
MATHEMATICS

9709/41

Paper 4

October/November 2017

MARK SCHEME

Maximum Mark: 50

Published

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- When a part of a question has two or more “method” steps, the M marks are generally independent unless the scheme specifically says otherwise; and similarly when there are several B marks allocated. The notation DM or DB (or dep*) is used to indicate that a particular M or B mark is dependent on an earlier M or B (asterisked) mark in the scheme. When two or more steps are run together by the candidate, the earlier marks are implied and full credit is given.
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The following abbreviations may be used in a mark scheme or used on the scripts:

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AG Answer Given on the question paper (so extra checking is needed to ensure that the detailed working leading to the result is valid)

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Question	Answer	Marks	Guidance
1	$[12 \cos 25 = 3a]$	M1	For use of Newton's second law
	$a = 4 \cos 25 = 3.625$	A1	
	$[s = \frac{1}{2} \times 4 \cos 25 \times 5^2]$	M1	For use of $s = ut + \frac{1}{2}at^2$ OE
	Distance = 45.3 m	A1	
		4	

Question	Answer	Marks	Guidance
2(i)	Power = $1150 \times 12 = 13\,800\text{W}$	B1	For use of $P = F \times v$ Allow 13.8 kW
		1	
2(ii)	Driving force = $\frac{25000}{12}$	B1	Using $F = \frac{P}{v}$
	$\frac{25000}{12} - 1150 - 3700g \sin 4 = 3700a$	M1	For applying Newton's 2nd law up the slope, 4 terms
	$a = -0.445 \text{ m s}^{-2}$	A1	
		3	
2(iii)	$\frac{25000}{v} - 1150 - 3700g \sin 4 = 0$	M1	For stating the equation for constant v , with 3 terms, and solving for v
	$v = 6.70 \text{ m s}^{-1}$	A1	
		2	

Question	Answer	Marks	Guidance
3(i)	640×18	M1	For use of work done = $F \times d$
	Work done = 11 520 J	A1	
		2	
3(ii)	KE at start $= \frac{1}{2} \times 840 \times 14^2 = 82\,320 \text{ J}$	B1	
	PE gained = $840g \times 8 \sin 30$ $- 840g \times 10 \sin 20 = 4870 \text{ J}$	B1	
	$\frac{1}{2} \times 840 \times v^2 = 82\,320 - 11\,520 - 4870$	M1	For using work – energy equation with 4 terms and solving for v
	$v = 12.5 \text{ m s}^{-1}$	A1	
		4	

Question	Answer	Marks	Guidance
4(i)	Acceleration = $\frac{(-25)}{2.5} = -10 \text{ m s}^{-2}$	B1	AG
		1	
4(ii)	$V = -15 + 7.5 \times 4$	M1	Using $v-t$ graph OE
	$V = 15 \text{ m s}^{-1}$	A1	
		2	
4(iii)	Using $v = 0$ at $t = 4.5$ and $t = 8$	B1	
		M1	Attempting to use area to find total distance travelled
	$\frac{1}{2} \times (4.5 + 2) \times 10$ $+ \frac{1}{2} \times (8 - 4.5) \times 15$ $+ \frac{1}{2} \times (T - 8) \times 15 = 100$	M1	For setting up an equation for total distance travelled and solving for T
	$T = 13.5$	A1	
		4	

Question	Answer	Marks	Guidance
5(i)	Acceleration = 0.4 m s^{-2}	B1	
		1	
5(ii)	$\frac{100}{t^2} - 0.1t = 0$	M1	For setting $v = 0$ and solving for t
	$t = 10 \text{ s}$	A1	
		2	
5(iii)	Distance $t = 0$ to $t = 5$ is $\frac{1}{2} (1.5 + 3.5) \times 5 = 12.5$	B1	Trapezium rule or integration
	$s(t) = \int \left(\frac{100}{t^2} - 0.1t \right) dt$	M1	For integration
	$= -\frac{100}{t} - 0.05t^2 (+C)$	A1	Correct integration
	$s(10) - s(5)$	M1	Use limits 5 and 10 used or find $+C$
	Total distance = $12.5 + 6.25 = 18.75 \text{ m}$	A1	
		5	

