

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/41

Paper 4, maximum raw mark 50

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	GCE AS/A LEVEL – October/November 2013	9709	41

Mark Scheme Notes

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B Mark for a correct result or statement independent of method marks.

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1	$[T\cos\alpha = mg]$ Tension is 3.4 N $[F = T\sin\alpha]$ $F = 1.6$	M1 A1 M1 A1	4	For resolving forces vertically For resolving forces horizontally
2	(i) $[WD = 30 \times 20 \times 0.6 + 40 \times 20 \times 0.8]$ Work done is 1000 J	M1 A1	2	For using $WD = Fd\cos\theta$
	(ii) $30 \times 0.6 + 40 \times 0.8 - 0.625W = 0$ Weight is 80 N	M1 A1 A1	3	For applying $F = \mu W$ and Newton's 2 nd law with $a = 0$
3	(i) $F - 780 \times (36 \div 325) - 32 = 78 \times (-0.2)$ $F = 103$ (102.8 exact)	M1 A2 A1	4	For applying Newton's 2nd law to the bicycle/cyclist (A2 for all correct, A1 for one error, A0 for more than one error)
	(ii) $[0 = 7^2 + 2(-0.2)s]$ Distance is 122.5 m (accept 122 or 123)	M1 A1	2	For using $0 = u^2 + 2as$
4	(i) $[-\mu mg = ma]$ Decelerations of P and Q are 2 ms^{-2} and 2.5 ms^{-2}.	M1 A1	2	For using Newton's 2 nd law, $F = \mu R$ and $R = mg$
	(ii) $8t - t^2 = 3t - 1.25t^2 + 5$ $t = \sqrt{120} - 10$ (=0.95445...) Speed of P = 6.09 ms^{-1}, speed of Q = 0.614 ms^{-1}	M1 A1 A1 M1 A1	5	For using $s = ut + \frac{1}{2}at^2$ and $s_P = s_Q + 5$ For using $v = u + at$ for both P and Q

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5	(i) Gain in PE = $15000g \times 16$ WD against resistance = 1800×1440 Work done is 4.99×10^6 J	B1 B1 M1 A1	4	For using:– WD by driving force = Gain in PE + WD against resistance
	(ii) $5030\,000 = \frac{1}{2} 15\,000(24^2 - 15^2) + 1600d$ Distance is 1500 m	M1 A1 A1	3	For using :– WD by engine = Increase in KE + WD against resistance
6	(i) $T - 0.3g = 0.3a$ or $0.7g - T = 0.7a$ $0.7g - T = 0.7a$ or $T - 0.3g = 0.3a$ or $0.7g - 0.3g = (0.7 + 0.3)a$ Tension is 4.2 N	M1 A1 B1 A1	4	For applying Newton's 2 nd law to A or to B
	(ii) $a = 4$ $s_{\text{taut}} = 1.6^2 / (2 \times 4) \quad (= 0.32)$ $[(0.52 + 0.32) = -1.6t + 5t^2]$ $[(t - 0.6)(5t + 1.4) = 0]$ Time taken is 0.6 s	B1 B1 M1 M1 A1	5	May be scored in (i) For using $s = ut + \frac{1}{2}gt^2$ For solving the resultant quadratic equation.
Alternative Marking Scheme for the last three marks				
	$0^2 = 1.6^2 - 2gs_{\text{up}},$ $t_{\text{up}} = 2s_{\text{up}} / (1.6 + 0) \quad (= 0.16)$ $0.52 + s_{\text{taut}} + s_{\text{up}} = 0 + \frac{1}{2}gt_{\text{down}}^2$ $(t_{\text{down}} = 0.44)$ Time taken = $t_{\text{up}} + t_{\text{down}} = 0.6$ s	M1 M1 B1		For using kinematic formulae to find t_{up} For using kinematic formulae to find t_{down}

