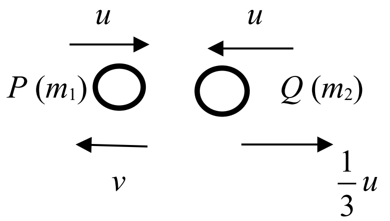
Mark Scheme (Results)

January 2020

Pearson Edexcel International GCE
in Mechanics M1 (WME01) Paper 01

Jan 2020 WME01
Final

Question Number	Scheme	Marks
1(a)		
	$\pm m_2\left(\frac{1}{3}u - -u\right)$	M1 A1
	$\frac{4m_2u}{3}$	A1 (3)
(b)	CLM: $m_1u - m_2u = -m_1v + m_2\frac{1}{3}u$ **OR** $\frac{4m_2u}{3} = m_1(v - -u)$	M1 A1
	$\frac{u(4m_2 - 3m_1)}{3m_1}$ oe	A1
		(3)
(c)	$\frac{u(4m_2 - 3m_1)}{3m_1} > 0$	M1
	$(4m_2 - 3m_1) > 0 \Rightarrow 4m_2 > 3m_1 \Rightarrow m_2 > \frac{3}{4}m_1$ * **Given answer**	A1*
	N.B. If they use $-v$ in (b), can score M1 for $-v < 0$ and possibly A1.	(2) **(8)**
	Notes for question 1	
1(a)	M1 for impulse-momentum principle applied to Q ; condone sign errors but must be using m_2 for mass and subtracting momenta M0 if it's dimensionally incorrect e.g if g is included.	
	First A1 for $\pm m_2\left(\frac{1}{3}u - -u\right)$	
	A1 Correct answer, must be positive and a single term (Allow fraction replaced by a decimal to at least 2 SF)	
(b)	M1 CLM , with usual rules (allow consistent extra g's), or impulse-momentum principle applied to P, using their answer from (a) which must be in terms of m_2 and u (but allow consistent extra g's)	
	A1 Correct equation (allow consistent use of $-v$ instead of v)	
	A1 Correct answer only. Any equivalent expression with m_2 terms collected (Allow fraction replaced by a decimal to at least 2 SF)	
(c)	M1 Correct inequality for their v, containing u. **N.B**. Their first statement must include u **and** > 0 or < 0 as appropriate	
	A1* Correct given answer correctly obtained. **N.B.** $\frac{3}{4}m_1 < m_2$ is A0	

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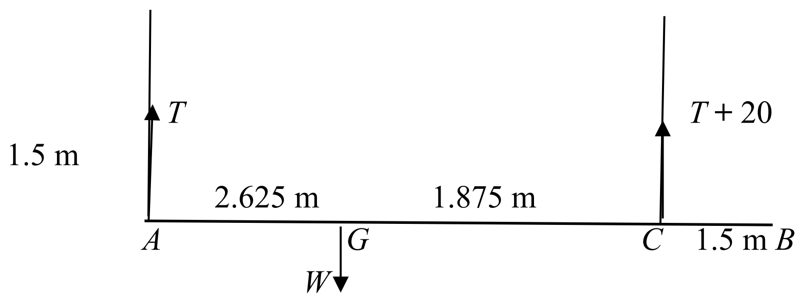
2.	 	
(a)	<u>Any two of these</u> $T + (T + 20) = W$ $M(A),\quad 4.5(T + 20) = 2.625W$ $M(G),\quad 2.625T = 1.875(T + 20)$ $M(C),\quad 4.5T = 1.875W$ $M(B),\quad 6T + 1.5(T + 20) = 3.375W$ **N.B.** The A marks and the DM1 can **only** be scored if the candidate is using T **and** $T + 20$ or T **and** $T - 20$ in **both** equations. **N.B.** Can score M1A1 for a correct vertical resolution, even if T and T +20 are the wrong way round. **N.B.** If they just use T_A and T_C, can score max M1A0 M1A0DM0A0 If they assume that $T_A = T_C$, can score max M1A0 M1A0DM0A0 If they assume that the tensions are T and 20, can score max M1A0 M1A0 DM0A0 If they use T and $20T$, can score max M1A0 M1A0DM0A0 **N.B.** If it's not clear from their working which way round they have the two tensions, use their diagram to decide.	M1 A1 M1 A1
	Solve for W	DM1
	$W = 120$	A1
		(6)
(b)	The beam remains straight,or rigid, or in a straight line or 1-dimensional or it doesn't bend	B1 (1)
		(7)
	Notes for question 2	
(a)	M1 First equation (vertical resolution or moments) with usual rules	
	A1 Correct equation (T may be replaced by $T - 20$)	
	M1 Second equation (vertical resolution or moments) with usual rules	
	A1 Correct equation (T may be replaced by $T - 20$)	
	DM1 Dependent on previous two M marks, for solving for W	
	A1 cao	
(b)	B1 any appropriate comment. **N.B.** Penalise incorrect extras.	

