating T and obtaining $a = \frac{2}{3} \text{ ms}^{-2}$ Tension is 1.07 N	M1 A1 B1 M1 A1	5	For applying Newton 2nd law to P or to Q or for applying N2 to the system Any two correct Allow sin 16.3 for 7/25 For substituting for a to find T Allow $T = 16/15$ N
	(ii)	$[v^2 = 2 \times \left(\frac{2}{3}\right) \times 0.7]$ $[2^2 = 2 \times \frac{2}{3} \times 0.7 + 2 \times 0.28g \times s]$ Length of string = $2.5 - s = 1.95$ m	M1 M1 A1	3	For using $v^2 = u^2 + 2as$ to find the speed of the particles immediately before the string breaks For applying $v^2 = u^2 + 2as$ for the motion of P when the string is slack and s is the distance travelled by P after the break until it reaches the floor Allow length = 41/21 m
6	(i)	$[0.195 \cos \theta = F]$ $F = 0.195 \cos 22.6 = 0.195 \times \frac{12}{13}$ $= 0.18 = \frac{9}{50}$ $[R = 0.24 + 0.195 \sin \theta]$ $R = 0.24 + 0.195 \sin 22.6 =$ $0.24 + 0.195 \times \frac{5}{13} = 0.315$ $= \frac{63}{200}$ Coefficient $\mu = 4/7$ or 0.571	M1 A1 M1 A1 M1 A1	6	For resolving forces horizontally For resolving forces vertically For using $\mu = F/R$

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	(ii)	$R = 0.24 - 0.195 \sin 22.6$ $= 0.24 - 0.195 \times \frac{5}{13}$ $= 0.165 = \frac{33}{200}$ $0.195 \times \frac{12}{13} - \left(\frac{4}{7}\right) \times 0.165$ $= 0.024a$ Acceleration is 3.57 ms^{-2}	B1 M1 A1 A1	4	For using Newton's second law for motion along the rod Allow acceleration = $25/7$
	7 (i)	$[WD = 14000 \times 25]$ Work done is 350 kJ or 350 000 J	M1 A1	2	For using $P = WD \div \Delta t$
	(ii)	$14000/v_A - 235 = 1600 \times 0.5 \rightarrow$ $v_A = 13.53 \text{ ms}^{-1}$ $14000/v_B - 235 = 1600 \times 0.25 \rightarrow$ $v_B = 22.05 \text{ ms}^{-1}$ $[KE \text{ gain} =$ $\frac{1}{2} 1600(22.05^2 - 13.53^2)]$ KE gain = 242.5 kJ or 242 500 J	M1 A1 A1 M1 A1	5	For using $DF = P/v$ and Newton's 2 nd law to find the speed of the car at <i>A</i> or at <i>B</i> $v_A = 2800/207$ $v_B = 2800/127$ For using KE gain $= \frac{1}{2} m(v_B^2 - v_A^2)$
	(iii)	$350\,000 = 242\,500 + 235 \times AB$ Distance <i>AB</i> is 457 m	M1 A1 A1	3	For using WD by DF $= KE \text{ gain} + \text{resistance} \times AB$

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1	Tension is 30 N $[R = (4g - 30) \times 0.8]$ Normal component is 8 N	B1 M1 A1	3	For resolving forces acting on <i>B</i>, perpendicular to the plane.
2	$F = T \cos \alpha = 0.96T$ $R = 0.2g - T \sin \alpha = 2 - 0.28T$ $[0.96T = 0.25(2 - 0.28T)]$ $[(0.96 + 0.07)T = 0.5 \rightarrow T = \dots]$ $T = 0.485$	B1 B1 M1 M1 A1	5	For using $F = \mu R$ For solving resultant equation for T
3	$120 \cos 75^\circ = 150 - 100 - P \cos \theta^\circ$ $120 \sin 75^\circ = P \sin \theta^\circ$ $[P^2 = 14400 - 12000 \cos 75^\circ + 2500]$ or $\tan \theta = [120 \sin 75^\circ / (50 - 120 \cos 75^\circ)]$ $P = 117$ or $\theta = 80.7$ $\theta = 80.7$ or $P = 117$	M1 A1 M1 A1 M1 A1 B1	7	For resolving forces in the x or $-x$ direction For resolving forces in the y direction For using $P^2 = (P \cos \theta)^2 + (P \sin \theta)^2$ or for using $P \sin \theta / P \cos \theta = \tan \theta$
4 (i)	$0.35g - T = 0.35a$ $T - 0.15g = 0.15a$ $(0.35 - 0.15)g = (0.35 + 0.15)a$ Acceleration is 4 ms^{-2} Tension is 2.1 N	M1 A1 B1 B1	4	For applying Newton's second law to <i>A</i> or to <i>B</i> or for using $m_A g - m_B g = (m_A + m_B)a$ Two of the three equations
(ii)	$[v_1^2 = 0 + 8 \times 1.6 (= 12.8)]$ $[H = 1.6 + (-12.8) \div (-20)]$ Greatest height is 2.24 m	M1 M1 A1	3	For using $v_1^2 = 0 + 2a \times 1.6$ For using $H = 1.6 + (0 - v_1^2) / (-2g)$ or for using $h = (0 - v_1^2) / (-2g)$

