

MARK SCHEME for the May/June 2011 question paper
for the guidance of teachers

9709 MATHEMATICS

9709/41

Paper 4, maximum raw mark 50

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1	(i) $[DF - 600 = 700 \times 2]$ Driving force is 2000 N	M1 A1	For using Newton's second law (3 terms needed) [2]
	(ii) $[P = 2000 \times 15]$ Rate of working is 30000 W (or 30 kW)	M1 A1ft	For using $P = Fv$ [2]
2	(i) Gain in PE = $1250g \times 1.54$ (= 19250 J) [WD = $1250g \times 1.54 + 5750$] Work done is 25000 J (or 25 kJ)	B1 M1 A1	 For using WD by crane = Gain in PE + WD against resistance [3]
	(ii) $[1250 = 25000 / T]$ Time is 20 s	M1 A1ft	for using $P = \Delta(WD) / \Delta t$ ft Ans(i) $\div 1250$ [2]
3	 $T\cos\theta + T\sin\theta = 15.5$ $-T\cos\theta + T\sin\theta = 8.5$ $T\sin\theta = 12$ and $T\cos\theta = 3.5$ $\theta = 73.7^\circ$ (or 1.29°)	M1 A1 A1 DM1 A1 B1	For resolving forces horizontally or vertically (3 terms needed) AEF AEF For solving for $T\sin\theta$ and $T\cos\theta$ AG [6]
4	(i) $2X + F = 11g\sin 30^\circ$ and $9X - F = 11g\sin 30^\circ$ $X = 10$	M1 A1 A1	For resolving forces parallel to the plane (either case) – 3 terms needed [3]
	(ii) $F = 35$ $R = 11g\cos 30^\circ$ Coefficient is 0.367	B1 B1 DM1 A1ft	May be implied. For using $\mu = F/R$ [4]
5	(i) $v(600) = 0.025 \times 600$ $0 = 15 - 0.0375t_3$ Total time is 3600 s	B1 M1 A1 A1	 For using $0 = v(600 + 2600) - 0.0375t_3$ and $v(600 + 2600) = v(600)$ [4]
	(ii) For correct graph $[d = \frac{1}{2}(2600 + 3600) \times 15$ or $d = \frac{1}{2}0.025 \times 600^2 + 2600 \times 15 +$ $\frac{1}{2}0.0375 \times 400^2]$ Distance is 46500	M1 A1ft A1ft	Shape only For method of finding distance [3]
	(iii) Values of t are 300 and 3400	B1	[1]

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6	(i)	M1	For using $s = \int v dt$
	$s = 2t^2 - t^4/64 (+ C)$	A1	
	$[t^4 - 128t^2 + 64^2 = 0]$	M1	For attempting to solve $s(t) = 64$
	$(t^2 - 64)^2 = 0$	A1	
	Time taken is 8 s	A1	[5]
	(ii)	M1	For using $a = dv/dt$
	$a = 4 - 3t^2/16$	A1	
	a is positive for $0 < t < \frac{8}{\sqrt{3}}$ or	B2	[4] SR: Allow B1 for $t < \frac{8}{\sqrt{3}}$
	$0 < t < 4.62$		SR: B1 for $0 \leq t \leq \frac{8}{\sqrt{3}}$ or 4.62
7	(i)	M1	For applying Newton's second law to A or to B
	$T - 12 = 1.2a$ and $20 - T = 2a$	A1	Accept $(2 - 1.2)g = (2.0 + 1.2)a$ as an alternative for one of these equations
	Acceleration is 2.5 ms^{-2}	B1	
	Tension is 15 N	A1	[4]
	(ii) (a) PE gain = $12 \times 1.5 = 18 \text{ J}$	B1	
	(b) WD on A = $15 \times 1.5 = 22.5 \text{ J}$	B1	
	(c) Gain in KE = ans (b) – ans (a) = 4.5 J	B1ft	[3] alt: KE = $\frac{1}{2} 1.2(2 \times 2.5 \times 1.5) = 4.5 \text{ J}$
	(iii) $v = 1.6 \times 2.5$	B1ft	
		M1	For using $v = u - gt$
	$t = 0.4 \text{ s}$	A1	May be implied
	Total time taken is 0.8 s	A1	[4]