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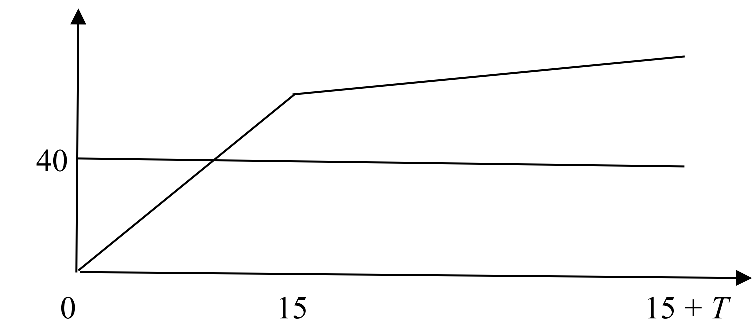
3.	Allow a numerical value of g used anywhere apart from the final A marks in (a) and (b) but penalise use of $g = 9.81$ once for whole question	
(a)	$0^2 = U^2 - 2gH$	M1
	$H = \dfrac{U^2}{2g}$	A1
		(2)
(b)	$s_P = \frac{1}{2}gt^2$ **OR** $s_P = Ut - \frac{1}{2}gt^2$	M1A1
	$s_Q = \frac{1}{2}Ut - \frac{1}{2}gt^2$ $\quad$ $s_Q = \frac{1}{2}U(t - \frac{U}{g}) - \frac{1}{2}g(t - \frac{U}{g})^2$	M1A1
	$s_P + s_Q = H$ $\quad$ $s_P = s_Q$ $\Rightarrow \frac{1}{2}Ut = \frac{U^2}{2g}$ $\quad$ $\Rightarrow Ut - \frac{1}{2}gt^2 = \frac{1}{2}U(t - \frac{U}{g}) - \frac{1}{2}g(t - \frac{U}{g})^2$	M1
	$t = \frac{U}{g}$ $\quad$ Answer $= (t - \frac{U}{g}) = \frac{U}{g}$	A1
		(6)
(c)	$s_P = \frac{1}{2}g\left(\frac{U}{g}\right)^2$ **OR** $s_P = U(\frac{2U}{g}) - \frac{1}{2}g(\frac{2U}{g})^2$ or $s_Q = \frac{1}{2}U\left(\frac{U}{g}\right) - \frac{1}{2}g\left(\frac{U}{g}\right)^2$ $\quad$ or $s_Q = \frac{1}{2}U\left(\frac{U}{g}\right) - \frac{1}{2}g\left(\frac{U}{g}\right)^2$	M1 A1
	Collide at the point O or at the point of projection. (At the same level as O is A0)	A1
		(3)
		(11)
	Notes for question 3	
3(a)	M1 Complete method to find an equation in H, U and g *only* .Condone sign errors	
	A1 Correct expression for H in terms of U and g. (A0 if they use h or s in their answer but allow for the M mark)	
3(b)	**N.B.** When awarding marks, must use EITHER the LH column OR the RH column, **not** a mixture of both. Award as many marks as possible. M1 Complete method to find s_P in terms of t, where $t = 0$ is when Q is projected upwards. The alternative arises when $t = 0$ is taken to be when P is projected *upwards*. Condone sign errors.	
	A1 Correct equation (using their H where it is used) Allow: $s_P = \frac{1}{2}gt^2$ or $s_P = -\frac{1}{2}gt^2$ or $s_P = H - \frac{1}{2}gt^2$ or $s_P = -(H - \frac{1}{2}gt^2)$	