Question	Answer	Marks	Guidance
6(i)		M1	For resolving forces (either direction)
	$X = 75 + 50 \cos 60 (= 100)$ $Y = 50 \sin 60 (= 43.3)$	A1	For both equations, unevaluated
	Resultant = $\sqrt{(100^2 + 43.3^2)} = 109 \text{ N}$	B1	
	Angle = $\arctan \left(\frac{43.3}{100} \right) = 23.4^\circ$	B1	Must state anticlockwise from the positive x -axis or show in a diagram
		4	
6(ii)	$50 \cos \alpha - F \cos 50 = 0$	B1	Resolving forces horizontally
	$50 \sin \alpha - 3F - F \sin 50 = 0$	B1	Resolving forces vertically
	$\tan \alpha = \frac{(3F + F \sin 50)}{(F \cos 50)}$	M1	For division to find θ or for using Pythagoras to find F
	$\alpha = 80.3$	A1	
	$F = 13.1$	A1	
		5	

Question	Answer	Marks	Guidance
7(i)		M1	For applying Newton's 2nd law to either particle (correct number of terms)
	$T - 0.9 g \sin 15 = 0.9a$	A1	
	$2.5 + 0.4 g \sin 25 - T = 0.4a$	A1	
	$1.3a = 1.86\dots$	M1	Solving simultaneously for a
	$a = 1.43 \text{ m s}^{-2}$	A1	
		5	

Question	Answer	Marks	Guidance
7(ii)	$F = 0.8 \times 0.4g \cos 25$	B1	
	$2.5 + 0.4 g \sin 25 - T - F = 0$	M1	For using equilibrium of forces acting on particle <i>B</i> with 4 terms
	$T - 0.9 g \sin \theta = 0$	M1	For using equilibrium of forces acting on particle <i>A</i> with 2 terms
		M1	For solving for θ
	$\theta = 8.2^\circ$	A1	
		5	

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1(i)	$F = 0.2g \sin 20 = 0.684 \text{ N}$	B1	AG
		1	
1(ii)	$R = 0.2g \cos 20$	B1	
	$F = \mu R [= 0.6 \times 0.2g \cos 20]$	M1	Using $F = \mu R$ $F = 1.1276\dots$
	$[0.9 + 0.2g \sin 20 - F = 0.2a]$	M1	Use of Newton's 2nd law along the plane (4 relevant terms)
	$a = 2.28 \text{ ms}^{-2}$	A1	
		4	

Question	Answer	Marks	Guidance
2	<i>EITHER:</i>	(M1	Attempt to resolve (either direction with correct number of terms and dimensionally correct)
	$T \sin \theta + 120 \sin 45 = 15g$	A1	Resolving vertically
	$T \cos \theta = 120 \cos 45$	A1	Resolving horizontally
	$[\tan \theta = \frac{(15g - 120 \sin 45)}{(120 \cos 45)}$ or $T = \sqrt{65.15^2 + 84.85^2}]$	M1	For using division to find θ or for using Pythagoras to find T
	$\theta = 37.5$	A1	
	$T = 107$	A1)	
	<i>OR:</i> $\frac{120}{\sin(90 + \theta)} = \frac{T}{\sin 135} = \frac{15g}{\sin(135 - \theta)}$	(A1	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	A1	
	$T = 107$	A1	
		M1)	Attempt to use triangle of forces

Question	Answer	Marks	Guidance
	OR2: $\frac{T}{\sin 45} = \frac{15g}{\sin(45 + \theta)} = \frac{120}{\sin(90 - \theta)}$	(A1)	One correct equation
		A1	A second correct equation
		M1	Attempt to solve for θ or T
	$\theta = 37.5$	A1	
	$T = 107$	A1)	
	OR3: $[T^2 = 150^2 + 120^2 - 2(150)(120) \cos 45]$	(M1)	Use cosine rule in a triangle with sides 120, 150 and T and with corresponding angles $90 - \theta$, $45 + \theta$, 45
		A1	Correct equation
	$T = 107$	A1	
		M1	Use sin rule or cosine rule in an attempt to find θ
	$120/\sin(90 - \theta) = 106.97/\sin 45$	A1	A correct equation in θ such as this
	$\theta = 37.5$	A1)	
		6	

