



Cambridge International AS & A Level

MATHEMATICS

9709/41

Paper 4 Mechanics

May/June 2020

MARK SCHEME

Maximum Mark: 50

Published

Students did not sit exam papers in the June 2020 series due to the Covid-19 global pandemic.

This mark scheme is published to support teachers and students and should be read together with the question paper. It shows the requirements of the exam. The answer column of the mark scheme shows the proposed basis on which Examiners would award marks for this exam. Where appropriate, this column also provides the most likely acceptable alternative responses expected from students. Examiners usually review the mark scheme after they have seen student responses and update the mark scheme if appropriate. In the June series, Examiners were unable to consider the acceptability of alternative responses, as there were no student responses to consider.

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This document consists of **12** printed pages.

Generic Marking Principles

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Marks awarded are always **whole marks** (not half marks, or other fractions).

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Mathematics Specific Marking Principles	
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WWW	Without Wrong Working
AWRT	Answer Which Rounds To

Question	Answer	Marks
1	Resultant = $100 - 2 \times 50 \cos \alpha$	M1
	20 N	A1
	Direction is to the left (or equivalent)	B1
		3

Question	Answer	Marks
2(a)	$[T - 100 = 400 \times 1.5]$	M1
	$T = 700 \text{ N}$	A1
		2
2(b)	$F - 250 - 100 = 2200 \times 1.5$ ($F = 3650 \text{ N}$) (M1 for using Newton's second law for the system or for the car using the result from 2(a))	M1
	For use of power = Fv	M1
	73 000 W or 73 kW	A1
		3

Question	Answer	Marks
3(a)	$0 = 5^2 - 2gs$	M1
	$s = 1.25$	A1
	[Height above ground =] 4.05 m	A1
		3
3(b)	Use of $s = ut + \frac{1}{2}at^2$	M1
	$0.8 = 5t - 5t^2$	A1
	$t = 0.2$ or 0.8	M1
	Length of time = 0.6 s	A1
		4

Question	Answer	Marks
4(a)	Resolving forces in either direction	M1
	$R = T \sin 30 + 0.1g$, $F = T \cos 30$	A1
	$T \cos 30 = 0.8 (T \sin 30 + 0.1g)$	M1
	$T = 1.72$ (1.7166...)	A1
		4
4(b)	$R = 3 \sin 30 + 0.1g$	B1
	$3 \cos 30 - 0.8(3 \sin 30 + 0.1g) = 0.1a$	M1
	$a = 5.98 \text{ ms}^{-2}$ (5.9807...)	A1
		3

Question	Answer	Marks
5(a)	Attempt at finding PE lost	M1
	PE lost = $35g(4\cos 22.5 - 4\cos 45)$	A1
	$\frac{1}{2} \times 35v^2 = 35g(4\cos 22.5 - 4\cos 45)$	M1
	Speed = 4.16 ms^{-1} (4.1643...)	A1
		4
5(b)	Use of the work-energy equation in the form: PE lost = KE gain + WD against resistance	M1
	$\frac{1}{2} \times 35 \times 4^2 = 35g(4 - 4\cos 45) - X$	A1
	$X = 130$ (130.05...)	A1
		3

Question	Answer	Marks
6(a)	$\int k(t^2 - 10t + 21)dt$	M1
	$s = k\left(\frac{1}{3}t^3 + 5t^2 + 21t\right) + C$	A1
	$2.85 = k\left(\frac{1}{3} \times 3^3 - 5 \times 3^2 + 21 \times 3\right) + C$ or $2.4 = k\left(\frac{1}{3} \times 6^3 - 5 \times 6^2 + 21 \times 6\right) + C$	M1
	$2.85 = 27k + C$, $2.4 = 18k + C$ (A1 for both)	A1
	Solving for k	M1
	$k = 0.05$	A1
	$s = 0.05\left(\frac{1}{3}t^3 - 5t^2 + 21t\right) + 1.5$	A1
		7
6(b)	Differentiating v or completing the square for v	M1
	$a = 0.05(2t - 10)$	A1
	Min value of v is at $t = 5$.	M1
	Displacement at $t = 5$ is 2.58 m (2.5833...)	A1
		4

Question	Answer	Marks
7(a)	$0.3g \sin 30 = 0.3a$ ($a = 5$) (M1 for applying Newton's second law parallel to the plane)	M1
	$v^2 = 0 + 2 \times 2.5 \times a$	M1
	$v = 5$	A1
	$0.3 \times 5 + 0 = 0.3 \times 2 + 0.2 w$	M1
	Velocity of $Q = 4.5 \text{ ms}^{-1}$	A1
		5

