

MARK SCHEME for the May/June 2013 series

9709 MATHEMATICS

9709/41

Paper 4, maximum raw mark 50

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Page 2	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	41

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Page 3	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	41

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Penalties

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PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	41

1	(i)	Less than $F = 1.25W$ so $W < F$	B1		
	(ii)	$[P - 60 \times 1.25 = 6 \times 4]$ $P = 99$	B1 M1 A1	[2] [2]	For applying Newton's second law.
2		Increase in PE = $1250 \times 10 \times 600 \sin 2.5^\circ$	B1		
		Decrease in KE = $\frac{1}{2} 1250(30^2 - v_{\text{top}}^2)$	B1		
		WD against resistance = 400×600	B1		
		$[562500 - 625v_{\text{top}}^2 = 327145 + 240000 - 450000]$	M1		For using WD by DF = Increase in PE – decrease in KE + WD against resistance
		Speed is 26.7 ms^{-1}	A1	[5]	
Special Ruling for candidates who assume, without justification, that the driving force (DF) is constant (maximum mark 4).					
		[DF – Weight component – Resistance = Mass $\times$ Accel'n] $750 - 545 - 400 = 1250a$ $v^2 = 30^2 + 2 \times (-0.156) \times 600$ Speed is 26.7 ms^{-1}	M1 A1 B1ft B1	 [4]	For applying Newton's second law. ft value of a
3	(i)	$u^2 = 2 \times 10 \times 45$; speed is 30 ms^{-1}	M1 A1	 [2]	For using $0 = u^2 - 2gs$
	(ii)	$[40 = 30t - 5t^2 \rightarrow t = 2, 4]$ $[5 = \frac{1}{2} 10t^2 \rightarrow t = 1]$ Time above the ground is 2 s	M1 A1ft	 [2]	For using $s = ut - \frac{1}{2} gt^2$ with $s = 40$, $u = 30$ and $T = t_2 - t_1$ or $s = ut + \frac{1}{2} gt^2$ $s = 5$, $u = 0$ and $T = 2t$
	(ii)	$5 = \frac{1}{2} 10t^2 \rightarrow t = 1$, the length of time required is 1 s	B1	B1	
	(iii)	Max. height above top of cliff = $\frac{1}{2} g(17 \div 4)$ (= 21.25) $[0 = V^2 - 2g(40 + 21.25)]$ Speed is 35 ms^{-1}	B1 M1 A1	 [3]	For using $0 = u^2 - 2gs$

Special Ruling for candidates who assume, without justification, that the length of time required is that of the upward movement only. (maximum mark 1).

Page 5	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	41

Alternative Marking Scheme for (iii)

(iii)		M1		For using $40 = Vt - 5t^2 \rightarrow$ $t_2 - t_1 =$ $\frac{1}{2} (V/5 + \sqrt{(V^2/25 - 32)}) - \frac{1}{2} (V/5 - \sqrt{(V^2/25 - 32)})$
	$17 = V^2/25 - 32$	A1		
	Speed is 35 ms^{-1}	A1	[3]	
4	(i)	DF = $1500\,000/37.5$ (= 40 000)	B1	For using Newton's second law
		[DF – R = ma]	M1	
		DF – 30 000 = 400 000a	A1	
	(ii)	Acceleration is 0.025 ms^{-2}	A1	For using Newton's 2 nd law with a = 0
		[$1500\,000/v - 30\,000 = 0$]	M1	
		Steady speed is 50 ms^{-1}	A1	
5	(i)	R = $2.6 \times (12 \div 13)$ (= 2.4)	B1	For using $F = \mu R$ For applying Newton's 2 nd law to A or to B.
		[$F = 0.2 \times 2.4$]	M1	
		[$T - 2.6(5 \div 13) - F = 0.26a$, $5.4 - T = 0.54a$]	M1	
		For any two of $T - 1 - 0.48 = 0.26a$, $5.4 - T = 0.54a$ or $(5.4 - 1 - 0.48) = (0.54 + 0.26)a$	A1	
		Acceleration is 4.9 ms^{-2}	B1	
	(ii)	Tension is 2.75 N (2.754 exact)	A1	For using $s = \frac{1}{2} at^2$
		[$s = \frac{1}{2} 4.9 \times 0.4^2$]	M1	
		Distance is 0.392 m	A1	
6	(i)		M1	For resolving forces in the x and y directions (or for sketching a marked triangle of forces) (= 3.4) (= 1.7) For using $F^2 = (F\cos\theta)^2 + (F\sin\theta)^2$ to find F or $\tan\theta = F\sin\theta \div F\cos\theta$ to find θ
		$F\cos\theta = 2.5 \times 24 \div 25 + 2.6 \times 5 \div 13$	A1	
		$F\sin\theta = 2.6 \times 12 \div 13 - 2.5 \times 7 \div 25$	A1	
			M1	
		For $F = 3.80 \text{ N}$ or $\tan\theta = 0.5$	A1	
		For $\tan\theta = 0.5$ or $F = 3.80 \text{ N}$	B1	

