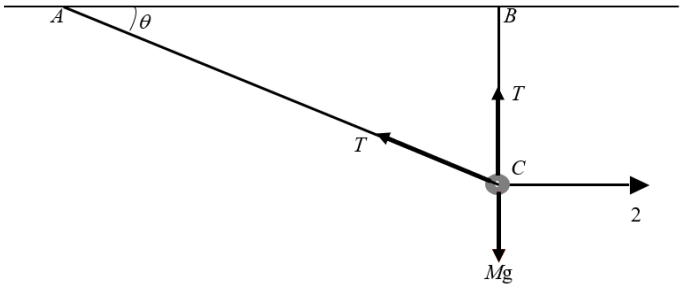
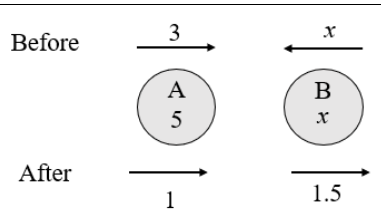
Mark Scheme (Results)

January 2024

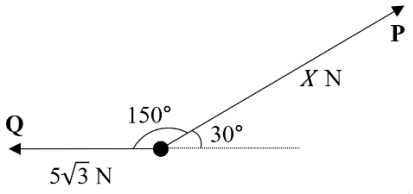
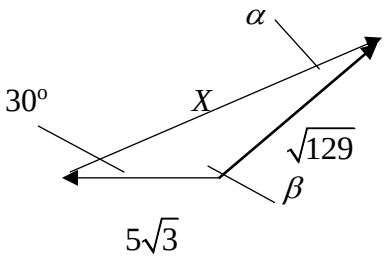
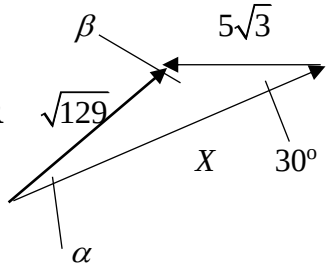
Pearson Edexcel International Advanced Level In Mechanics M1 (WME01) Paper 01

QUESTION NUMBER	SCHEME	MARKS
1		
(a)	Horiz: $2 = T\cos\theta$	M1 A1
	T = 2.5	A1
		(3)
(b)	Vert: $T + T\sin\theta = Mg$	M1 A1
	M = 0.41 or 0.408	A1
		(3)
		(6)
	Notes for question 1	
	N.B. If they have different tensions, they can score all the marks in (a) but nothing in (b). If they have 2= $T\cos(\frac{4}{5})$ or similar and never recover, allow M1A0.	
(a) **M1** **A1** **A1**	 Horizontal equilibrium. Correct no. of terms, dimensionally correct, condone sin/cos confusion. Correct unsimplified equation. Correct answer. (ignore units)	
(b) **M1** **A1** **A1**	 Vertical equilibrium. Correct no. of terms, dimensionally correct, condone sin/cos confusion and missing g, to give an equation which must include M. Correct unsimplified equation Correct answer. (ignore units)	

QUESTION NUMBER	SCHEME	MARKS
2		
2(a)	CLM $(5\times 3)-x^2=(5\times 1)+(x\times 1.5)$ **OR:** $5(-1--3)=x(1.5--x)$	M1A1
	$x=2.5$	A1
		(3)
2(b)	$I=\pm 5(1-3)$ or $I=\pm 2.5(1.5--2.5)$ $(I=\pm x(1.5--x))$	M1A1
	$\lvert I\rvert=10$ (Ns)	A1
		(3)
		(6)
	Notes for question 2	
(a) **M1** **A1** **A1**	 Forms CLM equation OR equates impulses, condone sign errors and extra *g*'s and any correct cancellation, to give an equation in *x* only. Correct unsimplified equation Correct answer. If – 4 is seen, it must be rejected. (ignore units)	
(b) **M1** **A1** **A1**	 Impulse-momentum equation, dimensionally correct, correct no. of terms for *A* or *B*. Condone sign errors but must be *attempting* a difference of momenta e.g. allow if they first state $I=\pm m(v-u)$ but then make a sign error and end up with a sum. If they clearly add the momenta, and there is no formula stated, M0. *x* does not need to be substituted. M0 if *g* is included. Correct numerical expression. cao must be positive. Ignore missing or wrong units. A0 if both 10 and another answer are given.	