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7	(i) $v(t) = 0.3t^2$ $s(t) = 0.1t^3$ Velocity is 30 ms^{-1} and displacement is 100 m	M1 A1 M1 A1 A1	5	For integrating $0.6t$ and using $v(0) = 0$ (may be implied by absence of constant of integration) For integrating $v(t)$ and using $s(0) = 0$ (may be implied by absence of constant of integration)
	(ii) $v(t) = -0.2t^2 + 50$ At A, $-0.2t^2 + 50 = 0 \rightarrow t = \sqrt{250}$ $s(t) = -t^3/15 + 50t - 1000/3$ Distance OA is 194 m	M1 A1 B1 M1 A1 M1 A1	7	For integrating $-0.4t$ and using $v(10) = 30$ For integrating $v(t)$ and using $s(10) = 100$ For finding $s(\sqrt{250})$

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1	Applying $T \cos \beta = W \sin \alpha$ Tension is 2.5 N	M1 A1 A1	3	For resolving forces parallel to the line of greatest slope $T (24/25) = 5.1 (8/17)$ or $T \cos 16.26 = 5.1 \sin 28.07$
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First Alternative Marking Scheme

	Applying $R \cos \alpha + T \sin (\alpha + \beta) = W$ and $R \sin \alpha = T \cos (\alpha + \beta)$ Tension is 2.5 N	M1 A1 A1	3	For resolving forces vertically or horizontally $R \cos 28.07 + T \sin 44.33 = 5.1$ and $R \sin 28.07 = T \cos 44.33$
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Second Alternative Marking Scheme

	Applying $T / \sin \alpha = 5.1 / \sin (90 + \beta)$ Tension is 2.5 N	M1 A1 A1	3	Using Triangle of forces $T / \sin 28.07 = 5.1 / \sin 106.26$
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2	Gain in KE = $\frac{1}{2} 25 \times 3^2$ or WD by pulling force = $220 \times 15 \cos \alpha$ WD by pulling force = $220 \times 15 \cos \alpha$ or Gain in KE = $\frac{1}{2} 25 \times 3^2$ [$3300 \cos \alpha = 112.5 + 3000$] $\alpha = 19.4$	M1 A1 B1 M1 A1	5	For using KE = $\frac{1}{2} m v^2$ or WD = $F d \cos \alpha$ For using WD by pulling force = KE gain + WD against resistance
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3	(i)	$100/4 - 4k = 0 \rightarrow k = 6.25$	M1 A1	2	For using $F = P/v$ and Newton's 2 nd law with $a = 0$ AG
	(ii)	$100/v - 70g \times 0.05 - 6.25v = 0$ $[6.25v^2 + 35v - 100 = 0]$ or $[v^2 + 5.6v - 16 = 0]$ Maximum speed is 2.08 ms^{-1}	M1 A1 M1 A1	4	For using Newton's 2 nd law with $a = 0$ uphill $\rightarrow$ 3 term equation For solving a 3-term quadratic for v

4			M1		For resolving three forces parallel to the plane
		$0.6g \sin \alpha = F + P \cos \alpha$	A1		Value of α used or values of $\sin \alpha$ and $\cos \alpha$ used
			M1		For resolving three forces perpendicular to the plane
		$R = 0.6g \cos \alpha + P \sin \alpha$	A1		Value of α used or values of $\sin \alpha$ and $\cos \alpha$ used
			M1		For using $F = \mu R$
		$0.6g \sin \alpha - P \cos \alpha =$ $0.4 (0.6g \cos \alpha + P \sin \alpha)$ $6(12/13) - P(5/13) =$ $2.4(5/13) + 0.4P(12/13)$ $P = 6.12$	A1 M1 A1	8	Value of α used or values of $\sin \alpha$ and $\cos \alpha$ used For solving the resultant equation for P

