

CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Level

MARK SCHEME for the May/June 2014 series

9709 MATHEMATICS

9709/41

Paper 4 (Mechanics 1), maximum raw mark 50

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1	DF = 28000 $[1330\ 000 = 28000V]$ $V = 47.5$	B1 M1 A1	[3]	For using $P = (DF)V$
2 (i)	$2.4 = 0.25g \cos \alpha$ $\alpha = 16.3$	B1 B1	[2]	For using $\mu = F/R$ or $\mu = \tan \alpha$
(ii)	$[\mu = 0.28 \div 0.96]$ Least possible value of μ is $7/24$ or 0.292	M1 A1	[2]	
3	$X = 5 - 7\cos 60^\circ - 3\cos 30^\circ \quad (= -1.098)$ $Y = 7\sin 60^\circ - 3\sin 30^\circ - 4 \quad (= 0.5622)$ Resultant is 1.23 N and Direction is 152.9° anticlockwise from +ve x -axis oe	M1 A1 M1 A1 M1 A1	[6]	For finding the component of the forces in the x direction For finding the component of the forces in the y direction For using $R^2 = X^2 + Y^2$ and $\tan \theta = Y/X$
4	For $s = 4.05$ Total distance = $4.05 + (3.15 + 4.05)$ $= 11.25\text{ m}$ $t_{\text{upwards}} = 0.9$ For downwards motion $(3.15 + 4.05) = \frac{1}{2}gt^2 \rightarrow t = 1.2$ Time taken is 2.1 s	M1 A1 B1 B1 B1 B1	[6]	For using $0 = u^2 - 2gs$ for the upwards motion

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(iii)	$[s_{\text{up}} = \frac{1}{2} 0.9 \times 3 \text{ and}$ $s_{\text{down}} = 0 + \frac{1}{2} g(1.6 - 0.9)^2]$ Distance upwards is 1.35 m and distance downwards is 2.45 m $h = 1.1$	M1		For using area property in graph or equivalent
		A1		
		B1	[3]	ft $s_{\text{down}} - s_{\text{up}}$
7	(i)	M1		For using $s = ut + \frac{1}{2} at^2$ to find the distance AB, or for using $v = u + at$ to find P's speed at B
	$AB = 3 \times 400 + \frac{1}{2} 0.005 \times 400^2 = 1600 \text{ m}$ (AG) or $v_B = 3 + 0.005 \times 400 = 5 \text{ ms}^{-1}$ $v_B = 3 + 0.005 \times 400 = 5 \text{ ms}^{-1}$ or $AB = 3 \times 400 + \frac{1}{2} 0.005 \times 400^2 = 1600 \text{ m}$ (AG)	A1		
		B1	[3]	
	(ii)	M1		For using $\int_0^{400} v \, dt = 1600$
	$[0.02t^2 - 0.0001t^3/3 + kt]_0^{400} = 1600$ $400k = 1600 - 0.02 \times 400^2 + 0.0001 \times 400^3 \div 3 \rightarrow$ $k = 4 - 8 + 16/3 = 4/3$	A1		
		A1		
	$[dv/dt = 0.04 - 0.0002t$ $(\text{= 0 when } t = 200)]$	M1		For differentiating and solving $dv/dt = 0$
	$v_{\text{max}} = 0.04 \times 200 - 0.0001 \times 200^2 + 4/3$	A1		ft incorrect k or incorrect value of t from $dv/dt = 0$
	Maximum speed is 5.33 ms^{-1}	A1	[6]	
	(iii)	M1		For using constant speed $5 \text{ ms}^{-1} = 1400/T$
	Time taken is 280 s	A1		
	$[1400 = 4/3 \times 280 + \frac{1}{2} 280^2 a]$	M1		For using $s = ut + \frac{1}{2} at^2$ to find a
	$a = 0.0262$	A1	[4]	