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	(ii)	[3.80 = 0.5a] Acceleration is 7.60 ms^{-2} Direction is 26.6° clockwise from +ve x-axis.	M1 A1ft B1ft	[3]	For using Newton's 2 nd law with the magnitude of the resultant force equal to the value of F found. ft value of F found in (i) ft value of $\tan\theta$ found in (i)
7	(i)	$[0.0000117(1200t^2 - 12t^3) = 0]$ $1200t^2 = 12t^3 \rightarrow t = 0, 100$ Distance AB = 1170 m	M1 A1 A1	[3]	For differentiating and solving $ds/dt = 0$ Accept just $t = 100$, if it is used to find distance AB.
	(ii)	$2400t - 36t^2 = 0 \rightarrow t = 0, 200/3$ $[v_{\max} = 0.0000117\{1200(200/3)^2 - 12(200/3)^3\}]$ Maximum speed is 20.8 ms^{-1}	M1 A1 M1 A1		For differentiating again and solving $d^2s/dt^2 = 0$ Accept just $t = 200/3$, if it is used to find $v_{\max}$.
	(iii)	At A $a(t) = 0$ At B $a(t) = 0.0000117(2400 \times 100 - 36 \times 100^2) = -1.40 \text{ ms}^{-2}$ (–1.404 exact)	B1 B1	[4]	For substituting into $v(t)$
	(iv)	Sketch has v increasing from 0 to maximum and decreasing to 0, with maximum closer to $t = 100$ than $t = 0$. Sketch has zero gradient at $t = 0$ and inflexion closer to $t = 0$ than $t = 100$.	B1 B1		
				[2]	
				[2]	
				[2]	

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1	(i)	[24 = μ 30]	M1		For using $R = W$, $F = T$ and $F = \mu R$
		Coefficient is 0.8	A1	[2]	
	(ii)		M1		For resolving forces vertically and using $F = \mu R$
		$F = 0.8(30 - 25\sin 30^\circ)$ (=14)	A1		
		[25 cos 30° – F = (30 ÷ g)a]	M1		For using of Newton's 2nd law
		Acceleration is 2.55 ms ⁻²	A1	[4]	
2	(i)		M1		For using work done by pulling force = increase in KE – decrease in PE + WD by resistance
		$1150 = \frac{1}{2} 16 \times 10^2 - 16g(50 \times 0.05)$ + WD by resistance	A1		
		WD by resistance = 750 J	A1	[3]	
	(ii)	$1150 = \text{increase in KE} + 16g(50 \times 0.05) + 750$	M1		For WD by pulling force = KE gain + PE gain + WD by resistance
		KE gain = 0 → speed at top = speed at bottom	A1	[2]	AG
3			M1		For resolving forces acting on P horizontally or vertically
		$T_A \times (40/50) + T_B \times (40/104) = 21$ or $T_A \times (30/50) = T_B \times (96/104)$	A1		
		$T_A \times (30/50) = T_B \times (96/104)$ or $T_A \times (40/50) + T_B \times (40/104) = 21$	B1		
		Solve for T_A and T_B	M1		Solving for both
		Tension in AP is 20 N and tension in BP is 13 N	A1	[5]	Both $T_A = 20$ and $T_B = 13$
First Alternative Marking Scheme					
3			M1		For using the sine rule in the triangle of forces
		$21/\sin 75.75$ (or 75.7 or 75.8) = $T_A/\sin 67.4$ (or $T_B/\sin 36.9$)	A1		
		$21/\sin 75.75$ (or 75.7 or 75.8) = $T_B/\sin 36.9$ (or $T_A/\sin 67.4$) or $T_B/\sin 36.9 = 20/\sin 67.4$	B1		
		Solve for T_A and T_B	M1		Solving for both