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Alternative Marking Scheme

	$W = R \cos \alpha + F \sin \alpha$ $P = R \sin \alpha - F \cos \alpha$ $0.6g = R(5/13) + 0.4R(12/13)$ and $P = R(12/13) - 0.4R(5/13)$ $78 = R(5 + 4.8)$ and $13P = R(12 - 2)$ $\rightarrow 13P = (78 \div 9.8) \times 10$ $P = 6.12$	M1 A1 M1 A1 M1 A1 M1 A1	8	For resolving three forces vertically Value of α used or values of $\sin \alpha$ and $\cos \alpha$ used For resolving three forces horizontally Value of α used or values of $\sin \alpha$ and $\cos \alpha$ used For using $F = \mu R$ in both equations Value of α used or values of $\sin \alpha$ and $\cos \alpha$ used For finding R and substituting into an expression for P
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5	(i)	$[s = t^2/2 - 0.1t^3/3]$ $[s_1 = 25/2 - 0.1 \times 125/3]$ $s_1 = 8.33$	M1* DM1* A1	3	For integrating to find s for $0 \leq t \leq 5$ For obtaining s_1 by using limits 0 to 5 or having zero for constant of integration (can be implied) and substituting $t = 5$
	(ii)	$s_2 = 2.5 \times 40$ $[s = 9t^2/2 - 0.1t^3/3 - 200t$ for $45 \leq t \leq 50]$ $s_3 = [9(50)^2/2 - 0.1(50)^3/3 - 200(50)]$ $- [9(45)^2/2 - 0.1(45)^3/3 - 200(45)]$ $[= 8.33]$	A1 M1 A1	M1	For using $s = v(5) \times (45 - 5)$ for $5 \leq t \leq 45$ For integrating to find s for $45 \leq t \leq 50$ and implying the use of limits 45 and 50 or equivalent via constant of integration For applying the limits at 45 and 50 correctly or equivalent via constant of integration

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Alternative mark scheme for previous 2 marks

	Recognising the symmetry of the velocity distribution due to the correspondence of the points $(0,0) \rightarrow (50,0)$ and $(5,2.5) \rightarrow (45,2.5)$ Complete the idea of symmetry with one further property and hence State $s_3 = s_1 = 8.33$ Distance from O to A is 117m Average speed is 2.33 ms^{-1}	(M1) (A1) A1 B1ft	6	Property is any one of $a(0) = -a(50)$ $a(5) = a(45)$ $v(2.5) = v(47.5)$ oe ft answer for total distance
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6	(i)	$T - 0.4g = 0.4a$ or $1.6g - T = 1.6a$ $1.6g - T = 1.6a$ or $T - 0.4g = 0.4a$ or $1.6g - 0.4g = (1.6 + 0.4)a$ $T = 6.4$ Work done by tension is 7.68 J	M1 A1 B1 A1 B1ft	5	For applying Newton's 2nd law to A or B
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Alternative mark scheme for 6 (i)

	$T - 0.4g = 0.4a$ or $1.6g - T = 1.6a$ $1.6g - T = 1.6a$ or $T - 0.4g = 0.4a$ or $1.6g - 0.4g = (1.6 + 0.4)a$ WD by T = initial PE – final KE $= 1.6 \times g \times 1.2 - \frac{1}{2} \times 1.6 \times 14.4$ WD by T = $19.2 - 11.52 = 7.68$	M1 A1 B1 M1 A1	5	For applying Newton's 2nd law to A or B For finding v^2 and applying Work/Energy equation to B
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6	(ii)	$[1.6 \times 10 \times 1.2 = \frac{1}{2} 1.6 v^2 + 7.68]$	M1		For using PE loss = KE gain + WD by T to find v^2
		$v^2 = 14.4$	A1		
		$14.4 = 2 \times 10 \times h$ $h = 0.72$ $H = 2 \times 1.2 + h$	M1		For using PCE for A's motion after B reaches the ground or $0 = u^2 - 2gh$ and $H = 2 \times 1.2 + h$
		Greatest height is 3.12 m	A1	4	

First Alternative Marking Scheme for 6 (ii)