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1	(i) [WD = $65 \times 76 \cos 5^\circ$] Work done is 4920 J	M1 A1	For using $WD = Td \cos \alpha$ [2]
	(ii) [P = $65 \cos 5^\circ \times 1.5$] Rate of working is 97.1 W	M1 A1ft	For using $P = Tv \cos \alpha$ ft for the value of ans(i) $\times 1.5 \div 76$ SR for candidates who assume without justification that the speed is constant (max 1/2) $t = 76 \div 1.5 = 50.6 \dots s$ $\text{rate} = WD/t = 4960 \div 50.6 \dots = 97.1 W$ B1
2	PE loss = $\frac{1}{2} 8(8^2 - 3^2) + 120 (= 340 \text{ J})$ [340 = 8gh] Height is 4.25 m	M1 A1 DM1 A1	For using 'loss of PE = gain in KE + WD against resistance' For using PE = mgh [4]
			SR for candidates who assume without justification that the resistance to motion is constant, usually implicitly by using constant acceleration formulae (max 3/4) For using Newton's second law with 3 terms, $v^2 - u^2 = 2as$ and $h = s \sin \alpha$ M1 For attempting to eliminate α , a and s from the equations $(80s \sin \alpha - 120/s = 8a$ $64 - 9 = 2as, h = s \sin \alpha)$ M1 $80s \sin \alpha - 120 = 4(64 - 9)$ $\rightarrow 80h - 120 = 220$ $\rightarrow h = 4.25$ A1
3	(i) [$\frac{1}{2} 5 \times 50 + \frac{1}{2} 7(8 + 50) + 90 \times 8$] Distance is 1048 m	M1 A1	For using the area property for distance or $s = \frac{1}{2} (u + v)t$ [2] AG
	(ii) $a = (8 - 50)/(12 - 5)$ or $d = (50 - 8)/(12 - 5)$ $850 - F = 85a$ (or $-85d$) Upward force is 1360 N	M1 A1 A1	For use of the gradient property for acceleration (deceleration) For using Newton's second law (3 terms) [5]

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4	(i)	M1	For resolving forces in the i and j directions	
	$F \cos \theta = 12 \cos 30^\circ$ (= 10.932)	A1		
	$F \sin \theta = 10 - 12 \sin 30^\circ$ (= 4)	A1		
		M1	For using $F^2 = X^2 + Y^2$ or $\tan \theta = Y/X$	
	$F = 11.1$ or $\theta = 21.1$ (accept 21.0)	A1		
	$\theta = 21.1$ (accept 21.0) or $F = 11.1$	B1	[6]	
SR for candidates who <u>consistently</u> have cos for sin and vice versa (max 4/6) M1 as above (resolving) A1 for $F \sin \theta = 12 \sin 30^\circ$ <u>and</u> $F \cos \theta = 10 - 12 \cos 30^\circ$ M1 as above $F^2 = \dots$ & $\tan \theta = \dots$ A1 for $F = 6.01$ <u>and</u> $\theta = 93.7$				
	(ii) Magnitude is 12N	B1		
	Direction is 30° clockwise from +ve 'x' axis	B1	[2]	
alternative for 4(i)				
	For triangle of forces with sides 12, F and 10 and at least one of the angles $(90^\circ - \theta)$ or 60° or $(\theta + 30^\circ)$	B1		
		M1	For use of cosine rule (with θ absent) or use of sine rule (with F absent) and use of $\sin(A \pm B) = \sin A \cos B \pm \sin B \cos A$	
	$F^2 = 12^2 + 10^2 - 2 \times 12 \times 10 \cos 60^\circ$ or $(12 \cos 30^\circ) \sin \theta = (10 - 12 \sin 30^\circ) \cos \theta$	A1		
	$F = 11.1$ or $\theta = 21.1$ (accept 21.0)	A1		
		M1	For correct method for θ or F	
	$\theta = 21.1$ (accept 21.0) or $F = 11.1$	A1	[6]	
second alternative for 4(i)				
	For using Lami's theorem with 12 N and 10 N	M1		
	$12 / \sin(90 + \theta) = 10 / \sin(150 - \theta)$	A1		
	$12 / \cos \theta = 20 \div (\cos \theta + 3^{1/2} \sin \theta)$			
	$\rightarrow 12 \times 3^{1/2} \sin \theta = 8 \cos \theta$			
	$\rightarrow \tan \theta = 2 \div (3 \times 3^{1/2})$			
	$\rightarrow \theta = 21.1$	A1		
	For using Lami's theorem with F N and (12 N or 10 N)	M1		
	$F / \sin 120^\circ = 12 / \sin 111.1^\circ$ (or $10 / \sin 128.9^\circ$)	A1		
	$F = 11.1$	A1	[6]	