Question Number	Scheme	Marks
	or $s_P = U(t+\frac{U}{g}) - \frac{1}{2}g(t+\frac{U}{g})^2$	
	M1 Complete method to find s_Q in terms of t. Condone sign errors.	
	A1 Correct equation (using their H where it is used) Allow: $s_Q = \frac{1}{2}Ut - \frac{1}{2}gt^2$ or $s_Q = -(\frac{1}{2}Ut - \frac{1}{2}gt^2)$ Or $s_Q = H - (\frac{1}{2}Ut - \frac{1}{2}gt^2)$ or $s_Q = -(H - (\frac{1}{2}Ut - \frac{1}{2}gt^2))$	
	M1 Use of $s_P + s_Q = H$ oe **OR** $s_P = s_Q$ oe to obtain a CORRECT equation in t, U and g *only*	
	A1 Correct expression for t in terms of U and g.	
3(c)	M1 Sub their t value, provided it's POSITIVE, into their equation for s_P or s_Q	
	A1 Correct <u>unsimplified</u> expression	
	A1 Correct conclusion	

Question Number	Scheme	Marks
4(a)	$2T\sin\beta = 3mg$ OR $\dfrac{T}{\sin(90^o-\beta)} = \dfrac{3mg}{\sin 2\beta}$	M1
	$T = \dfrac{3mg}{2\sin\beta}$ OR $T = \dfrac{3mg\cos\beta}{\sin 2\beta}$	A1
		(2)
(b)	For *A* or *B*: $(\uparrow)$ $R = mg + T\sin\beta$ OR For whole system: $(\uparrow)$ $2R = 3mg + mg + mg$ OR For *AC* or *BC*: $(\uparrow)$ $R + T\sin\beta = mg + 3mg$	M1 A1
	$R = 2.5mg$	A1
		(3)
(c)	$F = T\cos\beta$	M1A1
	$F = \dfrac{4}{5}\times 2.5mg$	B1 **ft**
	Eliminate *T* and solve for $\tan\beta$	M1
	$\tan\beta = \dfrac{3}{4}$	A1
		(5)
		(10)
	Notes for question 4	
4(a)	M1 Resolve vertically for *C* with usual rules or use triangle of forces	
	A1 Answer. Allow $\cos(90^o-\beta)$ for $\sin\beta$ or $\sin(90^o-\beta)$ for $\cos\beta$	
4(b)	M1 Resolve vertically for *A* or *B,* for whole system or for *AC* or *BC* with usual rules	
	A1 Correct equation	
	A1 Correct answer	
4(c)	M1 Resolve horizontally for *A* with usual rules	
	A1 Correct equation	
	B1 **ft** for $F = \dfrac{4}{5}\times$ their R (allow magnitude if $R < 0$) seen anywhere (B0 for just $F = 4/5\ R$)	
	M1 Eliminate *T* and solve for $\tan\beta$ *correctly*.	
	A1 $\dfrac{3}{4}$ oe	

