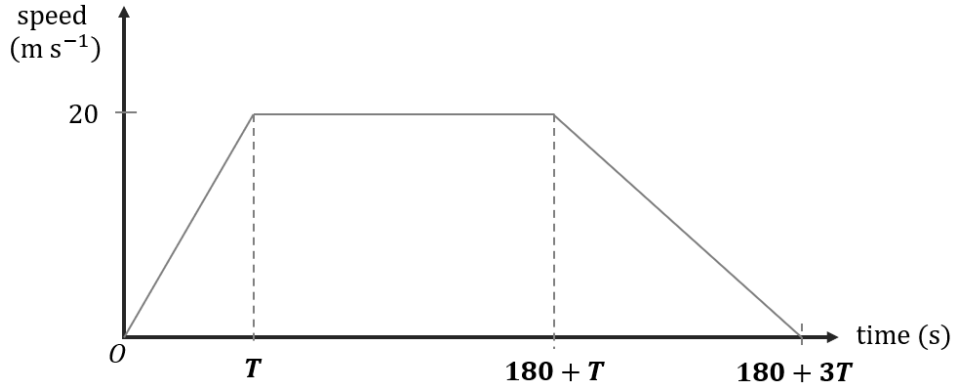
Pearson
Edexcel

Mark Scheme (Results)

January 2023

Pearson Edexcel International Advanced Level
In Mechanics M1 (WME01) Paper 01

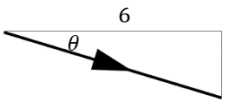
Question Number	Scheme	Marks
1(a)		B1 shape B1 20 B1 T, T+180, 3T+180
		(3)
1(b)	T and $2T$ seen or implied, for acceleration and deceleration in that order	B1
	Any of: $4800 = \left(\frac{20\times T}{2}\right) + (180\times 20) + \left(\frac{20\times 2T}{2}\right)$ $4800 = \left(\frac{20\times T}{2}\right) + \frac{1}{2}\times 20(180 + (180 + 2T))$ $4800 = \frac{1}{2}\times 20(180 + T + 180) + \left(\frac{20\times 2T}{2}\right)$ $4800 = \frac{1}{2}\times 20(180 + 3T + 180)$ $4800 = 20\times(180 + 3T) - \left(\frac{20\times T}{2}\right) - \left(\frac{20\times 2T}{2}\right)$	M1 A1 A1
	$T = 40$ (allow t)	A1
		(5)
1(c)	20 = a x their T oe	M1
	Acceleration = $\frac{1}{2}\left(\text{m s}^{-2}\right)$	A1 **ft**
		(2)
		(10)

NOTES

(a) **B1**	Correct shape with acceleration steeper than deceleration (**ignore** entries on the axes).
B1	Correct vertical label.
B1	Correct horizontal labels. Accept use of their T or appropriately labelled delineators.

(b)		
B1	Correct relationship seen or implied between the time accelerating and the time decelerating.	
M1	**A clear attempt** to use the total area under the graph (or use *suvat* formulae) and equate to 4800 (or 4.8) to form an equation in T only or their unknown only (e.g. replace T by $\frac{20}{a}$). Must involve a triangle or a trapezium (M0 if they use a *single suvat* formula for the whole motion)	
A1	An equation with at most one error. (use of 3 instead of 180 is one error) Having T and $2T$ round the wrong way, treat as one error	
A1	A fully correct equation	
A1	cao **N.B.** If attempting to use a single trapezium, and '180' appears in the bracket i.e. $\frac{1}{2}\times 20('T \text{ terms}' + 180)$, allow at least M1A1 for one correct parallel side. **N.B.** $\frac{1}{2}\times 20(x + 180) = 4800$ => $x = 300$ ONLY scores B0M1A1A0A0	
(c)		
M1	Correct equation in a, using their T	
A1 ft	Correct answer, follow through on their '40'	