Question	Answer	Marks
7(b)	$0.3 \times z + 0 = 0.5 \times 1.2$	M1
	Velocity of P before collision $z = 2$	A1
	Friction force on P after reaches horizontal plane $F = \mu \times 0.3 g$	B1
	$\mu \times 0.3g \times 1.5 = \frac{1}{2} \times 0.3 \times 5^2 - \frac{1}{2} \times 0.3 \times 2^2$	M1
	Coefficient $\mu = 0.7$	A1
	Alternative method for question 7(b)	
	$0.3 \times z + 0 = 0.5 \times 1.2$	M1
	Velocity of P before collision $z = 2$	A1
	Friction force on P after reaches horizontal plane $F = \mu \times 0.3 g$	B1
	$a = (5^2 - 2^2) / (2 \times 1.5) = 7, F = 0.3 \times 7$	M1
	Coefficient $\mu = 0.7$	A1
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Question	Answer	Marks
1(a)	Trapezium, deceleration steeper than acceleration	B1
	Time from 0 to 200	B1
		2
1(b)	$0.5(170 + 200)v = 2775$	M1
	$v = 15$	A1
		2
1(c)	$a = 15 \div 20$	M1
	$a = 0.75$	A1
		2

Question	Answer	Marks
2	Resolving forces in either direction	M1
	$20 \cos \theta = 4P \cos 30$	A1
	$4P + 2P \sin 30 = 20 \sin \theta$	A1
	$\cos \theta = \frac{\sqrt{3}}{10} P$ $\sin \theta = \frac{P}{4}$ $\frac{3}{100} P^2 + \frac{1}{16} P^2 = 1$	M1
	$P = 3.29$	A1
	$\theta = 55.3$	A1
		6

Question	Answer	Marks
3	$T \sin 60 + R = 25 \cos 20$	B1
	Attempt at resolving in any direction	M1
	$T \cos 60 = F + 25 \sin 20$	A1
	$T \cos 60 + F = 25 \sin 20$	A1
	Use of $F = \mu R$	M1
	$T \cos 60 = 25 \sin 20 \pm 0.3(25 \cos 20 - T \sin 60)$ $T = \frac{25 \sin 20 \pm 0.3 \times 25 \cos 20}{\cos 60 \pm 0.3 \sin 60}$	M1
	$T = 6.26$	A1
	$T = 20.5$	A1
		8

Question	Answer	Marks
4(a)	$4 \times 10 [+0] = 4 \times 0.5v + 2v$	M1
	$v_A = 5$ and $v_B = 10$	A1
		2
4(b)	Conservation of momentum <i>B, C</i> $2 \times 10 [+0] = 2 \times v + 3v$	M1
	$v = 4$	A1
	$v_A > v_B$, hence another collision	A1
		3
4(c)	Conservation of momentum <i>A, B</i>	M1
	$4 \times \text{their } 5 + 2 \times \text{their } 4 = 4v + 2v \quad v = \frac{14}{3} \text{ (ms}^{-1}\text{)}$	A1
	KE initial = $\frac{1}{2} \times 4 \times 10^2$	M1
	KE final = $\frac{1}{2} \times 6 \times \text{their } \left(\frac{14}{3}\right)^2 + \frac{1}{2} \times 1 \times \text{their } 12^2$	A1
	Loss of KE = $200 - \frac{412}{3} = \frac{188}{3}$	A1
		5

Question	Answer	Marks
5(a)(i)	$DF = 750$	B1
	Power = <i>their</i> (750) × 32 = 24kW	B1 FT
		2
5(a)(ii)	$16000 = DF \times 32$ $DF = 500$	M1
	$500 - 750 = 1250 \times a$	M1
	$a = [-]0.2$	A1
		3
5(b)	$DF = 1000 + 8v + 1250 \times 10 \times 0.096$	M1
	$2200 + 8v$	A1
	$60000 = (2200 + 8v)v$	M1
	$8v^2 + 2200v - 60000 = 0$	A1
	$v = 25$	A1
		5