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	Tension in AP is 20N and tension in BP is 13N	A1	[5]	Both $T_A = 20$ and $T_B = 13$
Second Alternative Marking Scheme				
3	$21/\sin 104.3 = T_A/\sin 112.6$ (or $T_B/\sin 143.1$) $21/\sin 104.3 = T_B/\sin 143.1$ (or $T_A/\sin 112.6$) or $T_B/\sin 143.1 = 20/\sin 112.6$ or $T_A/\sin 112.6 = 13/\sin 143.1$ Solve for T_A and T_B Tension in AP is 20 N and tension in BP is 13 N	M1 A1 B1 M1 A1	 [5]	For using Lami's Rule For using the equations to find T_A and T_B Both $T_A = 20$ and $T_B = 13$
4 (i)	$a = (16 \div 65)g$ $[8^2 = 2(16 \div 65)gS]$ $S = 13$ $[v^2 = 2(16 \div 65)g \times 6.5]$ or $v^2 \div 8^2 = \frac{1}{2}$ Speed is 5.66 ms^{-1}	B1 M1 A1 M1 A1	 [5]	For using $v^2 = 2as$ to find S For using $v^2 = 2a(\frac{1}{2}S)$ or $v^2 \propto s$
(ii)	$[s = \frac{1}{2} a \times (64 \div 4a^2)]$ or $s \div 13 = (\frac{1}{2})^2$ Distance is 3.25 m	M1 A1	 [2]	For using $8 = 0 + aT$ and $s = \frac{1}{2}a(T/2)^2$ or $s \propto t^2$
Alternative Marking Scheme				
4 (i)	$[\frac{1}{2} m v^2 = mgh]$ and $S = h \div \sin \alpha$ $S = (8^2 \div 20) \div (16 \div 65)$ $S = 13$ $\frac{1}{2} m v^2 = mg(\frac{1}{2} 13 \times (16/65))$ Speed is 5.66 ms^{-1}	M1 A1 A1 M1 A1	 [5]	For using KE gain = PE loss Or AEF Or AEF
(ii)	Distance is 3.25 m	A1	[2]	For eliminating at^2 from $s = \frac{1}{2}at^2$ and $13 = \frac{1}{2}a(2t)^2$
5 (i)	Driving force = 1000P/25	B1		

Page 6	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	42

	(ii)	$1000P/25 - 600 = 1000 \times 0.2$ $P = 20$ $20000/v_{\max} - 600 = 0$ Steady speed is 33.3 ms^{-1}	M1 A1 A1 M1 A1ft A1	[4] [3]	For using Newton's 2 nd law For using Newton's 2 nd law with $a = 0$ ft for their P in (i)
6	(i)	For sketch of single valued, continuous graph consisting of 3 straight line segments with + ^{ve} , then - ^{ve} , then + ^{ve} slope Sketch appears to show $v(0) = 0$ and $v(8) > v(26) > v(20)$	B1 B1	[2]	
	(ii)	For shading the triangle from $t = 0$ to $t = 8$, the trapezium from $t = 8$ to $t = 20$ and the trapezium from $t = 20$ to a value of t seen to be between 20 and 26	B1	[1]	
	(iii)	$s(20) = \frac{1}{2}(8 \times 8) + \frac{1}{2}(8 + 2) \times 12 \quad (= 92)$ $a = (6.5 - 2)/6 \quad (= 0.75)$ $[s(t) = 92 + 2(t - 20) + 0.375(t - 20)^2]$ Displacement is $0.375t^2 - 13t + 202 \text{ metres}$	M1 A1 M1 A1 M1 A1	 [6]	For using area property to find $s(20)$ For using the gradient property to find acceleration in 3 rd phase
Alternative Marking Scheme for final 2 marks of Q6					
		$[v(t) = 2 + 0.75(t - 20)]$ $s(t) = 0.375t^2 - 13t + A$ where $92 = 0.375 \times 400 - 13 \times 20 + A]$ Displacement is $0.375t^2 - 13t + 202 \text{ metres}$	M1 A1		For finding $v(t)$, integrating and using $s(20) = 92$
6	(iii)	First Alternative Marking Scheme for part (iii) of Q6			
		$a = (6.5 - 2) / (26 - 20) = 0.75$ $v = 0.75t (+ C1)$ $v = 0.75t - 13$	B1 M1 A1		Integrating Using $v(20) = 2$ or $v(26) = 6.5$

