CAMBRIDGE INTERNATIONAL EXAMINATIONS

GCE Advanced Subsidiary Level and GCE Advanced Level

MARK SCHEME for the October/November 2013 series

9709 MATHEMATICS

9709/41 Paper 4, maximum raw mark 50

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

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

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

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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 $T \cos 16.26 = 5.1 \sin 28.07$
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 $R \sin 28.07 = T \cos 44.33$
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 $T / \sin 28.07 = 5.1 / \sin 106.26$

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

3 (i)		M1		For using F = P/v and Newton's 2nd law with a = 0
	$100/4 - 4k = 0 \rightarrow k = 6.25$	A1	2	AG
(ii)		M1		For using Newton's 2nd law with a = 0 uphill → 3 term equation
	$100/v - 70g \times 0.05 - 6.25v = 0$	A1		
	$[6.25v^2 + 35v - 100 = 0]$ or $[v^2 + 5.6v - 16 = 0]$	M1		For solving a 3-term quadratic for v
	Maximum speed is 2.08 ms^{-1}	A1	4	

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 α and cos α 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 α and cos α used
		M1		For using F = μR
	$0.6g\sin\alpha - P\cos\alpha = 0.4(0.6g\cos\alpha + P\sin\alpha)$	A1		Value of α used or values of sin α and cos α used
	$6(12/13) - P(5/13) = 2.4(5/13) + 0.4P(12/13)$	M1		For solving the resultant equation for P
	$P = 6.12$	A1	8	

Alternative Marking Scheme				
		M1		For resolving three forces vertically
	$W = R\cos\alpha + F\sin\alpha$	A1		Value of α used or values of $\sin\alpha$ and $\cos\alpha$ used
		M1		For resolving three forces horizontally
	$P = R\sin\alpha - F\cos\alpha$	A1		Value of α used or values of $\sin\alpha$ and $\cos\alpha$ used
		M1		For using $F = \mu R$ in both equations
	$0.6g = R(5/13) + 0.4R(12/13)$ and $P = R(12/13) - 0.4R(5/13)$	A1		Value of α used or values of $\sin\alpha$ and $\cos\alpha$ used
	$78 = R(5 + 4.8)$ and $13P = R(12 - 2)$ $\rightarrow 13P = (78 \div 9.8) \times 10$	M1		For finding R and substituting into an expression for P
	$P = 6.12$	A1	8	

5 **(i)**	[$s = t^2/2 - 0.1t^3/3$]	M1*		For integrating to find s for $0 \leqslant t \leqslant 5$
	[$s_1 = 25/2 - 0.1 \times 125/3$]	DM1*		For obtaining s_1 by using limits 0 to 5 or having zero for constant of integration (can be implied) and substituting $t = 5$
	$s_1 = 8.33$	A1	3	
(ii)			M1	For using $s = v(5) \times (45 - 5)$ for $5 \leqslant t \leqslant 45$
	$s_2 = 2.5 \times 40$	A1		
	[$s = 9t^2/2 - 0.1t^3/3 - 200t$ for $45 \leqslant t \leqslant 50$]	M1		For integrating to find s for $45 \leqslant t \leqslant 50$ and implying the use of limits 45 and 50 or equivalent via constant of integration
	$s_3 = [9(50)^2 / 2 - 0.1(50)^3 / 3 - 200(50)] - [9(45)^2 / 2 - 0.1(45)^3 / 3 - 200(45)]$ [= 8.33]	A1		For applying the limits at 45 and 50 correctly or equivalent via constant of integration

Alternative mark scheme for previous 2 marks				
	Recognising the symmetry of the velocity distribution due to the correspondence of the points $(0,0) \to (50,0)$ and $(5,2.5) \to (45,2.5)$	(M1)		
	Complete the idea of symmetry with one further property and hence State $s_3 = s_1 = 8.33$	(A1)		Property is any one of $a(0) = -a(50)$ $a(5) = a(45)$ $v(2.5) = v(47.5)$ oe
	Distance from O to A is 117m	A1		
	Average speed is 2.33 ms^{-1}	B1ft	6	ft answer for total distance

6 (i)		M1		For applying Newton's 2nd law to A or B
	$T - 0.4g = 0.4a$ or $1.6g - T = 1.6a$	A1		
	$1.6g - T = 1.6a$ or $T - 0.4g = 0.4a$ or $1.6g - 0.4g = (1.6 + 0.4)a$	B1		
	$T = 6.4$	A1		
	Work done by tension is 7.68 J	B1ft	5	
Alternative mark scheme for 6 (i)				
		M1		For applying Newton's 2nd law to A or B
	$T - 0.4g = 0.4a$ or $1.6g - T = 1.6a$	A1		
	$1.6g - T = 1.6a$ or $T - 0.4g = 0.4a$ or $1.6g - 0.4g = (1.6 + 0.4)a$	B1		
	WD by T = initial PE – final KE $= 1.6 \times g \times 1.2 - \frac{1}{2} \times 1.6 \times 14.4$	M1		For finding v^2 and applying Work/Energy equation to B
	WD by T = $19.2 - 11.52 = 7.68$	A1	5	