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	Cambridge International AS/A Level – October/November 2015	9709	43

5	(i)	$a = (5^2 - 3^2) \div (2 \times 500) = 0.016$ $DF + 90g \times 0.05 - R = 90 \times 0.016$ $[R = \frac{420}{v} - 90(0.016 - 0.5)]$ $R = \frac{420}{v} + 43.56$	B1 M1 A1 M1 A1	5	AG SR for assuming constant R and DF (max 2/5) PE loss = $90g(500)(0.05)$ and KE gain = $\frac{1}{2}(90)(5^2 - 3^2)$ B1 $WD_{DF} + \text{PE loss} = \text{KE gain} + WD_R$ $\rightarrow R = 420/v + 43.56$ B1
	(ii)	$v_M^2 = 3^2 + 2 \times 0.016 \times 250 \rightarrow$ speed at mid-point is 4.12 ms^{-1} [Decrease in R from top to mid-way $= 420[(1 \div 3) - (1 \div \sqrt{17})]$ or [Decrease in R from midway to b'm $= 420[(1 \div \sqrt{17}) - (1 \div 5)]$ 38.1 and 17.9	B1 M1 A1	3	For finding the difference in R for either top to midway or midway to bottom
6	(i)	Time taken $= \frac{0.08}{0.0002} = 400 \text{ s}$ $v = \frac{dx}{dt} = 0.16t - 0.0006t^2$ [speed $= -0.16 \times 400 + 0.0006 \times 400^2]$ Speed at O is 32 ms^{-1}	B1 B1 M1 A1	4	For evaluating $\pm v(400)$
	(ii) (a)	Time to furthest point is $0.16/0.0006 \text{ s}$ $[0.08(800/3)^2 - 0.0002(800/3)^3]$ ($\times 2$) Distance moved is 3790 m	B1 M1 [*] A1	3	$v = 0.16t - kt^2$ or $v = kt - 0.0006t^2$ from part (i) For evaluating $x(t_{\text{furthest point}}) (\times 2)$
	(b)	[speed = $3790/400 \text{ ms}^{-1}$] Average speed is 9.48 ms^{-1}	dM1 [*] A1	2	For using 'average speed = total distance moved / time taken'

Page 6	Mark Scheme	Syllabus	Paper
	Cambridge International AS/A Level – October/November 2015	9709	43

7	(i)	Gain in KE $= \frac{1}{2} 1250(8^2 - 5^2)$ Loss in PE = $1250g \times 400\sin 4^\circ$ $400(DF) = \frac{1}{2} 1250(8^2 - 5^2) - 1250g \times 400\sin 4^\circ + 2000 \times 400$ Driving force is 1189 N or 1190 N	B1 B1 M1 A1 A1	5	For using WD by $DF = \text{Gain in KE} - \text{Loss in PE} + \text{WD by resistance}$ SR for using Newton's second law (max 2/5) $DF + 1250g\sin 4^\circ - 2000 = 1250a$ B1 $a = (8^2 - 5^2)/2 \times 400 \rightarrow DF = 1190 \text{ N}$ B1
	(ii)	$1189 \times 2 - 2000 = 1250a$ or $22.75^2 = 8^2 + 2a \times 750$ Acceleration is 0.302 ms^{-2}	M1 A1 $\frac{1}{2}$ A1	3	For using Newton's second law to find acceleration or for finding v_c and using $v^2 = u^2 + 2as$ to find acceleration $\frac{1}{2}$ DF from part (i)
	(iii)	$v_c^2 = 64 + 2 \times 0.302 \times 750$ $[P/ 22.75 - 2000 = 1250 \times 0.302]$ Power is 54.1 kW or 54100 W	B1 $\frac{1}{2}$ M1 A1	3	$\frac{1}{2}$ acceleration from part (ii)