

**MARK SCHEME for the October/November 2010 question paper
for the guidance of teachers**

9709 MATHEMATICS

9709/41

Paper 4, maximum raw mark 50

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SOS	See Other Solution (the candidate makes a better attempt at the same question)
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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 ✓” 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.
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1	(i)	M1	For using $-g = (0 - V)/(2 - 0)$ or $0 = V - gt$
	$V = 20$	A1	[2]
	(ii) Speed is 40 ms^{-1}	B1	[1]
	(iii)	M1	For using $h = \frac{1}{2} 4 \times 40$ or $h = \frac{1}{2} g \times 4^2$ or $40^2 = 2gh$
	Height is 80 m	A1	[2]
2	$[F - R = ma]$	M1	For using Newton's second law (3 terms)
	$F_A - 800 = 600a_A$	A1	
	$F_A = 40000/25$ (1600)	B1	
	$40000/v_B - 800 = 600$ (400/600)	A1	
	Speed is 33.3 ms^{-1}	A1	[5]
3		M1	For using triangle of forces or for resolving in dir ⁿ XP_1 or for using Lami's theorem or for resolving forces at X vertically and horizontally (equations must contain not more than one unknown angle)
	For correct Δ or resolve XP_1 and $\cos\alpha = 5.5/7.3$; or $5.5/\sin(90^\circ + \alpha) = 7.3/\sin 90^\circ$ (Lami); or $5.5\cos\alpha + W\sin\alpha = 7.3$ and $5.5\sin\alpha = W\cos\alpha$.	A1	
	Angle $AP_1X = 41.1^\circ$ or 0.718°	A1	
	For correct triangle and $W^2 = 7.3^2 - 5.5^2$; or $W/\sin(180^\circ - 41.1^\circ) = 7.3/\sin 90^\circ$; or $W\sin 41.1^\circ = 7.3 - 5.5\cos 41.1^\circ$ or $W\cos 41.1^\circ = 5.5\sin 41.1^\circ$	A1ft	ft incorrect α
	$W = 4.8$	A1	[5]
4	(i) $(1.5 + 3.5)/2 = s/10$	B1	For using $(u + v)/2 = s/t$
	Displacement is 25 m	B1	[2]
	(ii)	M1	For using $v = \int a dt$
	$v = 0.015t^2 (+ C)$	A1	
	$[3.5 = 0.015 \times 100 + C \rightarrow C = 2]$	B1	
	$[s = 0.005t^3 + 2t + (0)]$	M1	For using $s = \int v dt$
	Displacement is 25 m, same as P.	A1	[5]

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5	(i)	$[v^2 = 3^2 + 2 \times 2.5 \times 8]$ Speed is 7 ms^{-1}	M1 A1	For using $v^2 = u^2 + 2as$ [2]
	(ii)	KE gain = $\frac{1}{2} 0.8(7^2 - 3^2)$ (= 16) PE loss = $16 + 7$ $[0.8 \times 10 \times 8 \sin \alpha = 23]$ Angle is 21.1° or 0.368°	B1ft B1ft M1 A1	ft incorrect speed ft incorrect expression for KE For using PE loss = $mgL \sin \alpha$ [4]
	(ii)	ALTERNATIVELY $F = 7/8$ $[0.8 \times 10 \sin \alpha - F = 0.8 \times 2.5]$ $0.8 \times 10 \sin \alpha - 0.875 = 0.8 \times 2.5$ Angle is 21.1° or 0.368°	B1 M1 A1 A1	For using Newton's second law
	(iii)	$5^2 = 3^2 + 2 \times 2.5s$ ($s = 3.2$) [WD/7 = $3.2/8$ or WD = 0.875×3.2 or WD = $8 \times 3.2 \times (23/64)$ – $\frac{1}{2} 0.8(5^2 - 3^2)$] Work done is 2.8 J	B1 M1 A1	For using WD proport'l to dist. or WD = F(AX) or WD = PE loss – KE gain [3]
	6 (i) (a)	PE loss = $0.2g(3 - h)$ $[0.2g(3 - h) = 1.6]$ $h = 2.2$	B1 M1 A1	For using PE loss = KE gain [3]
	(b)	KE is 6 J	B1	[1]
	(c)	$[v_G / v_B = (3/(3 - 2.2))^{1/2}]$ or $v_G / v_B = \sqrt{6/1.6}$ Ratio is 1.94	M1 A1	For using $v^2 \propto (3 - ht)$ or $(v_G / v_B)^2 = \text{Ans. (i)(b)} \div 1.6$ Accept $\sqrt{60} \div 4$ or $\sqrt{15} \div 2$ [2]
	(ii)	$H/(H - 2.2) = 2.55^2$ $H = 2.6$	M1 A1 A1	For using $v^2 \propto (H - ht)$ or using $\frac{1}{2} m(2.55v_B)^2 = mgH$ and $\frac{1}{2} mv_B^2 = mg(H - 2.2)$ and eliminating v_B^2 [3]