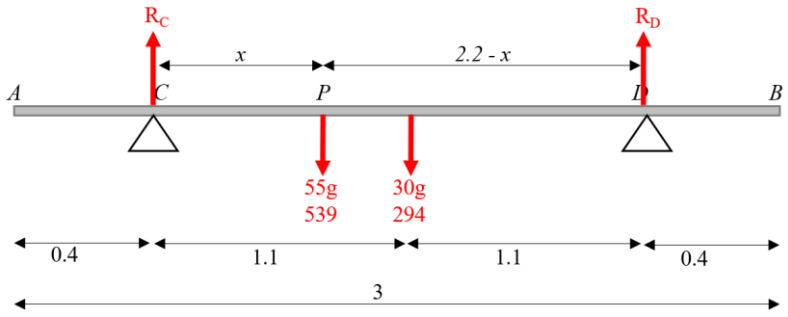
QUESTION NUMBER	SCHEME	MARKS
3(a)	A to B : $s=\left(\frac{u+v}{2}\right)t$: $400=\left(\frac{u+28}{2}\right)20$ Other possible equations: $28=u+20a$ $400=20u+\frac{1}{2}a\times 20^2$ $28^2=u^2+2\times 400a$ $400=(28\times 20)-\frac{1}{2}a\times 20^2$	M1
	$u=12$ *	A1* cso
		(2)
3(b)	A to B : Any of the above equations with u = 12 e.g. $v=u+at$ $28=12+20a$ (leads to $a=0.8$)	M1 A1
	A to midpoint: $200=12t+\frac{1}{2}0.8t^2$ **OR:** find v and use it to find t e.g. $v^2=12^2+(2\times 0.8\times 200)$ => $v=\sqrt{464}$ and then one of : $\sqrt{464}=12+0.8t$ $200=\left(\frac{12+\sqrt{464}}{2}\right)t$ $200=\sqrt{464}t-\frac{1}{2}\times 0.8t^2$	M1 A1
	$t=12$ (s) or better $(11.9258..)$, $5\sqrt{29}-15$	A1
		(5)
3(c)	$D-260=1200(0.8)$	M1A1ft
	D=1220 (N)	A1
		(3)
		(10)

	Notes for question 3	
(a)		
M1	Complete method to find the value of u. (they may use two equations, eliminate a and solve for u)	
A1*	Correctly reaches the given answer. **N.B**. If they use 2 equations, we need to see a eliminated and u found correctly for this A mark. **N.B.** No marks if they use u =12 in (b) to find a and then use it in (a) to show that u = 12.	
(b)		
M1	**Relevant *suvat* equation to find acceleration. This could be found in (a) or in (c) to earn these marks, but not necessarily used in (b).**	
A1	Correct equation(s).	
M1	Complete method to find an equation in t only. (they may find v (21.54065..) first). Must use their calculated acceleration and 12.	
A1	Correct unsimplified equation in t only.	
A1	Correct answer, t = 12 or better, t = 11.9258... If seen, the negative value for t (– 41.9258..) must be rejected.	
(c)		
M1	Use of $F=ma$. Correct no. of terms, dimensionally correct, a does not need to be substituted, condone sign errors. M0 if they use $a = g$.	
A1ft	Correct unsimplified equation, ft on their a.	
A1	Accept 1200 (N)	