		$[v^2 = 2 \times 6 \times 1.2]$	M1		For using $v^2 = 2as$ to find v^2
		$v^2 = 14.4$	A1		
		$14.4 = 2 \times 10 \times h$ $h = 0.72$ $H = 2 \times 1.2 + h$	M1		For using PCE for A's motion after B reaches the ground or $0 = u^2 - 2gh$ and $H = 2 \times 1.2 + h$
		Greatest height is 3.12 m	A1	4	

Second Alternative Marking Scheme for 6 (ii)

		WD by T = Increase in PE $7.68 = 0.4 \times g \times s$	M1		For applying WD by T to particle A's complete motion
		$s = 1.92$	A1		
		$H = 1.2 + s$	M1		For adding 1.2 to s
		$H = 1.2 + 1.92 = 3.12$ Height = 3.12 m	A1	4	

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7	(i)	$[s = \frac{1}{2} 5 \times 0.4 + 19 \times 0.4 + \frac{1}{2} 4 \times 0.4]$ Distance = 9.4	M1 A1	2	For using the area property for distance
	(ii)	Acceleration is 0.08 ms^{-2} Deceleration is 0.1 ms^{-2}	B1 B1	2	
	(iii)	$[T - (800 + 100)g = (800 + 100)a]$ $T - 900g = 900a$ $T = 9072 \text{ N}$ in 1 st stage $T = 9000 \text{ N}$ in 2 nd stage $T = 8910 \text{ N}$ in 3 rd stage	M1 A1 A1	3	For applying Newton's 2 nd law to the <u>elevator and box</u>
	(iv)	$[R - 100g = 100a]$ $R = 1008 \text{ N}$ $R = 990 \text{ N}$	M1 A1 A1	3	For applying Newton's 2 nd law to the <u>box</u> For obtaining the greatest value of the force on the box For obtaining the least value of the force on the box

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1	(i)	$[-(1 \div 3)(W \cos \alpha) - W \sin \alpha = (W/g)a]$ $(-0.32 - 0.28)g = a$ $a = -6.$	M1 A1 A1	3	For using Newton's 2 nd law and $F = \mu R$ AG
	(ii)	$[0 = 5.4^2 + 2(-6)s]$ or $[mgs(0.28) = \frac{1}{2} m(5.4)^2 - mgs(0.96)/3]$ Distance is 2.43 m	M1 A1	2	For using $0 = u^2 + 2as$ or for using PE gain = KE loss – WD against friction
2		$a = 5$ When B reaches the floor $v^2 = 2 \times 5 \times 1.6$; speed is 4ms^{-1} $0 = 16 - 20s$ (s = 0.8) $h + 1.6 + 0.8 = 3 \rightarrow h = 0.6$	M1 A1 B1ft M1 A1ft B1	6	For using $a = (M - m)g/(M + m)$ or for applying Newton's 2 nd law to A and to B and solving for a. ft a $a \neq g$ $v = \sqrt{3.2a}$ For using $0 = u^2 - 2gs$ or for using PE gain = KE loss ft speed
3		$T_A(1/2.6) + T_B(1/1.25) = 10.5$ $T_A(2.4/2.6) = T_B(0.75/1.25)$ Tension in AP is 6.5 N and tension in BP is 10 N.	M1 A1 M1 A1 M1 A1	6	For resolving forces on P vertically For resolving forces on P horizontally For solving for T_A and T_B

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First Alternative				
	75.7(5)° opposite to 10.5 N 36.8(7)° opposite to T_A 67.3(8)° opposite to T_B $T_A \div \sin 36.8(7) = 10.5 \div \sin 75.7(5)$ and $T_B \div \sin 67.3(8) = 10.5 \div \sin 75.7(5)$ Tension in AP is 6.5 N and tension in BP is 10 N.	M1 A1 M1 A1 M1 A1	6	For finding two angles in the triangle of forces For using the sine rule to find equations for T_A and T_B For solving for T_A and T_B
Second Alternative				
	104.2(5)° opposite to 10.5 N 143.1(3)° opposite to T_A 112.6(2)° opposite to T_B $T_A \div \sin 143.1(3) = 10.5 \div \sin 104.2(5)$ & $T_B \div \sin 112.6(2) = 10.5 \div \sin 104.2(5)$ Tension in AP is 6.5 N and tension in BP is 10 N.	M1 A1 M1 A1 M1 A1	6	For finding angles at P in the space diagram. For using Lami's rule to find equations for T_A and T_B For solving for T_A and T_B
4 (i)	[$W \sin \alpha + F = 40$] $F = 40 - 300 \times 0.1 \quad (= 10)$ $R = 300 \sqrt{1 - 0.1^2} \quad (= 298.496..)$ Coefficient is 0.0335	M1 A1 B1 M1 A1	5	For resolving forces parallel to the plane For using $\mu = F/R$