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7	(i)		M1	For resolving forces on Q vertically
		$R + 3.2\sin 30^\circ = 0.5g$	A1	
			M1	For resolving forces on Q horizontally and using $T = W_P$
		$F + 0.2g = 3.2\cos 30^\circ$	A1	
		$[\mu = (3.2\cos 30^\circ - 2)/(5 - 3.2\sin 30^\circ)]$	M1	For using $F = \mu R$
		Coefficient is 0.227	A1	[6]
	(ii)	$2 - T = 0.2a$	B1	
		$T - 0.227 \times 5 = 0.5a$	B1ft	
				Allow B1ft for $2 - 0.227 \times 5 = (0.2 + 0.5)a$ instead of <i>one</i> of the above equations
			M1	For solving for a or T
		Acceleration is 1.24 ms^{-2} and tension is 1.75 N	A1	Allow a = 1.25 [4]

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1	M1	For resolving forces vertically (3 terms required)
	A1	
$R + 2000\cos 15^\circ = 400\text{ g}$	B1	
$F = 2000\sin 15^\circ$	M1	For using $F = \mu R$
$[2000\sin 15^\circ = \mu (400\text{ g} - 2000\cos 15^\circ)]$	A1	[5]
Coefficient is 0.25		
SR(max. 4/5) for candidates who either: have sin and cos interchanged or have angle 15° above the horizontal		
	M1	For resolving forces vertically
$R + 2000\sin 15^\circ = 400\text{ g}$ and $F = 2000\cos 15^\circ$	A1	
$[2000\cos 15^\circ = \mu (400\text{ g} - 2000\sin 15^\circ)]$	M1	For using $F = \mu R$
Coefficient is 0.55	A1	
2	B1	
Driving force = $400/4$	M1	For using Newton's second law (either case) – 3 terms needed
$DF - 80\text{ g} \sin 2^\circ = 80a$ (i) or $DF + 80\text{ g} \sin 2^\circ = 80a$ (ii)	A1	
Acceleration is 0.9 ms^{-2} (i) or Acceleration is 1.6 ms^{-2} (ii)	A1	Accept 0.90 or 0.901 and 1.60
Acceleration is 1.6 ms^{-2} (ii) and Acceleration is 0.9 ms^{-2} (i)	B1ft	[5] ft Ans (i) + (ii) = 2.5
SR(max. 3/5) for candidates who have sin and cos interchanged		
Driving force = $400/4$	B1	
	M1	For using Newton's second law (either case) – 3 terms needed
$a = -8.74$ (i) and $a = 11.2$ (ii)	A1	
3	M1	For resolving forces in i and j directions (3 terms in at least one of the equations)
$6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ) = F$ and $6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ) = F$	A1	
$[6\cos\alpha^\circ + 5\sin\alpha^\circ = 6\sin\alpha^\circ - 5\cos\alpha^\circ$ $\rightarrow 11\cos\alpha^\circ = \sin\alpha^\circ]$	DM1	For attempting to solve for α° . Dependent on 1 st M1
$\alpha = 84.8$	A1	
$[F = 6\cos 84.8^\circ + 5\sin 84.8^\circ; F = 6\sin 84.8^\circ - 5\cos 84.8^\circ]$	DM1	For substituting to find F; dependent on the 1 st M1
$F = 5.52$	A1	[6]