Page 7	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	42

	$s(20) = 92$ or $s(26) = 117.5$ $s = 0.375t^2 - 13t (+ C_2)$ $s = 0.375t^2 - 13t + 202$	B1 M1 A1	[6]	Using area in diagram Integrating Using $s(20)$ or $s(26)$ to find $C_2 = 202$
6 (iii)	Second Alternative Marking Scheme for part (iii) of Q6			
	$s = 0.375t^2 - 13t + 202$ $v = 0.75t - 13$ $a = 0.75$ $a = (6.5 - 2)/(26 - 20) = 0.75$ $v(20) = 0.75(20) - 13 = 2$ or $v(26) = 0.75(26) - 13 = 6.5$ Show $s(20) = 92$ or $s(26) = 117.5$ $s(20) = 0.375(20)^2 - 13(20) + 202 = 92$ or $s(26) = 0.375(26)^2 - 13(26) + 202 = 117.5$	M1 M1 B1 B1 B1 B1		Given Differentiating Differentiating Check agreement from graph Check v agrees at a point between $t = 20$ and $t = 26$ Using area under graph Check s agrees at a point between $t = 20$ and $t = 26$
7 (i)	$T - 0.26g(16 \div 65) = 0.26a$ or $0.52g - T = 0.52a$ For $\{0.52g - T = 0.52a$ or $T - 0.26g(16 \div 65) = 0.26a\}$ or $0.52g - 0.26g(16 \div 65) = (0.52 + 0.26)a$ Acceleration is 5.85 ms^{-2} Tension is 2.16 N	M1 A1 B1 B1 A1		For applying Newton's 2 nd law to A or B
(ii)	$[v^2 = 2 \times (76/13) \times 0.6]$ Speed is 2.65 ms^{-1} $0 = 91.2/13 - 2(160/65)s$ $S = 57/40 (= 1.425)$ $[AP = 2.5 - 0.6 - 1.425]$ Distance AP is 0.475 m	M1 A1 M1 A1 M1 A1 M1 A1	[5] [6]	For using $v^2 = 2as$ For using $0 = v_B^2 - 2(g \sin \alpha)s$ For using $AP = 2.5 - 0.6 - s$

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BOD	Benefit of Doubt (allowed when the validity of a solution may not be absolutely clear)
CAO	Correct Answer Only (emphasising that no “follow through” from a previous error is allowed)
CWO	Correct Working Only – often written by a ‘fortuitous’ answer
ISW	Ignore Subsequent Working
MR	Misread
PA	Premature Approximation (resulting in basically correct work that is insufficiently accurate)
SOS	See Other Solution (the candidate makes a better attempt at the same question)
SR	Special Ruling (detailing the mark to be given for a specific wrong solution, or a case where some standard marking practice is to be varied in the light of a particular circumstance)

Penalties

MR –1	A penalty of MR –1 is deducted from A or B marks when the data of a question or part question are genuinely misread and the object and difficulty of the question remain unaltered. In this case all A and B marks then become “follow through $\sqrt{}$ ” marks. MR is not applied when the candidate misreads his own figures – this is regarded as an error in accuracy. An MR –2 penalty may be applied in particular cases if agreed at the coordination meeting.
PA –1	This is deducted from A or B marks in the case of premature approximation. The PA –1 penalty is usually discussed at the meeting.

Page 4	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	43

1	$[(W / g) a = W \sin \alpha - 0.02 W \cos \alpha]$ $a = (\sin 14^\circ - 0.02 \cos 14^\circ) g$ $(= 2.225 \dots)$ $[v^2 = 8^2 + 2 \times 2.225 \dots \times 50]$ Speed is 16.9 m s^{-1}	M1 A1 M1 A1	 [4]	For using Newton's second law For using $v^2 = u^2 + 2 a s$
Alternative Scheme				
1	WD against friction = $0.02 W \cos \alpha \times 50$ PE loss = $W \times 50 \sin \alpha$ Speed is 16.9 m s^{-1}	B1 B1 M1 A1	 [4]	For using Gain in KE = Loss in PE – WD against friction
2 (i)	Loss of PE = $2g \times 3.24$ $- 1.6 g (3.24 \times 0.8)$ Loss is 23.328 J.	M1 A1 A1	 [3]	PE loss = B's loss – A's gain AG
(ii)	$\frac{1}{2} (1.6 + 2) v^2 = 23.328$ Speed is 3.6 m s^{-1}	B1 B1	 [2]	 SR (max 1/2) for using Newton's second law and $v^2 = u^2 + 2 a s$ $2 g - T = 2 a$ and $T - 1.6g \times 0.8 = 1.6a$ $a = 2$ $v^2 = 2 \times 2 \times 3.24 \quad v = 3.6 \text{ B1}$
3	 $1000 P / 14 - R = 800 \times 1.4$ and $1000 P / 25 - R = 800 \times 0.33$ $P = 27.2$ $R = 825$	M1 M1 A1 M1 A1 B1	 [6]	For using $DF = P / v$ For using Newton's 2 nd law for both speeds / accelerations For solving for P Accept 825.5