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	(ii)	[The component of weight (30 N) is greater than the frictional force (10 N)]	M1		For comparing the weight component parallel to the plane and the frictional force or for using Newton's Second Law and finding the acceleration
		Box does not remain in equilibrium	A1	2	
5	(i)		B1		The sketch requires three straight line segments with +ve, zero and –ve slopes in order, which together with a segment of the t axis form a trapezium.
		$T_1 = V \div 0.3$, $T_3 = V$	M1 A1	3	For using $v = at$ for T_1 or $u = -at$ for T_3
	(ii)	$[S = \frac{1}{2} T_1 V + T_2 V + \frac{1}{2} T_3 V]$	M1		For using the area property for the distance travelled
		$S = 552V - V \{0.5(T_1 + T_3)\}$ $= 552V - 13V^2/6$	M1		For substituting for T_1 , T_2 and T_3 in terms of V
		$13V^2 - 3312V + 72000 = 0$	A1		
		$V = 24$	B1 B1	5	AG
6	(i)	$[144000/v - 4800 = 12500a]$	M1		For using $DF = P/v$ and Newton's 2 nd law at A or at B
		Acceleration at A is 0.336 ms^{-2}	A1		
		The speed at B 24 ms^{-1}	A1	3	AG
	(ii)	WD by DF = 5800×500 &			
		WD against res'ce = 4800×500	B1		
		Loss in KE = $\frac{1}{2}12500(24^2 - 16^2)$	B1		
		$5800 \times 500 = 12500gh - \frac{1}{2}12500(24^2 - 16^2) + 4800 \times 500$	M1		For using WD by DF = PE gain – KE loss + WD against res'ce
		Height of C is 20 m	A1	5	

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	(ii) Alternative			
	$[16^2 = 24^2 + 2 \times 500a]$ $a = -0.32 \text{ ms}^{-2}$ $5800 - 4800 - 12500g \times (h \div 500)$ $= 12500(-0.32)$ Height of C is 20 m	M1 A1 M1 A1 A1	5	For using $v^2 = u^2 + 2as$ For using Newton's second law
7 (i)	$[s = k_1 t^2/2 - 0.005t^3/3 + (C)]$ $[k_1(60^2/2) - 0.005(60^3/3) = 540]$ $k_1 = 0.5$ $0.5 \times 60 - 0.005 \times 60^2 = k_2 \div \sqrt{60}$ $k_2 = 12\sqrt{60}$	M1 DM1 A1 M1 A1	5	For using $s = \int v dt$ For using limits 0 and 60 and equating to 540 For using $v_1(60) = v_2(60)$ AG
(ii)	$[s = 540 + 12\sqrt{60}(2\sqrt{t} - 2\sqrt{60}) =]$ $24\sqrt{(60t)} - 900$	M1 A1	2	For using $s = 540 + 12\sqrt{60} \int_{60}^t (t^{-1/2}) dt$ Accept any other correct form for s if it is used in (iii)
(iii)	$[24\sqrt{(60t)} - 900 = 1260]$ $t = 135$ $v = 12\sqrt{60} \div \sqrt{135} \rightarrow \text{speed is } 8 \text{ ms}^{-1}$	M1 A1 B1	3	For solving $s(t) = 1260$ for t