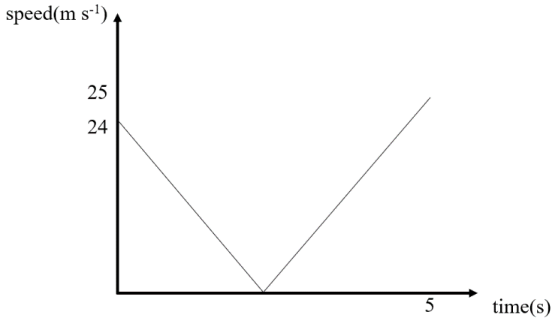
QUESTION NUMBER	SCHEME	MARKS
N.B. They may do (ii) first using the **OR** method to find α (and possibly β) and then use either angle to do (i), using the Sine Rule or Cosine Rule.		
4	  **OR** 	
4(i)	Complete method to find an equation in X only: • Using correct vector triangle with cosine rule: $129 = X^2 + \left(5\sqrt{3}\right)^2 - 2X \times 5\sqrt{3}\cos 30^\circ$ • Using correct vector triangle with sine rule to find α: $\frac{\sqrt{129}}{\sin 30^\circ} = \frac{5\sqrt{3}}{\sin\alpha}$ $\alpha = 22.4109..^o \Rightarrow \beta = 180^o - 30^o - 22.4109..^o = 127.589..^o$ Then sine rule: $\frac{X}{\sin\beta} = \frac{\sqrt{129}}{\sin 30^\circ} = \frac{5\sqrt{3}}{\sin\alpha}$ or cosine rule: $(5\sqrt{3})^2 = X^2 + 129 - 2X\sqrt{129}\cos\alpha$ or $X^2 = (5\sqrt{3})^2 + 129 - 2\times 5\sqrt{3}\times\sqrt{129}\cos\beta$ to find X. • Using components with magnitude: $\sqrt{129} = \sqrt{\left(X\cos 30^\circ - 5\sqrt{3}\right)^2 + \left(X\sin 30^\circ\right)^2}$	M1 A1
	Solves their equation (if quadratic, must include an X term) to find an X value.	M1
	$X = 18$	A1

QUESTION NUMBER	SCHEME	MARKS
4(ii)	**EITHER** Finds an equation in β only using their X: e.g. $\dfrac{18}{\sin\beta}=\dfrac{\sqrt{129}}{\sin 30^\circ}$ or $18^2=(5\sqrt{3})^2+129-2\times5\sqrt{3}\times\sqrt{129}\cos\beta$ or $\cos\beta=\dfrac{\mathbf{R.Q}}{\lvert\mathbf{R}\rvert\lvert\mathbf{Q}\rvert}$ *where* **R** *is the resultant* $(\beta)=128^o$ to nearest degree **OR** Finds a relevant angle (not β) first • Using triangle of forces: $\alpha=\sin^{-1}\left(\dfrac{\sin 30^\circ\times5\sqrt{3}}{\sqrt{129}}\right)$ = 22.4109^o Or: $\alpha=\cos^{-1}\left(\dfrac{18^2+129-(5\sqrt{3})^2}{2\times18\times\sqrt{129}}\right)$ = 22.4109^o • Using components: Resultant force = $\left(18\cos30^\circ-5\sqrt{3}\right)\mathbf{i}+\left(18\sin30^\circ\right)\mathbf{j}$ Leading to $\tan^{-1}\left(\dfrac{4\sqrt{3}}{9}\right)$ = 37.589^o or $\tan^{-1}\left(\dfrac{9}{4\sqrt{3}}\right)$ = 52.411^o or e.g $\sin^{-1}\left(\dfrac{9}{\sqrt{129}}\right)$ = 52.411^o	M2 A1 A1 M1 A1
	Completes the method to find required angle (β) eg • $150^o-\alpha$ or $210^o+\alpha$ • 180^o – 52.411^o or 180^o + 52.411^o • $90^o+37.859^o$ or $270^o-37.859^o$	M1
	$(\beta)=128^o$ to nearest degree Accept 232^o	A1
		(8)