Question Number	Scheme	Marks
5(a)		B1 shape B1 40, 15, 15+T Correctly Placed (2)
5(b)	$40 = 4t_1 \Rightarrow t_1 = 10$	M1 A1 (2)
5(c)	60 (m s^{-1})	B1
	$60 + T$ (m s^{-1})	B1 **ft**
	$\frac{1}{2}\times 15\times 60+\frac{1}{2}T(60+60+T)=40(15+T)$ **OR** $\frac{1}{2}\times 15\times 60+60T+\frac{1}{2}T\times T=40(15+T)$ **OR** $\frac{1}{2}(T+T+15)\times 60+\frac{1}{2}T\times T=40(15+T)$	M1 A2
	$T^2+40T-300=0$; $(k=40)$	A1
		(6) **(10)**
	Notes for question 5	
5(a)	B1 Correct graph shapes on same axes with intersection, a horizontal line and 2 lines, both with positive gradient, the second less steep than the first and both ending at the same t-value. B0 for a solid vertical line at the end but allow intermediate solid vertical lines.	
	B1 Figs. correctly placed. Allow appropriate delineators.	
5(b)	M1 Complete method to give an equation in t_1 only	
	A1 $t_1 = 10$	
5(c)	B1 60 m s^{-1} seen	
	B1 **ft** 60 + T seen or <u>implied</u>; ft on their graph (i.e. on their interpretation of T) **N.B.** If they use $s=ut+\frac{1}{2}at^2$, 60 + T is not needed	
	M1 Equating distances to give an equation in T *only*, with correct structure (e.g. M0 if a '½' is omitted or a 'section' is omitted but give BOD where possible e.g. treat middle term below as an attempt at a trapezium, with 60 and T as the parallel sides $\frac{1}{2}\times 15\times 60+\frac{1}{2}T(60+T)=40(15+T)$ B1B0M1A1A0A0)	
	A2 Correct unsimplified equation -1 e.e.	
	A1 Correct quadratic with $k = 40$	
	N.B. If they take T to be the end of the time period (instead of 15 + T), can score max: (a) B1B0 (b) M1A1 (c) B1B1ft M1A0A0A0 where T is replaced consistently by $(T-15)$ in the scheme above.	

Question Number	Scheme	Marks
6(a)	Magnitude = $\sqrt{10^2+1^2} = \sqrt{101}$ (N)	M1A1
		(2)
6(b)	$\tan\alpha = \frac{1}{10}$	M1
	$45°$	B1
	Angle $= 45° - \alpha = 39.289\ldots$ Accept $39°$ or better	M1 A1 (4)
	ALTERNATIVE 1 Scalar Product	
	$(10\mathbf{i}+\mathbf{j}).(\mathbf{i}+\mathbf{j}) = \sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$(10\mathbf{i}+\mathbf{j}).(\mathbf{i}+\mathbf{j}) = 11$	B1
	$11 = \sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$\theta = 39^O$ *or better*	A1 (4)
	ALTERNATIVE 2 Cosine Rule	
	$(10^2+1^2)+(1^2+1^2)-2\sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$(10\mathbf{i}+\mathbf{j})-(\mathbf{i}+\mathbf{j}) = 9\mathbf{i}$ or $(\mathbf{i}+\mathbf{j})-(10\mathbf{i}+\mathbf{j}) = -9\mathbf{i}$	B1
	$9^2 = (10^2+1^2)+(1^2+1^2)-2\sqrt{10^2+1^2}.\sqrt{1^2+1^2}\cos\theta$	M1
	$\theta = 39^O$ *or better*	A1 (4)
6(c)	$(10\mathbf{i}+\mathbf{j}) + (-15\mathbf{i}+a\mathbf{j}) = -5\mathbf{i}+(a+1)\mathbf{j}$	B1
	$\frac{a+1}{-5} = \frac{-3}{2}$	M1A1
	Solve for a	M1
	$a = 6.5$	A1
		(5)
		(11)
	Notes for question 6	
6(a)	M1 Use of Pythagoras	
	A0 if they *only* give a decimal	
6(b)	M1 For any relevant trig ratio for α or ($90°-\alpha$)	
	B1 $45°$ seen	
	M1 Finding the difference between $45°$ and α or ($90°-\alpha$) and $45°$	
	A1 Accept $39°$ or better	
6(c)	B1 Adding the two forces **and** collecting **i**'s and **j**'s. Seen or implied.	
	M1 For producing an equation in *a only* e.g. using ratios from their resultant (M0 if no resultant attempted and M0 if equation comes from *equating* their resultant to (2**i** – 3**j**). Condone sign error but M0 if ratio is upside down.	
	A1 Correct equation in *a* only	
	M1 Solve for *a* . This is an independent M mark but their equation must have come from a ratio equation obtained from using their resultant	
	A1 $a = 6.5$	