Question	Answer	Marks
6(a)	Correct for $0 \leq t \leq 5$	B1
	Correct for $5 \leq t \leq 7$	B1
	Correct for $7 \leq t \leq 13.5$	B1
		3
6(b)	$a = -2t$ by differentiating	M1
	$a = -12$	A1
		2
6(c)	$s = \int_0^5 (2t+1)dt + \int_5^6 (36-t^2)dt + \left \int_6^7 (36-t^2)dt + \int_7^{13.5} (2t-27)dt \right $	M1
	$s = \int_0^5 (2t+1)dt + \int_5^6 (36-t^2)dt + \left \int_6^7 (36-t^2)dt + \int_7^{13.5} (2t-27)dt \right $	A1
	$s = [t^2 + t] + [36t - \frac{t^3}{3}] + t^2 - 27t$	M1
	All correct	A1
	$s = 84.25$	A1
		5



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Question	Answer	Marks
1	Use of conservation of momentum	M1
	$m \times 2 + 0 = m \times (-0.5) + 0.2 \times 1$	A1
	$m = 0.08$	A1
		3

Question	Answer	Marks
2(a)	$F - 900 = 4000 \times 0.5$ (M1 for use of Newton's second law, 3 terms)	M1
	$F = 2900 \text{ N}$	A1
2(b)	900×25 (M1 for use of $P = Fv$ with $F = \text{resistance only}$)	M1
	22 500 W or 22.5 kW	A1

Question	Answer	Marks
3	Attempt to resolve, either direction with correct number of terms	M1
	$F\cos\alpha = 40\sin 30 + 20\sin 60 - 50\sin 45 (= 1.965\dots)$	A1
	$F\sin\alpha = 50\cos 45 + 20\cos 60 - 40\cos 30 (= 10.714\dots)$	A1
	Method for either F or α	M1
	$F = \sqrt{((1.965\dots)^2 + (10.714\dots)^2)} = 10.9(10.893)$	A1
	$\alpha = \tan^{-1}(10.714\dots / 1.965\dots) = 79.6 (79.606\dots)$	A1
		6

Question	Answer	Marks
4(a)	Trapezium shape with gradient of right-hand side approximately 2 times left side	B1
		1
4(b)	Constant velocity = $500/25 = 20 \text{ ms}^{-1}$	B1
	$20^2 = 0 + 2a \times 50$	M1
	$a = 4$	A1
		3
4(c)	Time to accelerate = $20/4 = 5 \text{ s}$	B1
	Deceleration time = 2.5 s	B1
	So total time = $5 + 25 + 2.5 = 32.5 \text{ s}$	B1
		3

Question	Answer	Marks
5(a)	Decrease in KE = $\frac{1}{2} \times 4 \times (12^2 - 8^2)$	M1
	160 J	A1
		2
5(b)	PE gained = $4g \times 10 \sin 30$ (= 200)	B1
	Total work done = $200 - 160$	M1
	Total work done = 40 J	A1 FT
		3
5(c)	$-4g \sin 30 = 4a$	M1
	$a = -5$	A1
	$-10 = 8t - \frac{1}{2} \times 5t^2$	M1
	$t = 4.16 \text{ s}$	A1
		4

Question	Answer	Marks
6(a)	$a = 4 - t$ (M1 for differentiation)	M1
	When $a = 0$, $t = 4$	A1
	At $t = 4$, $v = 12.5$	A1
		3
6(b)	Velocity = 0 when $4.5 + 4t - 0.5t^2 = 0$	M1
	$t = 9$ (reject $t = -1$)	A1
	$\int (4.5 + 4t - 0.5t^2) dt$	M1
	$4.5t + 2t^2 - \frac{1}{6}t^3 [+c]$	A1
	Apply limits (0 and 9)	M1
	Distance = 81 m	A1
		6

Question	Answer	Marks
7(a)	$T - 2mg = 0$	B1
	$3mg \sin \theta - T = 0$ (M1 for resolving forces parallel to the plane and solving for θ)	M1
	$\theta = 41.8$ (41.810...)	A1
		3
7(b)	$R = 3mg \cos 30$	B1
	Use of $F = \mu R$	M1
	$2mg - T = 0.1 \times 2m$ OR $T - 3mg \sin 30 - \mu \times 3mg \cos 30 = 0.1 \times 3m$	M1
	$2mg - 0.2m - 3mg \sin 30 - \mu \times 3mg \cos 30 = 0.1 \times 3m$	M1
	$\mu = \frac{\sqrt{3}}{10}$	A1
		5
7(c)	$v^2 = 0 + 2 \times 0.1 \times 0.8$ ($v = 0.4$)	M1
	$-3mg \sin 30 - \mu \times 3mg \cos 30 = 3ma$ ($a = -6.5$)	M1
	$0 = -0.4 - 6.5t$	M1
	$t = 0.4/6.5 = 0.0615$ s	A1
		4