Page 5	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	43

4	(i)	$V(t) = 1.5t + 0.006t^2$ $[0.006t^2 + 1.5t - 90 = 0 \rightarrow t^2 + 250t - 15000 = 0] \rightarrow (t - 50)(t + 300) = 0]$ Leaves the ground when $t = 50$	M1 A1 DM1 A1	[4]	For integrating $a(t)$ to obtain $v(t)$ Constant of integration zero or absent For using $v(t) = 90$ and solving for t (dependent on integration)
	(ii)	$s = 0.75t^2 + 0.002t^3$ Distance is 2125 m	M1 A1ft A1ft		For integrating $v(t)$ and using limits 0 to candidate's answer for part (i) ft if there is a non-zero constant of integration C in part (i) $s = 0.75t^2 + 0.002t^3 + C$ Accept 2120 or 2130 ft t from part (i) in $0.75t^2 + 0.002t^3$
5	(i)	$[T = 2 \times 1.7 - 2 \times 0.7]$ [for P $17t - 5t^2 = 0$ and for Q $7t - 5t^2 = 0]$ $T = 2$	M1 A1	[2]	$T = 2 \times \text{time to max. height for P} - 2 \times \text{time to max. height for Q}$ or For using $T = \text{time for P to return to ground} - \text{time for Q to return to ground}$
	(ii)	$17(t + 2) - 5(t + 2)^2 - (7t - 5t^2) = 5$ or $17t - 5t^2 - 7(t - 2) + 5(t - 2)^2 = 5$	M1		SR (max 1/2) for candidates who find difference in time to maximum height $T = 1.7 - 0.7 = 1$ B1
		$t = 0.9$ or $t = 2.9$	A1	ft	ft T from part (i)
			A1 M1		For using $v = u - 10t$ for P and Q

Page 6	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	43

	$v_P = 17 - 10(0.9 + 2),$ $v_Q = 7 - 10 \times 0.9 \rightarrow$ Magnitudes are 12 m s^{-1} & 2 m s^{-1} The direction for both is vertically downwards	A1 A1	ft [6]	ft using t_P and $t_P - T$ or using t_Q and $t_Q + T$
6 (i)	$100 \cos 30^\circ + 120 \cos 60^\circ - F \cos \alpha = 136$ ($F \cos \alpha = 10.6025 \dots$) or $100 \sin 30^\circ - 120 \sin 60^\circ + F \sin \alpha = 0$ ($F \sin \alpha = 53.9230 \dots$) $100 \sin 30^\circ - 120 \sin 60^\circ + F \sin \alpha = 0$ ($F \sin \alpha = 53.9230 \dots$) or $100 \cos 30^\circ + 120 \cos 60^\circ - F \cos \alpha = 136$ ($F \cos \alpha = 10.6025 \dots$) $F = 55.0$ or $\alpha = 78.9$ $\alpha = 78.9$ or $F = 55.0$	M1 A1 B1 M1 A1 B1	 [6]	For resolving the applied forces on the box in the x -direction or the y -direction. for using $F^2 = (F \cos \alpha)^2 + (F \sin \alpha)^2$ or $\tan \alpha = F \sin \alpha \div F \cos \alpha$
(ii)	Magnitude is 136 N $R = 40 \text{ g}$ Coefficient is 0.34	B1 B1 B1 B1	 [3]	

Page 7	Mark Scheme	Syllabus	Paper
	GCE AS/A LEVEL – May/June 2013	9709	43

7	(i)		M1		For applying Newton's 2 nd law to A or to B
		$T - (2/7) 1.26 g = 1.26 a$ or $0.9 g - T = 0.9 a$	A1		
		$0.9g - T = 0.9 a$ or $T - (2/7) 1.26 g = 1.26 a$ or $0.9 g - (2/7) 1.26 g = (0.9 + 1.26) a$	B1		
		Acceleration is 2.5 m s^{-2}	B1		AG
		Tension is 6.75 N	A1	[5]	
	(ii)	$[v^2 = 2 \times (2.5) \times 0.45]$	M1		For using $v^2 = 2 a h$
		Speed is 1.5 m s^{-1}	A1	[2]	
	(iii)	$[-(2/7) 1.26 g = 1.26 a]$	M1		For applying Newton's 2 nd law to A
		$a = -20/7$	A1		
		$[v^2 = 2.25 + 2(-20/7)(0.03)]$	M1		For using $v^2 = v_B^2 + 2 a s$
		Speed is 1.44 m s^{-1}	A1	[4]	