Question Number	Scheme	Marks
7(a)	$1.4 = \frac{1}{2}a \times 2^2$	M1
	$a = 0.7\ (\text{m s}^{-2})$ * **GIVEN ANSWER**	A1*
		(2)
7(b)	Inextensibility of string	B1
		(1)
7(c)	$3g - T = 3 \times 0.7$ (for B)	M1 A1
	Resultant = $2T\cos 45^o$ **OR** $= \sqrt{T^2 + T^2}$ **OR** $= \frac{T}{\cos 45^o}$	M1
	= 39 or 38.6 (N)	A1
		(4)
7(d)	$T - F = 4 \times 0.7$ (for A) **OR** $3g - F = 7 \times 0.7$ (whole system)	M1 A1
	$R = 4g$; $F = \mu \times R$	B1; B1
	$27.3 - \mu \times 4g = 4 \times 0.7$ **OR** $3g - \mu \times 4g = 7 \times 0.7$	**D**M1
	$\mu = 0.625$ or 0.63	A1
		(6)
7(e)	$v = 0.7 \times 2$ or $v = \sqrt{2 \times 0.7 \times 1.4}$	M1
	$-\mu \times 4g = 4a$	M1
	$0^2 = 1.4^2 - 2 \times \frac{5g}{8}s$	M1
	$s = 0.16$ or 0.159	A1
	0.16 + 1.4 < 2 => Does not reach pulley	A1 **cso**
		(5)
	ALTERNATIVE for final 3 marks:	**(18)**
	$v^2 = 1.4^2 - 2 \times \frac{5g}{8} \times 0.6$	M1
	$= -5.39$ or -5.4488	A1
	Since v^2 must be ≥ 0, does not reach pulley	A1 **cso**
	Notes for question 7	
7(a)	M1 Complete method to obtain an equation in a only. *Allow verification*	
	A1* Given answer correctly obtained or *verification completed correctly.*	
7(b)	B1 B0 if any extras given.	
7(c)	M1 Equation of motion for B with usual rules	
	A1 Correct equation	
	M1 for correct expression in terms of T	
	A1 39 or 38.6 (N)	
7(d)	M1 Equation of motion for A or whole system, with usual rules	
	A1 Correct equation	
	B1 $R = 4g$	
	B1 $F = \mu R$	
	DM1 Solving to give equation in μ only. Dependent on first M1	

Question Number	Scheme	Marks
	N.B. DM0 if they use $T = 3g$	
	A1 0.625 or 0.63 (5/8 is A0)	
7(e)	M1 Finding the speed or speed^2 of either particle when B hits the floor	
	M1 Equation of motion for A. Allow without the -ve sign.	
	M1 Complete method to find distance moved by A until it stops, condone sign error. **N.B.** This is an independent M mark but M0 if they have not found a new deceleration.	
	A1 Correct distance	
	A1 cso Correct conclusion correctly reached. Must see ‘ < 2’ or use 2 in their working	
	ALTERNATIVE for final 3 marks:	
	M1 Complete method to find v^2 where v is speed with which it would hit the pulley, condone sign error. **N.B.** This is an independent M mark but M0 if they have not found a new deceleration	
	A1 Correct value for v^2	
	A1 cso	