
MATHEMATICS

9709/41

Paper 4

May/June 2016

MARK SCHEME

Maximum Mark: 50

Published

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	Cambridge International AS/A Level – May/June 2016	9709	41

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SOS	See Other Solution (the candidate makes a better attempt at the same question)
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Qu	Answer	Part Mark	Marks	Guidance
1 (i)	Trapezium seen	B1		$v-t$ graph with three straight lines, with positive, zero and negative gradients, continuous
	0, 3, 9, 13 shown on the t axis	B1		
	$v = 2.7$ soi in either part	B1	[3]	
(ii)	$[0.5 \times (6 + 13) \times 2.7]$	M1		Using area of trapezium
	Total distance = 25.65 m	A1	[2]	Allow Distance = 513/20 m
Alternative method for 1(ii)				
(ii)	Stage 1 $s_1 = 0.5 \times 0.9 \times 3^2 = 4.05$ Stage 2 $s_2 = 2.7 \times 6 = 16.2$ Stage 3 $s_3 = 0.5 \times (2.7 + 0) \times 4 = 5.4$ Total distance = 25.65 m	M1 A1	 [2]	Complete method to find the total distance travelled by the lift using constant acceleration equations for all three stages
2 (i)	WD = $40 \times 36 = 1440$ J	B1	[1]	
(ii)		M1		Using PE = mgh
	PE = $25 \times g \times 36 \sin 20 = 3080$ J	A1	[2]	[PE = 3078.18]
(iii)	WD by pulling force = (i) + (ii)	M1		For using WD by pulling force = Gain in PE + WD against F
	WD = 4520 J	A1	[2]	[WD = 4518.18]
Alternative for (iii)				
(iii)	$[(25g \sin 20 + 40) \times 36]$	M1		For attempting to find the pulling force and multiply it by 36 to find the work done
	WD = 4520 J	A1	[2]	[WD = 4518.18]

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3 (i)	Driving Force = 300	B1	[3]	Using DF = Resistance	
	$P = 300 \times 40$	M1		Using $P = Fv$	
	$P = 12000 \text{ W} = 12 \text{ kW}$	A1		Must give answer in kW	
	(ii)	$P = 0.9 \times 12000 = 10800$		B1✓	ft on 12000
		$\frac{10800}{25} - 300 = 1000a$		M1	Applying Newton's second law with 3 terms to the car
		$a = 132/1000 = 0.132 \text{ ms}^{-2}$		A1	[3]
4	$P \cos \theta = 48 \cos \alpha - 14 \sin \alpha$ and/or $P \sin \theta = 50 - 48 \sin \alpha - 14 \cos \alpha$	M1	[6]	For resolving forces horizontally and/or vertically	
	$P \cos \theta = 48(24/25) - 14(7/25)$ $= 42.16$	A1		Allow $\alpha = 16.3$ used throughout	
	$P \sin \theta = 50 - 48(7/25) - 14(24/25)$ $= 23.12$	A1		For attempting to find P or θ	
	$P = \sqrt{42.16^2 + 23.12^2} = 48.1$	A1		Allow $P = 34\sqrt{2}$	
	$\tan \theta = \frac{23.12}{42.16}$	B1			
	$\theta = 28.7$				

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Qu	Answer	Part Mark	Marks	Guidance
5	$R = 5g \cos \alpha = 4g$ $F = 0.5 \times 4g = 2g$ $T - 2g - 5g \sin \alpha = 5a \rightarrow$ $T - 5g = 5a$ $10g - T = 10a$ $[5g = 15a]$ $a = g/3 = 3.33 \text{ ms}^{-2}$ $T = 10g - 10(g/3)$ $= 20g/3 = 66.7 \text{ N}$	B1 M1 A1 A1 M1 A1 B1	 [7]	For finding the normal reaction R acting on the 5 kg particle and using $F = \mu R$ For applying Newton's second law to one or both particles or to the system System equation is $10g - 5g \sin \alpha - 2g = 5g = 15a$ For eliminating T and solve for a
6 (i)	$a = 12t - 30$ $t < 2.5$	M1 A1	 [2]	For differentiating v to find a
(ii)	$v = 0$ at $t = 1$ and $t = 4$ $s = \int (6t^2 - 30t + 24) dt$ $= \frac{6}{3}t^3 - \frac{30}{2}t^2 + 24t$ $s = [2t^3 - 15t^2 + 24t]_1^4$ Distance = 27 m	B1 M1 M1 A1	 [4]	Using $v = 6(t - 4)(t - 1)$ For using integration to find s For using limits
(iii)	$2t^3 - 15t^2 + 24t = 0$ $2t^2 - 15t + 24 = 0$ $t = 2.31$ and $t = 5.19$	M1 M1 A1	 [3]	State $s = 0$ Reduce to a quadratic and attempt to solve