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Alternative for 4(ii)			
For $X = 11.1 \cos 21.1^\circ$ and $Y = 11.1 \sin 21.1^\circ - 10$, $R^2 = X^2 + Y^2$ and $\tan \Phi = Y/X$		M1	
Magnitude 12 N and direction 30° clockwise from +ve x-axis		A1	[2]
5 (i)	M1	For using $0 = u - gt$ to find times at maximum heights.	
Times to max. height are 1.2s and 0.7s	A1		
Range of values is $0.7 < t < 1.2$	A1	[3]	
(ii)	M1	For using $h = ut - \frac{1}{2}gt^2$ and attempting to solve $3h_A = 8h_B$ for t	
$36t - 1.5gt^2 = 56t - 4gt^2$	A1		
$t = 8/g$	A1		
	M1	For using $v = u - gt$	
Velocities are 4m^{-1} and -1ms^{-1}	A1	[5]	
Alternative for part 5(ii)			
For using $3h_P = 8h_Q \rightarrow 3(v_P^2 - 144) \div$ $(-20) = 8(v_Q^2 - 49) \div (-20) \rightarrow 3v_P^2 - 8v_Q^2$ $= 40$		B1	
For using $v_P = 12 - 10t$ and $v_Q = 7 - 10t$ $\rightarrow v_P - v_Q = 5$		B1	
For eliminating v_Q (or v_P) and solving for v_P (or v_Q).		M1	
$v_P^2 - 16v_P + 48 = 0 \rightarrow v_P = 4$ (or 4, 12)		A1	
Upward velocities are 4ms^{-1} and -1ms^{-1}		A1	[5]
6 (i)	M1	For resolving forces on R vertically	
$2T \cos \alpha = 0.6g$	A1	Where $\alpha = \frac{1}{2}$ angle ARB	
Tension is 5N	A1	[3]	
(ii) $[F = T \sin \alpha]$	M1	For resolving forces on B horizontally	
Frictional component is 4N	A1		
$[N = 0.4g + T \cos \alpha]$	M1	For resolving forces on B vertically	
Normal component is 7 N	A1	[4]	
(iii)	M1	For using $\mu = F/N$	
Coefficient is $4/7$ or 0.571	A1ft	[2]	ft conditional on both M1 marks scored in (ii); ft F and/or N

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Alternative for Q6(i)/(ii)			
7	(i) For finding the relevant angles and using Lami's theorem	M1	
	$6/\sin 106.26^\circ = T/\sin 126.87^\circ$	A1	
	Tension is 5N	A1	[3]
	(ii) $F/\sin 126.87^\circ = 5/\sin 90^\circ$	B1	
	Frictional component is 4N	B1	
	$(R - 4)/\sin 143.13^\circ = 5/\sin 90^\circ$	B1	
	Normal component is 7 N	B1	[4]
	(i) $[1.3 = 0.9 + 0.004T,$ $1.3^2 = 0.9^2 + 2 \times 0.004S]$	M1	For using $v = u + at$ or $v^2 = u^2 + 2as$
	Time is 100 s (or distance is 110 m)	A1	
	Distance is 110 m (or time is 100 s)	B1	[3]
	(ii) $\int kt^3 dt = \frac{1}{4} kt^4$	B1	
	$[k(\frac{1}{4} 100^4 - 0) = 110]$	M1	For using limits 0 to T and equating definite integral to S
	$k = 4.4 \times 10^{-6}$	A1	
	$[v_w = 0.9 + 0.004 \times 64.05,$ $v_c = 4.4 \times 10^{-6} \times 64.05^3]$	M1	For attempting to find the speed of the walker and of the cyclist.
	Both are equal to 1.16 ms^{-1} correct to 3 sf.	A1	[5]
	(iii) Acceleration = $3kt^2$	B1	
	Acceleration at B is 0.132 ms^{-2}	B1	[2]

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$8200 = 180 \times 50 \cos \alpha$	A1	
$\alpha = 24.3$	A1	[3]
2	M1	For using $DF = P/v$
	M1	For using Newton's second law when $v = 19$ or when $v = 30$
$P/19 - R = 1250 \times 0.6$ and $P/30 - R = 1250 \times 0.16$	A1	
$[19R + 19 \times 1250 \times 0.6$ $= 30R + 30 \times 1250 \times 0.16]$	M1	For attempting to eliminate P or R
$R = 750$ or $P = 28500$	A1	
$P = 28500$ or $R = 750$	B1ft	ft wrong answer for R or P substituted into a correct linear equation.
		[6]
3 (i) $a_p = g \sin 30^\circ$	B1	
$3.2 = \frac{1}{2} g t_q^2$	B1	
$[6.4 = u(0.8) + \frac{1}{2} 5 \times (0.8)^2]$	M1	For applying $s = ut + \frac{1}{2} at^2$ to P
$u = 6$	A1	[4]
(ii) $[v = 6 + 5 \times 0.8$ or $v^2 = 36 + 2 \times 5 \times 6.4]$	M1	For using $v = u + at$ or $v^2 = u^2 + 2as$ for P
Speed of P is 10 ms^{-1}	A1	[2]
Alternative for Parts (i) and (ii) when a is not used:		
Part (i)		
$3.2 = \frac{1}{2} g t_q^2$	B1	
For using KE gain = PE loss to obtain an equation in u and v		
$[\frac{1}{2} (v^2 - u^2) = 6.4 g \sin 30^\circ]$	M1	
For using $s = \frac{1}{2} (u + v)t$ to obtain a second equation in u and v		
$[6.4 = \frac{1}{2} (u + v) \times 0.8]$	DM1	
$u = 6$	A1	[4]
Part (ii)		
Substitutes for u to find v	M1	
Speed is 10 ms^{-1}	A1	[2]