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First alternative scheme			
$[2F^2 = 25 + 36]$	M1	For using ‘(resultant of forces of magnitude F) ² = (resultant of forces of magnitudes 5 and 6) ² ,	
F = 5.52	A1		
	M1	For using ‘resultant of forces of magnitudes 5 and 6 makes angle 45° with x-axis’	
	M1	For using relevant trigonometry	
$\tan(\alpha^\circ - 45^\circ) = 5/6$ or $\tan(135^\circ - \alpha^\circ) = 6/5$ or $\cos(\alpha^\circ - 45^\circ)$ or $\sin(135^\circ - \alpha^\circ) = 6/\sqrt{61}$ or $\sin(\alpha^\circ - 45^\circ)$ or $\cos(135^\circ - \alpha^\circ) = 5/\sqrt{61}$	A1		
$\alpha = 84.8$	A1		
Second alternative scheme			
$[6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ) = 6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ)]$	M1	For using $R_x = R_y$	
$[11\cos\alpha^\circ - \sin\alpha^\circ = 0]$	M1	For attempting to solve for α°	
$\alpha = 84.8$	A1		
For $F = 6\cos\alpha^\circ + 5\cos(90^\circ - \alpha^\circ)$ or $F = 6\sin\alpha^\circ - 5\sin(90^\circ - \alpha^\circ)$	B1		
	M1	For substituting for α	
F = 5.52	A1		
4	(i)	$[\frac{1}{2} 20(2.5^2 - 1.5^2), 20 \times 10 \times 10 \sin 4.5^\circ]$	For using KE loss = $\frac{1}{2} m(u^2 - v^2)$ or PE gain = $mg(L \sin \alpha)$
		KE loss = 40 J or PE gain = 157 J	
		PE gain = 157 J or KE loss = 40 J	[3]
	(ii)	$[WD = 157 - 40 + 50]$	For using WD by pulling force = PE gain – KE loss + WD against resistance
		Work done is 167 J	[2] ft incorrect PE gain + 10, even if –ve
	(iii)	$[167 = F \times 10 \cos 15^\circ]$	For using WD = $FL \cos 15^\circ$
		Magnitude is 17.3 N	[2]
SR (max. 1/2) for candidates who (implicitly) make the unjustifiable assumption that acceleration is constant and apply Newton’s second law			
For magnitude is 17.3 N from $F \cos 15^\circ - 20g \sin 4.5^\circ - 50/10 = 20 \times (-0.2)$			
			B1

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5	(i) $[15 = 20t - 5t^2 \rightarrow 5(t^2 - 4t + 3) = 0]$ $t = 1, 3$ Duration is 2 s (accept $1 < t < 3$)	M1 A1 B1ft	For use of $h = ut - \frac{1}{2}gt^2$ [3] ft $t_2 - t_1$
	(ii) $20t - 5t^2 = 25(t - 0.4) - 5(t - 0.4)^2$ (or $20(t + 0.4) - 5(t + 4)^2 = 25t - 5t^2$ or $(20 \times 0.4 - 5 \times 0.4^2) + 16t - 5t^2 =$ $25t - 5t^2$) $t = 1.2$ (or $t = 0.8$) $[v_P = 20 - 10 \times 1.2; v_Q = 25 - 10 \times (1.2 - 0.4)$ (or $v_P = 20 - 10 \times (0.8 + 0.4); v_Q = 25 - 10 \times 0.8]$ Velocities are 8 ms^{-1} and 17 ms^{-1}	M1 A1 A1 M1 A1	For using $h_P = h_Q$ at time t after P's (or Q's) projection For using $v = u - gt$ for both v_P and v_Q [5]
	6 (i) $[\frac{1}{2} 2.5(\text{speed}_{\max}) = 4]$ Greatest speed is 3.2 ms^{-1}	M1 A1	For using area property for distance [2]
	SR (max. 1/2) for candidates who (implicitly) make the unjustifiable assumption that $\text{speed}_{\max}$ occurs when $t = 1.25$ Greatest speed is 3.2 ms^{-1} from $2 \times \frac{1}{2} 1.25(\text{speed}_{\max})v = 4$	B1	
	(ii) $[V = 3 \times 2]$ $V = 6$	M1 A1	For using $a = (V - 0)/(4.5 - 2.5)$ or $V = 0 + at$ [2]
	(iii) $\frac{1}{2} 6(12 + T) = 48$ or $\frac{1}{2} 6 \times 2 + 6T + \frac{1}{2} 6(10 - T) = 48$ or $\frac{1}{2} 6 \times 2 + 6(10 - \tau) + \frac{1}{2} 6\tau = 48$ $t = 8.5$	M1 A1ft A1	For using area property for distance from $t = 2.5$ to $t = 14.5$ [3] from $4.5 + T$ or $14.5 - \tau$
	(iv) Deceleration is 1 ms^{-2}	M1 A1ft	For using $a = (0 - V)/(14.5 - 8.5)$ or $0 = V + a(14.5 - 8.5)$ [2]