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Qu	Answer	Part Mark	Marks	Guidance
7 (i) (a)	$200 - 30g \sin 20 = 30a$	M1		For applying Newton's second law with 3 terms parallel to the plane
	$a = 3.25 \text{ ms}^{-2}$	A1	[2]	[$a = 3.2465$]
	(b) $[v^2 = 2 \times 3.2465 \times 12 = 77.9]$	M1		For using $v^2 = u^2 + 2as$ and attempting to find KE change
	KE change = $0.5 \times 30 \times 77.9 = 1170 \text{ J}$	A1	[2]	[KE = 1168.7 J]
Alternative method for 7(i)(b)				
(ii) (a)	(b) KE change = $200 \times 12 - 30g \times 12 \sin 20$	M1		Using KE gain = WD by DF – PE gain
	KE change = 1170 J	A1	[2]	
	$N = 30g \cos 20$	B1		[$N = 281.9$]
	$F = 0.12 \times 30g \cos 20 [= 33.8]$	M1		Using $F = \mu Na$
	$200 - 30g \sin 20 - 33.8 = 30a$	M1		For using Newton's second law with 4 terms applied to the particle
	$a = 2.12 \text{ ms}^{-2}$	A1	[4]	
	(b) $N + 200 \sin 10 = 30g \cos 20$ [$N = 247.2$]	M1		For resolving forces perpendicular to the plane. Three term equation.
	$F = 0.12 N [= 0.12 \times 247.2 = 29.66]$	M1		N must be from a 3 term equation
	$200 \cos 10 - 29.66 - 30g \sin 20 = 30a$	M1		For using Newton's second law with 4 terms applied to the particle
	$a = 2.16 \text{ ms}^{-2}$	A1	[4]	

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1	$[X = 7 - 8 \cos \alpha - 6 \sin \alpha = -3]$ $X = 7 - 8 \times (4/5) - 6 \times (3/5) = -3$ $[Y = 8 \sin \alpha - 6 \cos \alpha = 0]$ $Y = 8 \times (3/5) - 6 \times (4/5) = 0$ Resultant force is 3N to the left	M1 A1 M1 A1 B1	5	For resolving forces horizontally Allow $\alpha = 36.9$ used For resolving forces vertically Allow $\alpha = 36.9$ used
2 (i)	$4t^2 - 8t + 3 = 0$ $(2t - 3)(2t - 1)$ $t = 0.5$ and $t = 1.5$	M1 A1	2	Set $v = 0$ and attempt to factorise or use the quadratic formula or completing the square.
(ii)	$s = - \int (4t^2 - 8t + 3) dt$ $-\left[\frac{4}{3} t^3 - 4t^2 + 3t \right]_{0.5}^{1.5}$ Distance travelled = 2/3 m	M1 M1 A1	3	Integrating v to find s . Allow minus sign omitted. Attempted integration with limits substituted and then subtracted but not necessarily fully evaluated. $[= - (0 - 2/3)]$ Allow first minus sign omitted Must justify sign of answer
3 (i)	$[80x \sin 22.6 \text{ or } 80x(5/13)]$ $= \frac{400}{13} x = 30.8x$	M1 A1	2	For using PE change = mgh PE change = $8 \times g \times x \sin \alpha$ Allow $\alpha = 22.6$ used
(ii)	WD against friction = $15 \times x$ $\frac{1}{2} \times 8 \times 5^2$ $\frac{1}{2} \times 8 \times 5^2 = \frac{400}{13} x + 15x$ $x = \frac{260}{119} = 2.18$	B1 B1 M1 A1	4	For using KE loss = PE gain + WD against friction