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4	(i) For correct shading composite figure consisting of 2 rectangles: 1 st has boundaries $t = 0$ & $t = 20$, $v = 0$ and $v = 2.5$; 2 nd has boundaries $t = 20$ & $t = T$, $v = 0$ and $v = 4$	B1	[1]	
	(ii) $[50 + 4(T - 20) = 70 \text{ or } 4T - 30 = 70]$ $T = 25$	M1 A1		For attempt to find equation in T [2]
	(iii) [Distance = $70 + (4 - 2.5)20$ or $50 + 4[(T - 20) + 20] - 50]$ Distance between P and Q is 100 m	M1 A1ft		For identifying and using area representing required distance [2] ft 4T
	(iv) For 2 straight line segments representing P, 1 st with +ve slope and 2 nd with steeper slope, $t = 20$ indicated appropriately For Q, 1 st & 2 nd segments parallel to P's and displaced to the right, $t = 25$ and $t = 45$ indicated appropriately	B1 B1ft		ft T and T + 20 [2]
5	(i) $F_x - 6.1 - 5 \times 0.28 = 0$ and $F_y + 4.8 - 5 \times 0.96 = 0$ Frictional force acts parallel to x axis and to the right $F_y = 0 \rightarrow F = F_x$ $\rightarrow$ Frictional force has magnitude 7.5 N	M1 A1 A1 A1		For resolving forces in the x direction or the y direction [4] AG
	(ii) $[\mu = 7.5/(1.25 \times 10)]$ Coefficient is 0.6	M1 A1		For using $F = \mu R$ and $R = mg$ [2]
	(iii) $[7.5 - 8.6 - 1.4 = 1.25a \rightarrow a = -2]$ Magnitude of acceleration is 2 ms^{-2} Direction of acceleration is parallel to x axis and to the left	M1 A1 B1		For applying Newton's second law [3]

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6	(i)	Gain in PE = $15000g \times 500\sin 2.5^\circ$ J	B1		
		WD against the resistance = 800×500 J	B1		
		[3271454 + 400000]	M1		For using WD by driving force = Gain in PE + WD against resistance
		Work done is 3670000 J or 3670 kJ	A1	[4]	Alternatively, For resolving forces up the plane M1 Driving Force = $800 + 15000g\sin 2.5^\circ$ A1 For using WD = Driving Force $\times$ 500 M1 Work done is 3670000J A1
	(ii)	Work done by DF = 2000×500 J	B1		
		Gain in KE = $\frac{1}{2} 15000(v^2 - 20^2)$	B1		
			M1		For using Gain in KE = Loss in PE – WD against resistance + WD by driving force
		$\frac{1}{2} 15000(v^2 - 20^2) = 3271454 - 400000 + 1000000$	A1		
		Speed of the lorry is 30.3 ms^{-1}	A1	[5]	Alternatively, For applying Newton's second law M1 $2000 + 15000g\sin 2.5 - 800 = 15000a$ A1 For using $v^2 = u^2 + 2as$ M1 $v^2 = 20^2 + 2 \times 0.5162 \times 500$ A1 Speed is 30.3 ms^{-1} A1
7	(i)		M1		For using $v(t) = \int a dt$
		$v = \frac{1}{160}t^3 - \frac{1}{3200}t^4 (+ C_1)$	A1		
		[$0 = 8000/160 - 160000/3200 + C_1$ $\rightarrow C_1 = 0$]	M1		For using $v(20) = 0$
		Initial speed is zero	A1	[4]	AG
	(ii)	[$t^2/800(15 - t) = 0$]	M1		For solving $a = 0$
		$v_{\max} = v(15) = 5.27 \text{ ms}^{-1}$	A1	[2]	
	(iii)		M1		For using $s(t) = \int v dt$
		$s = \frac{1}{640}t^4 - \frac{1}{16000}t^5 (+ C_2)$	A1ft		
		[250 – 200]	M1		For using limits 0 and 20 (or equivalent)
		Distance AB is 50 m	A1	[4]	