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1	(i)	$DF = 22500 \div 18$ $22500/18 - R = 600 \times 1.4$ $R = 410 \text{ N}$	B1 M1 A1 A1	4	For using Newton's second law with 3 terms
	(ii)	Rate of working is 6150 W	B1✓	1	ft on incorrect R, i.e. $R \times 15$
2	(i)	$\frac{1}{2} 0.5T^2 + 0.75T = 10$ $[T^2 + 3T - 40 = 0 = (T + 8)(T - 5)]$ $T = 5 \text{ only}$	M1 A1 M1 A1	4	For using $s = ut + \frac{1}{2} at^2$ to obtain an equation in T from $s_{AP} + s_{BP} = 10$ For solving the resulting 3 term quadratic equation either by factorising or formula and finding a value for T Reject/ignore $T = -8$
Alternative mark scheme for 2(i)					
	(i)	$x = \frac{1}{2} \frac{1}{2} T^2$ $10 - x = \frac{3}{4} T$ Eliminate T $x = \frac{1}{4} [4/3(10 - x)]^2$ $x = 6.25$ $10 - 6.25 = \frac{3}{4} T$ or $6.25 = \frac{1}{4} T^2$ $T = 5$	M1 A1 M1 A1		Set up an equation for x, the distance travelled by particle A Solve for x reject/ignore $x = 16$ Substitute for x into either of the above equations Reject/ignore $T = -5$
	(ii)	Speed is 2.5 ms^{-1}	B1✓	1	ft for speed = $0.5T$
3		$0.8T_1 + 0.96T_2 = 10$ or $T_1 \cos 36.9 + T_2 \cos 16.3 = 10$ $0.6T_1 - 0.28T_2 = 0.7g$ or $T_1 \sin 36.9 - T_2 \sin 16.3 = 0.7g$ $T_1 = 11.9$ and $T_2 = 0.5$	M1 A1 M1 A1 M1 A1	6	For resolving forces acting on P horizontally (3 terms) For resolving forces acting on P vertically (3 terms) For solving simultaneous equations and finding both T_1 and T_2

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4	(i)		M1		For differentiation to find $a(t)$ for $t \geq 8$
		$a(t) = t^{1/3} / 3$	A1		
		$[0.25 - (1/2) / 3 = 1/4 - 1/6]$	M1		Decrease = $a(8^-) - a(8^+)$
		Decrease is $1/12 \text{ ms}^{-2}$	A1	4	AG
(ii)			B1		$s_1 = \frac{1}{2} \times \frac{1}{4} \times 8^2 = 8$
		$s_2 = \int_8^{27} \frac{1}{2} t^{2/3} dt = [0.3t^{5/3}]_8^{27}$	M1		Using definite integration to find s_2
		Distance is 71.3 m	A1	3	$s_1 + s_2 = 71.3$
Alternative method for the final two marks					
		$s = \int \frac{1}{2} t^{2/3} dt = 0.3t^{5/3} + c$	M1		Using indefinite integration to find s and finding the constant of integration by using the value of s_1
		$s(8) = 8$ gives $c = -1.6$			
		$s(27) = 0.3(27)^{5/3} - 1.6 = 71.3$	A1		Finding $s(27)$
5	(i)	KE gain is $10.5v^2 \text{ J}$	B1	1	
	(ii) (a)	[PE Loss = $16(10)x - 5(10)x \sin 30$]	M1		For use of PE = mgh and Loss by system = loss by B – gain by A
		PE loss by system is $135x \text{ J}$	A1	2	
	(b)	$R = 5(10) \times (\sqrt{3} \div 2)$	B1		
		$F = 25$	B1		
		Work done is $25x \text{ J}$	B1✓	3	ft incorrect F
	(iii)	$[10.5v^2 = 135x - 25x]$	M1		For using ‘Gain in KE = Loss in PE – WD against friction’
		$21v^2 = 220x$	A1	2	AG
6	(i)	$v^2 = 2 \times g \times 7.2$ → speed at surface is 12 ms^{-1}	B1		
		$[6^2 = 12^2 + 2a \times 0.8]$	M1		For using $6^2 = v^2 + 2as$ and finding a
		Deceleration is 67.5 ms^{-2}	A1		
		$[0.2g - R = -0.2 \times 67.5]$	M1		For using Newton’s 2 nd law with three terms for P in the liquid
		$R = 15.5$	A1	5	

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(ii)	$[3.6 = \frac{1}{2} a \times 4^2]$	M1	4	For using $s = 0 + \frac{1}{2} at^2$ and finding a
	$a = 0.45 \text{ ms}^{-2}$	A1		
	$[T - R - 0.2g = 0.2 \times 0.45]$	M1		For using Newton's 2 nd law with P in the liquid
	Tension is 17.6 N (17.59 exact)	A1✓		ft incorrect R
Alternative Energy Method				
(i) (ii)		M1	5	For using PE lost = WD by R in liquid + KE gain
	$0.2g \times 8 = R(0.8) + \frac{1}{2} (0.2) 6^2$	A1		
	$R = 15.5$	A1		Finding R
	$0.2g - 15.5 = 0.2a$	M1		For using Newton's 2 nd law in the liquid
	$a = -67.5$	A1		
		M1		For using $s = (0 + v)/2 \times t$ to find v at surface of liquid
	$3.6 = v/2 \times 4 \quad v = 1.8$	A1		
	$T(3.6) = R(3.6) + 0.2g(3.6) + \frac{1}{2}(0.2)1.8^2$	M1		For using WD by T = WD by R + PE gain + KE gain
	$T = 17.6 \text{ N}$	A1	4	
7 (i) (ii)	$[T_A - 2.5 = 0.25 \times a] \quad [7.5 - T_B = 0.75 \times a]$	M1	3	For applying Newton's 2 nd law to either particle A or particle B
	$T_A = 2.5 + 0.25a$	A1		
	$T_B = 7.5 - 0.75a$	A1		
	$F = 0.4 \times 5$	B1		
	$[T_B - T_A - F = 0.5a]$	M1	For using Newton's 2 nd law for P with friction and both tensions represented (4 terms)	
	$7.5 - 0.75a - (2.5 + 0.25a) - 2 = 0.5a \rightarrow a = 2$	A1	3	AG