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4	(i)	$\frac{1}{2} \times 6 \times 8.2 + 36 \times 8.2$ Or $\frac{1}{2} \times 8.2 \times (36 + 42)$ Distance = 319.8 m	M1 A1	2	For using distance = total area under graph
	(ii)	$s = 80.2$ $80.2 = \frac{8.2 + V}{2} \times 10$ $V = 7.84$	B1 M1 A1		Distance from $t = 42$ to $t = 52$ For equating remaining distance to total area under graph between $t = 42$ and $t = 52$
	(iii)		M1	3	AG
			M1		Use gradient property for deceleration
		$d = \frac{8.2 - 7.84}{10} = 0.036$	A1	2	
Alternative for 4(iii)					
(iii)	$80.2 = 8.2 \times 10 + \frac{1}{2} a \times 10^2$ $a = -0.036 \text{ ms}^{-2}$ or $d = 0.036 \text{ ms}^{-2}$	M1 A1	2	For using $s = ut + \frac{1}{2}at^2$ between $t = 42$ and $t = 52$	
5		M1	7	For resolving forces perpendicular to the plane (3 term equation)	
	$R + T \sin 20 = 2.5g \cos 30$	A1		May be implied	
	$F = 0.25 \times R$	B1			
		M1		For resolving forces parallel to the plane (3 term equation)	
	$T \cos 20 = F + 2.5g \sin 30$	A1		For solving and obtaining T	
	$T = 17.5$	A1			

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Qu	Answer	Part Marks	Mark	Notes
Alternative scheme				
5	$F = 0.25 \times R$ $T \cos 50 = F \cos 30 + R \sin 30$ $R \cos 30 + T \sin 50 = F \sin 30 + 2.5g$ $T = 17.5$	B1 M1 A1 M1 A1 M1 A1	 7	May be implied For resolving forces horizontally (3 term equation) For resolving forces vertically (4 term equation) For solving and obtaining T
6 (i) (a)	Power = 1550×40 W Power = 62000 W = 62 kW	M1 A1	 2	Using Power = Fv where F = Resistance force Answer must be in kW
(b)	$(62000 - 22000) = DF \times 40$ [DF = 1000] $DF - 1550 = 1100a$ $a = -0.5 \text{ ms}^{-2}$ or $d = 0.5 \text{ ms}^{-2}$	B1ft M1 A1	 3	For stating $P - 22000 = DF \times 40$ to find the new driving force. ft on Power found in (i)(a) For applying Newton's second law to the car (3 terms)
(ii)	$DF = 1100g \sin 8 + 1550$ [= 3081] $80000 = 3081v$ $v = 26(.0) \text{ ms}^{-1}$	M1 M1 A1	 3	For stating the equilibrium of the three forces For using $P = Fv$ with F involving a weight and a resistance term