Question Number	Scheme	Marks
2(a)	Correct relationship between the speeds after the collision. v and $v+1$ OR $w-1$ and w	B1
	$(3m\times 1.5)+(m\times -1.5)=3mv+m(v+1)$ [Or $(3m\times 1.5)+(m\times -1.5)=3m(w-1)+mw$]	M1 A1
	Speed of $A=\frac{1}{2}$ (m s^{-1}) Speed of $B=\frac{3}{2}$ (m s^{-1})	A1 A1
		(5)
2(b)	For B: $\pm m(1.5--1.5)$ **OR** For A: $\pm 3m(0.5-1.5)$	M1 A1**ft**
	$3m$ (Ns)	A1
		(3)
		(8)
	NOTES	
(a) **B1** **M1** **A1** **A1** **A1** **(b)** **M1** **A1ft** **A1**	*speed* of B = 1 + *speed* of A . Must be seen **before** the CLM equation is used i.e. algebraic not numerical quantities Dimensionally correct CLM equation with correct number of terms. Allow consistent extra g 's or cancelled m 's. Ignore sign errors. Allow the use of 2 unknowns for speeds after. (M0 if same speeds) Correct equation in 1 unknown Correct speed of A Correct speed of B Dimensionally correct impulse-momentum equation using A or B with correct number of appropriate terms. Condone sign errors but must be difference of momenta. M0 if g is included. Correct unsimplified equation. Follow through their answer in (a),but if using B, terms must have same signs, if using A, terms must have opposite signs. Cao (must be positive)	

Question Number	Scheme	Marks
3(a)	Velocity $= (14\mathbf{i} - 5\mathbf{j}) + 2(-4\mathbf{i} + \mathbf{j})$	M1
	Speed $= \sqrt{6^2 + (-3)^2}$	M1
	Speed $= \sqrt{45} = 3\sqrt{5} = 6.7\left(\text{ms}^{-1}\right)$ or better	A1 cso
		(3)
3(b)	 $\tan^{-1}\left(\frac{3}{6}\right)$	M1 A1ft
	27° or better **OR** 333° or better 0.46 rads or better **OR** 5.8 rads or better	A1
		(3)
3(c)	$\mathbf{v} = (14\mathbf{i} - 5\mathbf{j}) + (-4\mathbf{i} + \mathbf{j})T$ (allow t) **OR** $\mathbf{v} = (6\mathbf{i} - 3\mathbf{j}) + (-4\mathbf{i} + \mathbf{j})t$ $(t = T - 2)$	M1
	$\frac{14 - 4T}{-5 + T} = \frac{2}{-3}$	M1 A1
	$T = 3.2$	A1
		(4)
(10)		
	NOTES	
	Accept the use of column vectors throughout	
(a) **M1** **M1** **A1**	Correct use of $t = 2$ to find the velocity (unsimplified). Use of Pythagoras to find the speed when $t = 2$ with <u>their</u> velocity. $\sqrt{45} = 3\sqrt{5} = 6.7\left(\text{ms}^{-1}\right)$ or better $(6.70820\ldots)$. Must come from correct velocity.	
(b) **M1** **A1ft** **A1**	Use trig to find an equation in a relevant angle e.g. $(90° - \theta)$ for their *velocity*. Correct equation for a relevant angle, ft on their **v** Cao. No isw (A0 for a negative answer)	

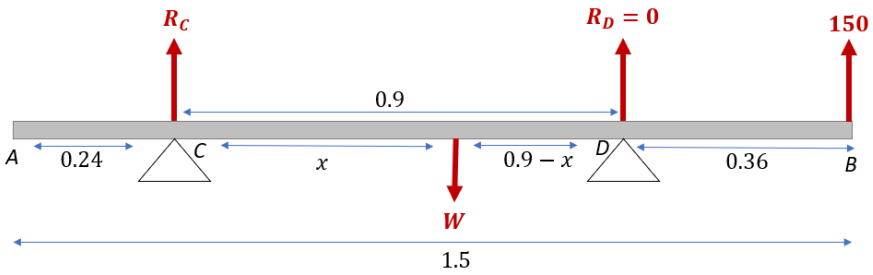
(c) **M1** **M1** **A1** **A1**	Use of $\mathbf{v} = \mathbf{u} + \mathbf{a}T$ to obtain a velocity vector in T (allow t) Use ratios, using *their* **velocity**, to produce an equation in T only (Allow reciprocal and incorrect sign) Correct equation in T only Cao **N.B.** If they use their answer to (a) instead of $\mathbf{u} = (14\mathbf{i} - 5\mathbf{j})$ but never correct their value of t, can score M1M1A0A0 **N.B.** If they use $\mathbf{v} = k(2\mathbf{i} - 3\mathbf{j})$ to produce 2 simultaneous equations in k and T, and then they use a calculator to solve and get $T = 3.2$, award all the marks, but if they get the wrong answer, they lose the last 3 marks.	