Question	Answer	Marks	Guidance
3(i)	$s_{AB} = 14 \times 5 + \frac{1}{2}a \times 5^2$	B1	or $s_{AB} = \frac{1}{2}(14 + 14 + 5a) \times 5$ OE
	$s_{AC} = 14 \times 8 + \frac{1}{2}a \times 8^2$	B1	or $s_{AC} = \frac{1}{2}(14 + 14 + 8a) \times 8$ OE
	$[112 + 32a = 2(70 + 12.5a)]$	M1	Using $AC = 2AB$ and solving for a or for substituting $a = 4$ and finding AB and AC
	$a = 4 \text{ m s}^{-2}$	A1	AG, If substituting $a = 4$ must show $AB = 120$ and $AC = 240$ OE
		4	
3(ii)	$[v = 14 + 4 \times 8]$	M1	Use of $v = u + at$ or any complete method to find v
	Velocity = 46 m s^{-1}	A1	
		2	

Question	Answer	Marks	Guidance
4(i)	$[12t - \frac{1}{2}gt^2 = 0]$ or $[0 = 12 - gT]$ with $t = 2T$ used	M1	Using $s = ut + \frac{1}{2}at^2$ or equivalent such as finding time T to highest point and doubling.
	$t = 2.4$ s	A1	
		2	
4(ii)	Critical point at $t = 1.2$	B1	Seen in 4(ii)
	Critical point at $t = 2$	B1	Seen in 4(ii)
	Both moving in same direction $1 < t < 1.2$	B1	
	Both moving in same direction $2 < t < 2.4$	B1	
		4	

Question	Answer	Marks	Guidance
5(i)	<i>EITHER:</i> Resistance force = $\frac{600}{25} = 24$ N	(B1)	
	Weight component = 80 g (0.04) = 32 N	B1	For correct unsimplified numerical form of the weight component
	[Power = 56×4]	M1	For use of $P = Fv$ where F is from two relevant force terms
	Power = 224 W	A1)	
		4	
	<i>OR:</i> PE gain = $80g \times 25$ (0.04) = 800	(B1)	For a correct unsimplified numerical expression for PE
	Time taken = $\frac{25}{4} = 6.25$	B1	
	[WD by cyclist = $P \times 6.25 = 800 + 600$]	M1	For using $WD = P \times t$ where WD is from two relevant terms
	Power = 224 W	A1)	
		4	

Question	Answer	Marks	Guidance
5(ii)	Work done by cyclist $= 224 \times 10 (= 2240\text{J})$	B1 FT	For stating $WD = \text{power} \times \text{time}$ FT on P value found in 5(i)
	Initial KE $= \frac{1}{2} \times 80 \times 4^2 [= 640\text{ J}]$	B1	
	$[\frac{1}{2} \times 80v^2 = 640 + P \times 10 - 1200]$	M1	For using Work/Energy equation
	Speed $= 6.48\text{ m s}^{-1}$	A1	Allow speed $= \sqrt{42}$
		4	

Question	Answer	Marks	Guidance
6(i)	$R = mg \cos \alpha$ ($R = 9.6m$)	B1	Allow use of $\alpha = 16.3^\circ$ throughout
	$[T = mg$ $F = mg \sin \alpha + T]$	M1	For resolving forces on P and Q and eliminating T or for considering the equilibrium of the system
	$F = mg \sin \alpha + mg$	A1	($F = 12.8m$)
		M1	For use of $F = \mu R$
	Coefficient of friction $= 1\frac{1}{3} = \frac{4}{3}$	A1	AG so must be from exact working
		5	

Question	Answer	Marks	Guidance
6(ii)	<i>EITHER:</i> P equation is $10 - mg \sin \alpha - F - T = 2.5 m$ Q equation is $T - mg = 2.5m$	(*M1	For applying Newton's 2nd law to P (5 terms) or Q (3 terms)
		*M1	For applying Newton's 2nd law to the other particle and eliminate T
	$10 - mg \sin \alpha - \mu mg \cos \alpha - mg = 2m (2.5)$	A1	If evaluated then this is $10 - 2.8m - 12.8m - 10m = 5m$
		DM1	For solving this equation for m as far as m = Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	A1)	Allow $m = \frac{50}{153}$
	<i>OR:</i> $[10 - mg \sin \alpha - F - mg = m(2.5 + 2.5)]$	(*M1	For applying Newton's 2nd law to the system. Allow with 5 terms
		*M1	System equation with all 6 terms
	$10 - mg \sin \alpha - \mu mg \cos \alpha - mg = 2m (2.5)$	A1	
		DM1	For solving this equation for m as far as m = Dependent on one or other of the previous M marks having been scored
	$m = 0.327$	A1)	Allow $m = \frac{50}{153}$
		5	