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	Alternative method for (ii)			
(ii)	$F = 0.4 \times 5$	B1		
	$a = 2$ used to find $T_A = 3$, $T_B = 6$ and used in $T_B - T_A - F = 0.5 \times a$	M1		Assume given value of a , find T_A and T_B and use the values in 4 term Newton's 2 nd law
	$a = 2$	A1		Justify the value $a = 2$
(iii)	$[v^2 = 2 \times 2 \times 0.36]$	M1		For using $v^2 = 2as$ with $s = 1 - \frac{1}{2}(5.28 - 4)$
	Speed is 1.2 ms^{-1}	A1	2	
(iv)	$-T_A - 2 = 0.5a$ and $T_A - 2.5 = 0.25a$	M1		For applying Newton's 2 nd law to particle P and substituting for T_A
	Deceleration is 6 ms^{-2}	A1	2	$a = -6$ or $d = 6$

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1	(i)	[N + component of X = Weight of B]	M1		For resolving forces acting on the block vertically (3 terms required)
	(ii)	Normal component is $(70 - X\cos 15^\circ)$ N $F = X\sin 15^\circ$ $[X\sin 15^\circ = 0.4(70 - X\cos 15^\circ)]$ Value of X is 43.4	A1 B1 M1 A1	[2] [3]	For using $F = \mu R$
2		DF – 600 – $1250 \times 0.02g = 1250 \times 0.5$ $v = 23000 \div (625 + 600 + 250)$ Speed of car is 15.6 ms^{-1}	M1 A1 M1 A1ft A1		For using Newton's 2 nd law For using $DF = 23000/v$ ft error in one term for DF above (1 st A mark)
Alternative Method					
		WD = $1250 \times 0.5s + 1250g \times 0.02s + 600s$ $v = 23000 \div (625 + 600 + 250)$ Speed of car is 15.6 ms^{-1}	M1 A1 M1 A1ft A1		For using WD by driving force = KE gain + PE gain + WD against resistance For using WD by driving force = $DF \times s$ and $DF = 23000/v$ ft error in one term for WD above (1 st A mark)
3		$0.8T_1 + 12T_2/13 = 2.24$ $0.6T_1 - 5T_2/13 = 1.4$ $T_1 = 2.5$ and $T_2 = 0.26$	M1 A1 M1 A1 M1 A1		For resolving forces acting on P horizontally. For resolving forces acting on P vertically. For solving for T_1 and T_2 SR for using Lami's Rule for T_1, T_2 and 2.24 N (weight missing) (max 3/6) $T_1/\sin 157.38 = 2.24/\sin 59.49$ B1 $T_2/\sin 143.13 = 2.24/\sin 59.49$ B1 $T_1 = 1(.00)$ and $T_2 = 1.56$ B1

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4 (i)	PE loss = $0.4g \times 5 \text{ J} = 20 \text{ J}$	B1		
	Initial KE _{up} = $0.4g \times 5 - 12.8 = 7.2 \text{ J}$	B1		
	[$0.4gh = 2g - 12.8$]	M1		
	Height reached is 1.8 m	A1	[4]	Uses PE gain = KE loss to form equation in h AG
(ii)	$5 = 0 + \frac{1}{2} g t_{\text{down}}^2 \quad (t_{\text{down}} = 1)$	B1		
	$0 = 6 - g t_{\text{up}} \text{ or } 1.8 = \frac{1}{2} g t_{\text{up}}^2 \quad (t_{\text{up}} = 0.6)$	B1		
	Total time is 1.6 s	B1	[3]	
First Alternative for part (i)				
	$v^2 = 2 \times 10 \times 5 \rightarrow (v = 10)$	B1		
	KE loss = $\frac{1}{2} 0.4(10^2 - v_{\text{up}}^2) = 12.8$	B1		
	[$v_{\text{up}} = 60, 0 = 6^2 - 2gh$]	M1		Uses $v^2 = u^2 - 2gs$ to form equation in h
	Height reached is 1.8 m	A1	[4]	AG
Second Alternative for part (i)				
	$0.4gh = 12.8$	M1		Uses PE gain = KE loss
	$h = 3.2 \text{ m}$	A1		
	[Height reached = $5 - 12.8/0.4g$]	M1		Uses height reached = 5 – ‘height not reached’
	Height reached is 1.8 m	A1	[4]	AG
Third Alternative for part (i)				
	$\frac{1}{2} \times 0.4v^2 = 12.8 \quad (v=8) \text{ and}$	M1		Uses KE loss = 12.8 and $v^2 = u^2 + 2gs$
	[$8^2 = 0^2 + 2gh$]			
	$h = 3.2 \text{ m}$	A1		
	[Height reached = $5 - 3.2$]	M1		Uses height reached = 5 – ‘height not reached’
	Height reached is 1.8 m	A1	[4]	AG