Question Number	Scheme	Marks
4.	$R_D = 0$ for scenario 1 or $R_C = 0$ for scenario 2	B1
	Scenario 1 $\text{M}(C) \quad (150 \times 1.26) = Wx$	M1 A1
	Scenario 2 $\text{M}(D) \quad (225 \times 0.36) = W \times (0.9 - x)$	M1 A1
	Solve simultaneously for W (or x) e.g. $0.81W = 243$	dM1
	$W = 300$	A1
	$x = 0.63$	A1
		(8)

NOTES

B1	**N.B**. B0 means there are no other marks available. $R_D = 0$ for scenario 1 seen on a diagram or implied by working. OR: $R_C = 0$ for scenario 2 seen on a diagram or implied by working.
M1	Complete method to form an equation in W and a consistent unknown distance *only*, for scenario 1. All equations used must be dimensionally correct and have the correct no. of terms but condone sign errors. (M0 if $R_D = 0$ is never used)
A1	Correct unsimplified equation in W and x or their defined unknown distance.
M1	Complete method to form an equation in W and a consistent unknown distance *only*, for scenario 2. All equations used must be dimensionally correct and have the correct no. of terms but condone sign errors. (M0 if $R_C = 0$ is never used)
A1	Correct unsimplified equation in W and x or their defined unknown distance
dM1	Dependent on both M's, solve simultaneous equations for either W or their unknown Correct answer for W
A1	Correct answer for x This must be the distance stated in the question, from C to the centre of mass.
A1	**N.B**. If they include g in a moments equation, they lose the A mark for that equation and both final A marks.

Scenario 1



Equations with unknown distance, x, measured from C.

Complete method will involve one moments equation with $R_D = 0$ or two equations with R_C eliminated and $R_D = 0$.

M0 if R_D never equals zero

Vert $\quad R_C + 150 = W$

M(A) $\quad \left(R_C \times 0.24\right) + \left(150 \times 1.5\right) = W\left(x + 0.24\right)$

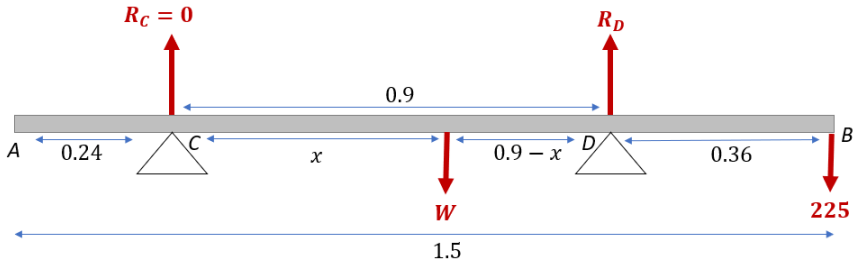
M(C) $\quad \left(150 \times 1.26\right) = Wx$

M(G) $\quad R_C\, x = 150\left(1.26 - x\right)$

M(D) $\quad \left(R_C \times 0.9\right) = \left(150 \times 0.36\right) + W\left(0.9 - x\right)$

M(B) $\quad \left(R_C \times 1.26\right) = W\left(1.26 - x\right)$

Scenario 2



Equations with unknown distance, x, measured from C

Complete method will involve one moments equation with $R_C = 0$ or two equations with R_D eliminated and $R_C = 0$.