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7	(i) $a(t) = 0.006t^2 - 0.24t + 1.8$	B1	
	$[0.006(t^2 - 40t + 300) = 0]$	M1	For solving $a(t) = 0$
	$T_1 = 10, T_2 = 30$	A1	
		M1	For integrating $v(t)$
	$s(t) = 0.0005t^4 - 0.04t^3 + 0.9t^2 + 5t + (C)$	A1	
	$[405 - 1080 + 810 + 150]$	M1	For using limits 0 to T_2 or equivalent
	Distance is 285 m	A1	[7]
	(ii) Velocity is 5 ms^{-1}	B1	
	For curve with v increasing from a +ve value at $t = 0$ to a maximum	B1	
	Then decreases to a +ve minimum and thereafter increases	B1	[3]

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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.

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1	$a = g \sin 30^\circ$	B1	
	[(i) $v_1^2 = 2(g \sin 30^\circ)0.9$ or $\frac{1}{2} m v_1^2 = mg(0.9 \sin 30^\circ)$ or (ii) $v_2 = (g \sin 30^\circ)0.8$	M1	For using $v^2 = 2as$ or $\frac{1}{2} m v^2 = mgh$ or $v = at$
	(i) Speed is 3 ms^{-1} or (ii) Speed is 4 ms^{-1}	A1	
	(ii) Speed is 4 ms^{-1} or (i) Speed is 3 ms^{-1}	B1	[4]
2	(i) [$\frac{1}{2} v^2 = 10 \times 1.8$] Speed is 6 ms^{-1}	M1 A1	For using $\frac{1}{2} m v^2 = mgh$ [2]
	(ii) [$WD = \frac{1}{2} \times 0.5(6^2 - 5^2)$ or $0.5 \times 10 \times 1.8 = \frac{1}{2} \times 0.5 \times 5^2$] Work done is 2.75 J	M1 A1	For using $WD = \text{loss of KE}$ or $KE_A + PE_A - WD = KE_C + PE_C$ [2]
	(i) [$2T \cos 30^\circ = 3\sqrt{3}$ or $T/\sin 30^\circ = 3\sqrt{3}/\sin 120^\circ$ or $T^2 = T^2 + (3\sqrt{3})^2 - 2T(3\sqrt{3})\cos 30^\circ$ or $\sqrt{\{(T \cos 30^\circ)^2 + (T + T \cos 60^\circ)^2\}} = 3\sqrt{3}$] Tension is 3 N	M1 A1	For expressing resultant in terms of T and equating with value or for using sine rule or for using cosine rule or for finding R_x and R_y and equating resultant to $3\sqrt{3}$ AG [2]
	(ii) [$T = F + mg \sin 30^\circ$ $R = mg \cos 30^\circ$ $3 = 0.75(10 \cos 30^\circ)m + 10m \sin 30^\circ$ Mass is 0.261 kg]	M1 B1 M1 A1 A1	For resolving forces on Q parallel to AC For using $F = \mu R$ [5]
4	(i) $v(4) = 0.75 \times 4$	B1	
	$v(54) = v(4)$ and $v(60) = v(54) - 0.5(60 - 54)$	B1	
	Velocity is 3 ms^{-1} when $t = 4$ and 0 when $t = 60$	B1	
	 2 nd segment has zero slope; end points of segments are seen to be correct $\{(0,0), (4,3),$ $(54,3), (60,0)\}$	M1 A1 ft	Graph consists of 3 straight line segments with 1 st and 3 rd having +ve and -ve slopes respectively; v is single valued and continuous throughout, and $v(0) = 0$. ft incorrect value(s) for $v(4)$ and $v(60)$ [5]
(ii)	[$XY = \frac{1}{2} (60 + 50) \times 3$ or $XY = \frac{1}{2} \times 0.75 \times 4^2 + 3 \times 50 - \frac{1}{2} \times 0.5 \times 6^2$] Distance is 165 m	M1 A1	For using area property for distance or $s_1 = \frac{1}{2} a_1 t_1^2$, $s_2 = u_2 t_2$, $s_3 = \frac{1}{2} a_3 t_3^2$ and $XY = s_1 + s_2 - s_3$ [2]