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7 (i)	$[2.4g - T = 2.4a$ $T = 1.6a$ $2.4g = (1.6 + 2.4)a]$ $a = 6 \text{ ms}^{-2}$ $0.5 = \frac{1}{2} \times 6 \times t^2$ $t = 0.408 \text{ s}$	M1 M1 A1 M1 A1	5	For applying Newton's second law to one of the particles or to the combined system For applying Newton's second law to a second particle if needed and/or solving for a For using $s = ut + \frac{1}{2}at^2$ Accept $t = \sqrt{6/6}$
Alternative for 7(i)				
(i)	$[PE \text{ loss} = 2.4 \times g \times 0.5 = 12]$ $KE \text{ gain} = \frac{1}{2}(1.6 + 2.4)v^2 = 2v^2]$ $[12 = 2v^2]$ $v^2 = 6 \rightarrow v = 2.45 \text{ ms}^{-1}$ $[0.5 = \frac{1}{2} \times (0 + 2.45) \times t]$ $t = 0.408 \text{ s}$	M1 M1 A1 M1 A1	5	For attempting to find PE and KE as B reaches the ground Using PE loss = KE gain Using $s = \frac{1}{2}(u + v)t$ Accept $t = \sqrt{6/6}$
(ii)	$R = 1.6g = 16$ and $F = 3/8 R = 6$ System is $[2.4g - 6 = (1.6 + 2.4)a]$ $2.4g - T = 2.4a$ and $T - 6 = 1.6a$ $[a = 4.5]$ $v = \sqrt{2 \times 4.5 \times 0.5} = \sqrt{4.5} = 2.12 \text{ ms}^{-1}$ $-6 = 1.6a \rightarrow a = -3.75 \text{ ms}^{-2}$ $0 = 4.5 + 2 \times (-3.75) \times (s - 0.5)$ $s = 1.1 \text{ m}$	B1 M1 A1 M1 A1 M1 A1	7	For using Newton's second law for both particles or the system Both or system equation For finding a and using $v^2 = u^2 + 2as$ to find v as B reaches the ground For finding the deceleration of A and using $v^2 = u^2 + 2as$ to find s the total distance travelled by A

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First Alternative for 7(ii)				
(ii)	$R = 1.6g = 16$ and $F = 3/8 R = 6$ PE loss = $2.4 \times g \times 0.5 [= 12]$ KE gain = $\frac{1}{2} \times (1.6 + 2.4) \times v^2 [= 2v^2]$ $12 = 2v^2 + 6 \times 0.5 \rightarrow v^2 = 4.5 \rightarrow v = 2.12$ Loss of KE = WD against F $[\frac{1}{2} \times 1.6 \times 4.5 = 6 \times (s - 0.5)]$ $s = 1.1 \text{ m}$	B1 M1 A1 M1 A1 M1 A1	7	For attempting PE loss and KE gain as B reaches the ground For both PE and KE correct For using PE loss = KE gain + WD against F For considering the motion of A after B reaches the ground to find s the total distance travelled

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Qu	Answer	Part Marks	Marks	Notes
1 (i)	[PE gain = $8g \times 20\sin 30^\circ$] Change in PE is 800 J	M1 A1	 2	For using PE gain = mgh
(ii)	[$8g \times 20\sin 30^\circ + 20F = 1146$] Frictional force is 17.3 N	M1 A1	 2	For using PE gain + WD against friction = 1146
2 (i)	$s_B = \frac{1}{2} \times 1.2 \times 5^2$ Distance travelled is 15 m	B1		
	$v_B = 1.2 \times 5$ Speed is 6 ms^{-1}	B1	2	
(ii)	[$4T = 15 + 6(T - 10)$] or [$4(T + 5) = 15 + 6(T - 5)$] or [$4(T + 10) = 15 + 6T$] $T = 22.5$ or $T = 17.5$ or $T = 12.5$ Distance OP = $4 \times 22.5 = 90 \text{ m}$	M1 A1 B1	 3	For using $s_A = s_B$ after T seconds or after $T + 5$ seconds or after $T + 10$ seconds
3	 $12\cos 75^\circ + P\cos \theta^\circ = 18\cos 65^\circ$ $18\sin 65^\circ + 12\sin 75^\circ = 15 + P\sin \theta^\circ$ [$P^2 = (18\sin 65^\circ + 12\sin 75^\circ - 15)^2 + (18\cos 65^\circ - 12\cos 75^\circ)^2$] or [$\theta = \tan^{-1}(18\sin 65^\circ + 12\sin 75^\circ - 15) / (18\cos 65^\circ - 12\cos 75^\circ)$] $P = 13.7$ or $\theta = 70.8$ $\theta = 70.8$ or $P = 13.7$	M1 A1 A1 M1 A1 B1	 6	For resolving forces horizontally and/or vertically For eliminating either θ or P from the simultaneous equations