Question	Answer	Marks	Guidance
7(i)	$-0.01t(t^2 - 22t + 40) = 0$ $-0.01t(t - 20)(t - 2) = 0$	M1	Attempting to solve $v = 0$ for t for a solvable quadratic using factors or quadratic formula and obtaining two non-zero solutions
	$t = 2$ or $t = 20$	A1	
		2	
7(ii)	$a = -0.03t^2 + 0.44t - 0.4$	M1	For differentiation
	a is greatest (maximum) when $0.44 - 0.06t = 0$	M1	For differentiation or finding values of $t = t_1$ and $t = t_2$ where $a = 0$ and using $t = \frac{1}{2}(t_1 + t_2)$ or completing the square or other method to find maximum value
	Max acceleration when $t = 7.33$	A1	Allow $t = \frac{22}{3}$
		3	
7(iii)	$\int (-0.01t^3 + 0.22t^2 - 0.4t) dt$	*M1	For using integration.
	$s(t) = -\frac{0.01}{4}t^4 + \frac{0.22}{3}t^3 - 0.2t^2$	A1	Correct Integration Allow $+ C$ included
	$s(20) - s(2)$	DM1	Limits 2 and 20 used correctly Dependent on previous M1 having been scored
	Distance = 107 m	A1	Distance = $\frac{2673}{25} = 106.92$
		4	

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1	$(X=) 20 \cos 60 + 30 \cos 60 - F$	B1	
	$[F = 20 \cos 60 + 30 \cos 60]$	M1	Use of horizontal component of resultant = 0
	$F = 25$	A1	
		3	

Question	Answer	Marks	Guidance
2(i)	$[F = 1480 + 7850g \sin 3] (= 5588)$	M1	
	$[\frac{P}{10} = 1480 + 7850g \sin 3] \rightarrow P = \dots$	M1	Using $P = Fv$ and solving for P
	Power = 55 900 W	A1	
		3	
2(ii)	$[F + 7850g \sin 3 - 1480 = 7850 \times 0.8]$ $(F = 3652)$	M1	Use of Newton's Second Law
	$[\frac{P}{15} + 7850g \sin 3 - 1480 = 7850 \times 0.8]$ $\rightarrow P = \dots$	M1	Using $P = Fv$ and solving for P
	Power = 54800 W	A1	
		3	

Question	Answer	Marks	Guidance
3(i)	$R = mg \cos 25$	B1	
	$[F = 0.4mg \cos 25]$	M1	Using $F = \mu R$
	$[mg \sin 25 - 0.4mg \cos 25 = ma]$	M1	Use of Newton's Second Law
	$a = 0.601 \text{ ms}^{-2}$	A1	
		4	
3(ii)	$[s = \frac{1}{2} \times 0.601 \times 3^2]$	M1	Use of $s = ut + \frac{1}{2}at^2$
	Distance = 2.70 m	A1 FT	FT $4.5 \times a$ from (i)
		2	

Question	Answer	Marks	Guidance
4(i)	<i>EITHER:</i> [$T - 0.35g = 0.35a$ or $0.45g - T = 0.45a$ or $0.45g - 0.35g = 0.8a$]	(M1)	Applies Newton's Second Law to one of the particles or forms system equation in a ($m_B g - m_A g = (m_A + m_B)a$)
	[$0.45g - T = 0.45a$ or $T - 0.35g = 0.35a$] $\rightarrow a = \dots$	M1	Applies Newton's Second Law to form second equation in T and a and solves for a or solves system equation for a
	$a = 1.25 \text{ m s}^{-2}$	A1	
	[$v^2 = 2 \times 1.25 \times 0.64$] ($= 1.6$)	M1	Using $v^2 = u^2 + 2as$
	Velocity = 1.26 ms^{-1}	A1)	
	<i>OR:</i> [PE loss = $0.45g \times 0.64 - 0.35g \times 0.64$]	(M1)	Attempts PE loss
	[KE gain = $\frac{1}{2} (0.35 + 0.45) v^2$]	M1	Attempts KE gain
	PE loss = $0.45g \times 0.64 - 0.35g \times 0.64$ and KE gain = $\frac{1}{2} (0.35 + 0.45) v^2$	A1	
	[$\frac{1}{2} (0.8) v^2 = 0.1g \times 0.64$] ($v^2 = 1.6$)	M1	Using PE loss = KE gain
	Velocity = 1.26 ms^{-1}	A1)	
4(ii)		5	
	<i>EITHER:</i> [$0 = 1.6 - 2gs$] ($s = 0.08$)	(M1)	Using $v^2 = u^2 + 2as$
	Distance = 0.16 m	A1)	
	<i>OR:</i> [$0.35gh = \frac{1}{2} (0.35) \times 1.6$] ($h = 0.08$)	(M1)	Using PE gain = KE loss for particle A
	Distance = 0.16 m	A1)	
		2	