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5	(i) $[F^2 = 27.5^2 + (-24)^2]$ $F = 36.5$ $[\tan \alpha^\circ = -(-24/27.5)]$ $\alpha = 41.1$	M1 A1 M1 A1	For using $F^2 = X^2 + Y^2$ (may be scored in (ii)) For using $\tan \alpha^\circ = -Y/X$	
	(ii) $R = 94.9$ $[\alpha^\circ + \theta^\circ = \tan^{-1}(87.6/36.5);$ or $(\alpha^\circ + \theta^\circ) = \cos^{-1}(36.5/94.9)$ or $\theta^\circ = \tan^{-1}(87.6 \sin 48.9^\circ - 24)/(27.5 + 87.6 \cos 48.9^\circ)]$ $\theta = 26.3$	B1 M1 A1 ft	For using $\tan(\alpha^\circ + \theta^\circ) = 87.6/F$ or $\cos(\alpha^\circ + \theta^\circ) = F/R$ or $\tan \theta^\circ = Y/X$ ft 67.4 – incorrect α	[4] [3]
6	(i) $a_1(t) = 1.44t - 0.288t^2$, $a_2(t) = 2.4 - 0.48t$ $[a_1 = 1.44 \times 5 - 0.288 \times 25, a_2 = 2.4 - 0.48 \times 5]$ $a_1 = a_2 (= 0) \rightarrow$ no instantaneous change	M1 A1 M1 A1	For using $a(t) = \dot{v}(t)$ For evaluating $a_1(5)$ and $a_2(5)$	[4]
	(ii) $s_1 = 0.24t^3 - 0.024t^4$, $s_2 = 1.2t^2 - 0.08t^3$ $[\{(0.24 \times 5^3 - 0.024 \times 5^4) - (0 - 0)\} + \{(1.2 \times 10^2 - 0.08 \times 10^3) - (1.2 \times 5^2 - 0.08 \times 5^3)\}]$ Distance is 35 m	M1 A1 M1 A1	For using $s = \int v dt$ For using limits 0 to 5 and 5 to 10 or equivalent	[4]
7	(i) $DF = 24000/20$ $[DF - R = 1250 \times 0.32]$ $R = 800$	B1 M1 A1	For using Newton's second law (3 terms)	[3]
	(ii) $24000/29.9 - 800 = 1250a$ Acceleration is 0.002 ms^{-2}	B1 B1		[2]
	(iii) $[a = (24000/30 - 800)/1250]$ $24000/v - 800 > 0 \rightarrow v < 30]$ Car not accelerating when $v = 30$ or Speed cannot reach 30 ms^{-1}	M1 A1	For finding a when $v = 30$ or for using $a > 0$ to obtain an inequality for v AG	[2]
	(iv) $29.9 \leq v < 30 \rightarrow$ speed approximately constant	B1		[1]
	(v) 30 ms^{-1} (max error 0.1) or 29.95 ms^{-1} (max error 0.05) or 29.9 ms^{-1} (max error 0.1)	B1		[1]
	(vi) (a) $[24 = 1200/T]$ Time taken is 50 s	M1 A1	For using $P = \Delta W D / \Delta t$	
	(b) $[s = 30 \times 50 \text{ or } 29.95 \times 50 \text{ or } 29.9 \times 50]$ Distance BC is 1500 m or 1500 m or 1495 m	M1 A1	For using $s = vt$	[4]

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ALTERNATIVE FOR PART (vi)

(b) [1200 000 = 800d]	M1	For using 'no change in KE' → WD by car's engine = WD against resistance' (may be implied)
Distance BC is 1500m	A1	
(a) [t = 1500/30 or 1500/29.95 or 1500/29.9]	M1	For using t = s/v
Time taken is 50 s or 50.1 s or 50.2 s	A1	