M0 if R_C never equals zero

Vert $\quad R_D = 225 + W$

M(A) $\quad \left(R_D \times 1.14\right) = \left(225 \times 1.5\right) + W\left(x + 0.24\right)$

M(C) $\quad \left(225 \times 1.26\right) + Wx = \left(R_D \times 0.9\right)$

M(G) $\quad R_D\left(0.9 - x\right) = 225\left(1.26 - x\right)$

M(D) $\quad \left(225 \times 0.36\right) = W\left(0.9 - x\right)$

	M(B) $\left(R_D \times 0.36\right) = W\left(1.26 - x\right)$	
Question Number	**Scheme**	**Marks**
5(a)	P to Q $6x = \left(\frac{u+2u}{2}\right)12$ **OR** $6x = 12u + \frac{1}{2} \times \frac{u}{12} \times 12^2$ **OR** $(2u)^2 = u^2 + 2 \times \frac{u}{12} \times 6x$	M1
	Reaches given answer from correct working $x = 3u$ *	A1*
		(2)
5(b)	Q to R e.g. $\left(3u\right)^2 = \left(2u\right)^2 + 2\left(1.5\right)\left(15u\right)$	M1 A1
	$u = 9$	A1
		(3)
5(c)	Q to S (t = 14 position) $QS = 2u \times 2 + \frac{1}{2} \times 1.5 \times 2^2$	M1 A1
	$(4u + 3) + 18u$	M1
	201 (m)	A1
		(4)
(9)		

	NOTES	
(a)		
M1	Considers P to Q and forms a relevant equation in terms of u and x	
A1*	Reaches given answer from correct working	
(b)		
M1	Uses the given answer in (a) to form an equation in u only **N.B.** If brackets missing, allow M1, but allow recovery.	
A1	Correct unsimplified equation in u only	
A1	Correct answer	
(c)		
M1	Complete method to find the distance travelled in the 2 seconds after passing Q	
A1	Correct unsimplified expression in u only (or 39 m)	
M1	Complete method to find the required distance (need 18u or 6x)	
A1	Correct answer	

Question Number	Scheme	Marks
6.	Perpendicular to direction of motion: $500\sin 40° = P\sin\alpha°$	M1 A1
	Parallel to direction of motion: $500\cos 40° + P\cos\alpha° = 900$	M1 A1
	(i) Form and solve an equation in α $\tan\alpha° = \dfrac{500\sin 40°}{900 - 500\cos 40°}$	M1
	$\alpha = 32$ or better $(31.8683\ldots)$	A1
	(ii) Form and solve an equation in P $P = \dfrac{500\sin 40°}{\sin 31.868\ldots°}$	M1
	$P = 610$ or better $(608.736\ldots)$	A1
	N.B. Penalise over accurate answers only once for the question.	
	ALTERNATIVE USING A TRIANGLE OF FORCES: Cosine Rule**:** $P^2 = 500^2 + 900^2 - 2\times 500\times 900\cos 40^o$ OR: $500^2 = P^2 + 900^2 - 2\times P\times 900\cos\alpha°$ OR: $900^2 = P^2 + 500^2 - 2\times P\times 500\cos(140^o - \alpha°)$	M1 A1
	Sine Rule /Lami's Theorem: $\dfrac{P}{\sin 40^o} = \dfrac{500}{\sin\alpha°} = \dfrac{900}{\sin(140^o - \alpha°)}$ (any two)	M1 A1
	(i) Solve for α $\alpha = 32$ or better $(31.8683\ldots)$	M1 A1
	(ii) Solve for P $P = 610$ or better $(608.736\ldots)$	M1 A1
		(8)
	NOTES	
M1	Form an equation perpendicular to the direction of motion. Correct number of terms, condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation	
M1	Form an equation parallel to the direction of motion. If using $F = ma$ then must have $a = 0$. Correct number of terms, condone sign errors and sin/cos confusion.	
A1	Correct unsimplified equation	
(i) M1	Form and solve an equation in α (This an M mark so do not penalise accuracy of manipulation)	
A1	Accept 32 or better (i.e 32, 31.9, 31.87,… as their **<u>final</u>** answer)	
(ii) M1		

A1	Form and solve an equation in P (This an M mark so do not penalise accuracy of manipulation) Accept 610 or better (i.e 610, 609, 608.7,… as their **final** answer)	
M1 **A1**	**ALTERNATIVE** Use cosine rule to give an equation in P (and α possibly) Correct equation	
M1 **A1**	Use sine rule to give an equation in P and α Correct equation	
	N.B. They could use the Sine or the Cosine Rule **twice** to obtain their two equations.	
(i) M1 **A1** **(ii) M1** **A1**	Form and solve an equation in α Accept 32 or better (i.e 32, 31.9, 31.87,… as their **final** answer) Form and solve an equation in P Accept 610 or better (i.e 610, 609, 608.7,… as their **final** answer)	