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5 (i)		M1		For using WD by driving force = Gain in PE + WD against resistance
	WD against resistance = $4500 \times 1200 - 16000g \times 18$	A1		
	WD against resistance = 2.52×10^6 J	A1	[3]	
Alternative Method for part (i)				
(ii)	[R + $16000g \times 18/1200 = 4500$]	M1		For resolving along the plane
	[WD=($4500 - 16000g \times 18/1200$) $\times 1200$]	M1		For using WD against resistance = Rs
	WD against resistance = 2.52×10^6 J	A1	[3]	
	KE gain = $\frac{1}{2} 16000(21^2 - 9^2)$ J	B1		
		M1		For using F = (KE gain + 2000×2400) $\div 2400$
	F = $7680000 \div 2400 = 3200$	A1	[3]	
(iii)	[P _A = ($3200 + 1280$) $\times 9$ and P _B = ($3200 - 1280$) $\times 21$] P _A = P _B = 40320 W	M1		SR (max 1/3) for using v ² =u ² +2as and Newton's 2 nd law $21^2 - 9^2 = 2a \times 2400$, a = 0.075 F – 2000 = 16000×0.075 F = 3200 B1
		A1	[2]	For using P = Fv to find P _A and P _B
6 (i)	Velocity immediately before is 1.2ms^{-1}	B1		
(ii)	Velocity immediately after is -1ms^{-1}	B1	[2]	
		M1		For using distance OW = $\int vdt$ with limits 0 to 60 (W is wall) or For using distance WA = $-\int vdt$ with limits 60 to 100
	Distance OW = $0.025 \times 60^2 - 0.0005 \times 60^3 \div 3$	A1		
	Distance WA = $-\left[(0.0125 \times 100^2 - 2.5 \times 100) - (0.0125 \times 60^2 - 2.5 \times 60)\right]$	A1		
	Distance is $54 + 20 = 74\text{m}$	A1	[4]	

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(iii)	$[dv/dt = 0.05 - 0.001t = 0 \quad \text{or}$ $0.0005t(100 - t) = 0 \rightarrow t = 0 \text{ or } 100]$ Maximum speed $(= 0.05 \times 50 - 0.0005 \times 50^2)$ is 1.25 ms^{-1} Plausible quadratic curve starting at (0,0), with max. at (50, 1.25) and terminating at (60, 1.2) Straight line segment from (60, -1) to (100, 0)	M1 A1 B1 B1	 [4]	For using v_{max} occurs when $dv/dt = 0$ or when $t =$ the midpoint of the roots of the quadratic equation $v = 0$.
7 (i)	For $T - (40 \div 160) \times 0.76g = 0.76a$ <u>or</u> $0.49g - T = 0.49a$ For $0.49g - T = 0.49a$ <u>or</u> $T - (40 \div 160) \times 0.76g = 0.76a$ <u>or</u> $0.49g - (400 \div 160) \times 0.76g =$ $(0.49 + 0.76)a$ Acceleration is 2.4 ms^{-2} and tension is 3.72 N (3.724 exact)	M1 A1 B1 A1	 [4]	For applying Newton's 2 nd law to P or to Q
(ii)	$[v^2 = 2 \times 2.4 \times 0.3]$ Speed is 1.20 ms^{-1}	M1 A1ft	 [2]	For using $v^2 = 0 + 2as$ ft a from (i) ($a \neq \pm g$)
(iii)	Distance while Q is on the ground $= (2 \times 2.4 \times 0.3) \div 2(40g \div 160)$ $(= 0.288 \text{ m})$ Distance travelled is 0.588 m	M1 A1ft A1	 [3]	For using $v^2 = u^2 + 2as$ with $v = 0$ and $a = -(40 \div 160)g$ ft a from (i) and/or $s = 30$