Question	Answer	Marks	Guidance
5(i)	$v = \int k(3t^2 - 12t + 2) dt$ $= k(3t^3/3 - 12t^2/2 + 2t) + C$	*M1	Use of $v = \int a dt$
	$v = k(t^3 - 6t^2 + 2t) + C$	A1	Condone C missing
	$C = 0.4$	B1	
	$0.1 = k(1 - 6 + 2) + 0.4 \quad [-0.3 = -3k]$	DM1	Substitutes $t = 1, v = 0.1$
	$k = 0.1$	A1	AG
		5	
5(ii)	$[s = \int 0.1(t^3 - 6t^2 + 2t) + 0.4 dt$ $= 0.1(t^4/4 - 6t^3/3 + 2t^2/2) + 0.4t + C]$	M1	Use of $s = \int v dt$
	$s = 0.025t^4 - 0.2t^3 + 0.1t^2 + 0.4t$	A1	$C = 0$ seen or implied
		2	
5(iii)	Substitutes $t = 2$ to show $s = 0$	B1	AG
		1	

Question	Answer	Marks	Guidance
6(i)	[Area = $\frac{1}{2}(10 + 4) \times 6 = 42$ m] Displacement = 42 m	B1	
		1	
6(ii)	$\frac{v}{2} = \frac{6}{4}$ or [gradient = 1.5, $v = 6 + 1.5 \times 6$]	M1	Using similar triangles or using acceleration = gradient and $v = u + at$
	$v = 3 \text{ ms}^{-1}$	A1	
		2	
6(iii)	Total distance travelled $= 42 + \frac{1}{2}(T - 10) \times 3$	B1 FT	Area found with FT distance from (i) and FT speed from (ii)
	$[42 + \frac{1}{2}(T - 10) \times 3 = 49.5] \rightarrow T = \dots$	M1	For equation and solving for T
	$T = 15 \text{ s}$	A1	
		3	

Question	Answer	Marks	Guidance
6(iv)	$V = 1.75 \times 4 = 7 \text{ ms}^{-1}$	B1	
	Q travels [$\frac{1}{2} (13 + 6) \times 7 = 66.5 \text{ m}$] Distance apart = [$66.5 + 42 - 7.5$]	M1	Finding area for Q and interpreting total distance between particles
	Distance between P and $Q = 101 \text{ m}$	A1	
		3	

Question	Answer	Marks	Guidance
7(i)	$R = 0.2g \cos 30 - T \sin 15$	B1	
	$[F = 0.3 \times (0.2g \cos 30 - T \sin 15)]$	M1	Use of $F = \mu R$
		M1	For resolving along the plane
	$T \cos 15 + 0.3 \times (0.2g \cos 30 - T \sin 15) = 0.2g \sin 30$	A1	
		M1	For solving a 4 term equation for T
	$T = 0.541$	A1	
		6	
7(ii)	$0.3 \times 0.2g \cos 30 \times 3 \quad [= 1.5588 \text{ J}]$	B1	WD against $F = \text{friction} \times \text{distance}$
	WD = $0.25 \times 3 \quad [= 0.75 \text{ J}]$	B1	WD against 0.25 force
	$0.2g \times 3 \sin 30 \quad [= 3 \text{ J}]$	B1	PE loss = mgh
	$[\frac{1}{2} (0.2) v^2 = 3 - 1.5588 - 0.75]$	M1	Work/Energy equation
	Speed = 2.63 ms^{-1}	A1	
		5	