Question Number	Scheme	Marks
7(a)	$\frac{42mg}{5}-(m+M)g=(m+M)\frac{2g}{5}$ where $M = (p + q)$ **OR** : $\frac{42mg}{5}-Mg=M\frac{2g}{5}$ where $M = p + q + m$	M1 A1
	$(p + q) = 5m$	dM1 A1
		(4)
7(b)	$\frac{14mg}{5}-pg=p\left(\frac{2g}{5}\right)$	M1 A1
	$p = 2m$	A1
		(3)
		(7)
	NOTES	
	N.B. Use the mass in the '*ma*' term to determine which part of the system is being considered.	
(a) **M1**	Form an equation of motion for the whole system with the combined mass of *P* and *Q*. Correct terms, condone sign errors. **N.B.** They may consider the 2 masses (*M*) and the lift separately and eliminate the normal reaction e.g. $R-Mg=M\frac{2g}{5}$ **AND** $\frac{42mg}{5}-mg-R=m\frac{2g}{5}$ AND add to eliminate *R*	
A1	Correct equation in *M* and *m*_for their *M* **N.B.** Award marks for a correct equation only if no wrong working seen.	
dM1	Rearrange to find an expression for the combined mass of *P* and *Q*. Must be a multiple of *m*	
A1	Cao	
(b) **M1**	Form an equation of motion for box *P*. Correct terms, condone sign errors. Fully correct equation.	
A1	Cao	

A1	**N.B.** They may find q (M1A1) and subtract from $5m$	
Question Number	**Scheme**	**Marks**
8(a)	Perpendicular to the plane: $R + 18\sin 40° = 2g\cos 30°$	M1 A1
	Equation of motion parallel to the plane: $18\cos 40° - F - 2g\sin 30° = 2a$ (or -2a)	M1 A1 A1
	$F = 0.3R$	B1
	$18\cos 40° - 0.3\left(2g\cos 30° - 18\sin 40°\right) - 2g\sin 30° = 2a$	dM1
	$a = 1.18$ or 1.2 $\left(\text{m s}^{-2}\right)$	A1 cao
		(8)
8(b)	$v^2 = 2^2 + 2\left('1.18'\right)5$	M1 A1**ft**
	$v = 3.98$ or 4.0 or 4 (m s^{-1})	A1 cao
	N.B. For (a) and (b), penalise over accurate answers ONCE only.	(3)
8(c)	$R = 2g\cos 30°\left(= g\sqrt{3}\right)$	B1
	Friction = $0.3\times 2g\cos 30°$ OR $0.3\times 2g\sin 30°$	M1
	Compares Friction with weight component parallel to plane Eg Consider: $2g\sin 30^o - 0.3\left(2g\cos 30^o\right)$ (= 2a) **OR** $0.3\left(2g\cos 30^o\right) - 2g\sin 30^o$ (= 2a)	dM1
	$(a) > 0$ **OR** $(a) < 0$ Concludes that P will not remain at rest oe	A1
		(4)
(15)		
NOTES		
(a) **M1** **A1** **M1** **A1** **A1** **B1** **dM1** **A1**	Correct number of terms, forces resolved *perp to the plane* where appropriate, condone sign errors and sin/cos confusion, forces and angles paired up correctly Correct unsimplified equation. Equation of motion parallel to the slope. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion, forces and angles paired up correctly Correct unsimplified equation with at most one error Fully correct unsimplified equation Use of $F = 0.3R$ Eliminate F and R to form an equation in a, dependent on two M's Correct value for a. Must be 2 or 3sf	

(b)		
M1	Complete method to form an equation in v or v^2	
A1ft	Correct unsimplified equation. Follow through on their value for a.	
A1	Cao. Must be positive. Note that $a = 1.2$ leads to $v = 4$.	
(c)		
B1	Correct expression or value for **new** R	
M1	Find the max friction. M0 if the previous R is used.	
dM1	Correct comparison between max friction value and weight component (force parallel to slope), dependent on previous M	
A1	Correct statement from fully correct working. Concludes that P will not remain at rest.	