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Qu	Answer	Part Marks	Marks	Notes
4	$R = 15g\cos 20^\circ$ $F = \mu R = 0.2 \times 15g\cos 20^\circ$ $X + 0.2 \times 15g\cos 20^\circ = 15g\sin 20^\circ$ Least value of X is 23.1 $[X = 15g\sin 20^\circ + 0.2 \times 15g\cos 20^\circ]$ Greatest value of X is 79.5	B1 B1 M1 A1 A1 M1 A1	7	140.95 28.19 For resolving parallel to the plane (F acting up plane) AG For resolving parallel to the plane (F acting down plane)
5 (i)	$[20000/v = 650]$ Speed is 30.8 ms^{-1}	M1 A1	2	For using $DF = P/v$ and for resolving forces along the direction of motion
(ii)	$[DF = 650 + 1400g \times \frac{1}{7}]$ $P/10 = 650 + 1400g \times \frac{1}{7}$ Power is 26500 W	M1 M1 A1	3	For resolving forces along the direction of motion For using $DF = P/v$
(iii)	$P = 0.8 \times 26500(21200)$ $[21200/20 + 1400g \times \frac{1}{7} - 650 = 1400a]$ Acceleration is 1.72 ms^{-2}	B1 M1 A1	3	ft $0.8 \times P$ from (ii) For using Newton's Second Law
6 (i) (a)	$1.3g - T = 1.3a$ and $T - 0.7g = 0.7a$ or $1.3g - 0.7g = (1.3 + 0.7)a$ and either $1.3g - T = 1.3a$ or $T - 0.7g = 0.7a$ Tension is 9.1 N	M1 A1 B1		For applying Newton's Second Law to one particle or for using $m_1g - m_2g = (m_1 + m_2)a$

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Qu	Answer	Part Marks	Marks	Notes
(b) (ii)	Acceleration is 3 ms^{-2}	B1	6	For using $s = \frac{1}{2} at^2$ For using $v^2 = u^2 + 2as$ to find the speed on reaching plane ft√(4a) or at from (i) For using $v^2 = u^2 + 2as$ to find the distance 0.7 kg particle continues upwards
	$[2 = \frac{1}{2} \times 3 \times t^2]$	M1		
	Time taken is 1.15 seconds	A1		
	$[v^2 = 2 \times 3 \times 2]$	M1		
	$v = \sqrt{12}(3.464)$	A1 ^{ft}		
	$[0 = 12 - 2gs \rightarrow s = \dots]$	M1		
	Greatest height is 4.6 m	A1	4	
Alternative				
(ii)	$[1.3g \times 2 = \frac{1}{2} (1.3)v^2 + 9.1 \times 2]$ or $[9.1 \times 2 = \frac{1}{2} (0.7)v^2 + 0.7g \times 2]$ $v = \sqrt{12}(3.464)$ $[\frac{1}{2} \times 0.7v^2 = 0.7gs \rightarrow s = \dots]$ Greatest height is 4.6 m	M1 A1 ^{ft} M1 A1	4	For using PE loss = KE gain + WD _T for 1.3 kg or for using WD _T = KE gain + PE gain for 0.7 kg ft√(4a) or at from (i) For using KE loss = PE gain
7 (i)	$[6t - 2 < 0 \rightarrow t < \dots]$ $0 < t < 1/3$	M1 A1	2	For solving $a(t) < 0$
(ii)	$[v = 3t^2 - 2t + c]$ $s = t^3 - t^2 + ct + d$ $[c + d = 7$ $3c + d = 11 \rightarrow c = \dots, d = \dots]$ $s = t^3 - t^2 + 2t + 5$	M1 M1 A1 M1 A1	5	For using $v(t) = \int a(t) dt$ For using $s(t) = \int v(t) dt$ For using $t=1, s=7$ and $t=3, s=29$ to form and solve simultaneous equations
(iii)	$[3t^2 - 2t + 2 = 10]$ $t = 2$	M1 DM1 A1	3	For using $v(t) = 10$ For solving 3 term quadratic $v(t) = 10$