6 **(ii)**	$[1.6 \times 10 \times 1.2 = ½\ 1.6\ v^2 + 7.68]$	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	

7	**(i)**	[s = ½ 5 × 0.4 + 19 × 0.4 + ½ 4 × 0.4]	M1		For using the area property for distance
		Distance = 9.4	A1	2	
	(ii)	Acceleration is 0.08 ms^{-2}	B1		
		Deceleration is $0.1ms^{-2}$	B1	2	
	(iii)	[T – (800 + 100) g = (800 +100)a]	M1		For applying Newton's 2^{nd} law to the <u>elevator and box</u>
		T – 900g = 900a	A1		
		T = 9072 N in 1^{st} stage T = 9000 N in 2^{nd} stage T = 8910 N in 3^{rd} stage	A1	3	
	(iv)	[R – 100g = 100a]	M1		For applying Newton's 2^{nd} law to the <u>box</u>
		R = 1008 N	A1		For obtaining the greatest value of the force on the box
		R = 990 N	A1	3	For obtaining the least value of the force on the box

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	$(-0.32 - 0.28)g = a$	A1		
	$a = -6.$	A1	3	AG
(ii)	$[0 = 5.4^2 + 2(-6)s]$ or $[mgs(0.28) = ½ m(5.4)^2 - mgs(0.96)/3]$	M1		For using $0 = u^2 + 2as$ or for using PE gain = KE loss – WD against friction
	Distance is 2.43 m	A1	2	
2		M1		For using $a = (M - m)g/(M+m)$ or for applying Newton's 2nd law to A and to B and solving for a.
	$a = 5$	A1		
	When B reaches the floor $v^2 = 2 \times 5 \times 1.6$; speed is 4ms^{-1}	B1ft		ft a $a \neq g$ $v = \sqrt{(3.2a)}$
		M1		For using $0 = u^2 - 2gs$ or for using PE gain = KE loss
	$0 = 16 - 20s$ $(s = 0.8)$	A1ft		ft speed
	$h + 1.6 + 0.8 = 3 \Rightarrow h = 0.6$	B1	6	
3		M1		For resolving forces on P vertically
	$T_A(1/2.6) + T_B(1/1.25) = 10.5$	A1		
		M1		For resolving forces on P horizontally
	$T_A(2.4/2.6) = T_B(0.75/1.25)$	A1		
		M1		For solving for T_A and T_B
	Tension in AP is 6.5 N and tension in BP is 10 N.	A1	6	

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

(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.
		M1		For using v = at for T_1 or u = –at for T_3
	$T_1 = V \div 0.3$, $T_3 = V$	A1	3	
(ii)	[$S = ½\ T_1V + T_2V + ½\ T_3V$]	M1		For using the area property for the distance travelled
		M1		For substituting for T_1, T_2 and T_3 in terms of V
	$S = 552V – V\ \{0.5(T_1 + T_3)\}$ $= 552V – 13V^2/6$	A1		
	$13V^2 – 3312V + 72000=0$	B1		AG
	V = 24	B1	5	
6 (i)	[144000/v – 4800 = 12500a]	M1		For using DF = P/v and Newton's 2nd 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 = $½12500(24^2 – 16^2)$	B1		
		M1		For using WD by DF = PE gain – KE loss + WD against res'ce
	5800x500 = 12500gh – $½12500(24^2 – 16^2)$ + 4800 × 500	A1		
	Height of C is 20 m	A1	5	

	(ii) Alternative			
	$[16^2 = 24^2 + 2 \times 500a]$	M1		For using $v^2 = u^2 + 2as$
	$a = -0.32$ ms^{-2}	A1		
		M1		For using Newton's second law
	$5800 - 4800 - 12500g \times (h \div 500) = 12500(-0.32)$	A1		
	Height of C is 20 m	A1	5	
7 (i)	$[s = k_1t^2/2 - 0.005t^3/3 + (C)]$	M1		For using $s = \int v\,dt$
	$[k_1(60^2/2) - 0.005(60^3/3) = 540]$	DM1		For using limits 0 and 60 and equating to 540
	$k_1 = 0.5$	A1		
	$0.5 \times 60 - 0.005 \times 60^2 = k_2 \div \sqrt{60}$	M1		For using $v_1(60) = v_2(60)$
	$k_2 = 12\sqrt{60}$	A1	5	AG
(ii)		M1		For using $s = 540 + 12\sqrt{60}\int_{60}^{t} (t^{-1/2})\,dt$
	$[s = 540 + 12\sqrt{60}(2\sqrt{t} - 2\sqrt{60}) =]$ $24\sqrt{(60t)} - 900$	A1	2	Accept any other correct form for s if it is used in **(iii)**
(iii)	$[24\sqrt{(60t)} - 900 = 1260]$	M1		For solving $s(t) = 1260$ for t
	$t = 135$	A1		
	$v = 12\sqrt{60} \div \sqrt{135} \rightarrow$ speed is 8 ms^{-1}	B1	3	