	Notes for question 4	
N.B. If 150° is used in either the sine or cosine rule, they are using an incorrect vector triangle and no M marks are available.		
(i)		
M1	Complete method to form an equation in X only. This could involve cosine rule and/or sine rule or components. Note the component forms: $\mathbf{P} = X\cos 30^\circ\,\mathbf{i} + X\sin 30^\circ\,\mathbf{j}$, condone cos/sin confusion $\mathbf{Q} = -5\sqrt{3}\mathbf{i}$ oe (they could have chosen different + directions)	
A1	Correct equation	
M1	Provided they have found an X value, not necessarily correctly, this mark can be awarded.	
A1	Correct answer. If seen, a negative value must be rejected.	
(ii)	**EITHER**	
M2	Complete method to find an equation in β only	
A1	Correct equation	
A1	cao	
	OR	
M1	Complete method to find a relevant angle	
A1	Correct relevant angle: $22.4109^o, 37.589^o, 52.411^o$	
M1	Completes the method to find the required angle	
A1	cao	

QUESTION NUMBER	SCHEME	MARKS
5		
5(a)	M(D) $(R_C \times 2.2) = 55g(2.2-x) + 30g(1.1)$	M1A1
	$(R_C) = (686 - 245x)$ (N) *	A1 *
	N.B. The M mark here is not available if they use $R_C = 4R_D$ to obtain the given result.	
		(3)
5(b)	$R_C = 4R_D$	M1
	Vert: $R_C + R_D = 55g + 30g \Rightarrow \frac{5}{4}(686 - 245x) = 55g + 30g$ Relevant moments equations: M(C): $55gx + 30g(1.1) = R_D(2.2)$ M(A): $R_C(0.4) + R_D(2.6) = 55g(x+0.4) + 30g(1.5)$ M(P): $R_C x + 30g(1.1-x) = R_D(2.2-x)$ M(G): $R_C(1.1) = 55g(1.1-x) + R_D(1.1)$ M(B): $R_D(0.4) + R_C(2.6) = 30g(1.5) + 55g(2.6-x)$	M1A1
	$x = 0.08$	A1
		(4)
5(c)	M(C): $Mg(0.4) = 30g(1.1)$	M1 A1
	M = 83 or 82.5 or $\frac{165}{2}$ oe	A1
	Other possible equations with $S_D = 0$ Vert: $S_C = Mg + 30g$ M(A): $S_C(0.4) = 30g(1.5)$ M(G): $S_C(1.1) = Mg(1.5)$ M(D): $S_C(2.2) = 30g(1.1) + Mg(2.6)$ M(B): $S_C(2.6) = 30g(1.5) + Mg(3)$ from which S_C would need to be eliminated to give an equation in M only.	
		(3)
		(10)

	Notes for question 5	
(a)		
M1	Forms an equation in R_C and x only. Dimensionally correct and the correct no. of terms. Either a moments equation about D or two other equations combined to eliminate R_D.	
A1	Correct unsimplified equation	
A1*	Correctly reaches the given answer with at **least one line of intermediate working.**	
(b)		
M1	**Use** of $R_C = 4R_D$	
M1	Complete method to form an equation in x only. Dimensionally correct and the correct no. of terms. Either vertical resolution or a moments equation(s) with R_C and R_D eliminated. R_C **must be replaced with the given expression in (a)**. R_D replaced with $\frac{1}{4}R_C$ but condone $4R_C$ for the method mark.	
A1	Correct unsimplified equation in x only.	
A1	Correct answer	
(c)		
M1	Use $S_D = 0$ and forms an equation in M only. Dimensionally correct and the correct no. of terms. M0 if $S_D \neq 0$.	
A1	Correct unsimplified equation	
A1	Correct answer, 83 or 82.5 o.e.	

QUESTION NUMBER	SCHEME	MARKS
6(a)	A to B: $V^2 = 24^2 + 2(-g)(-2.5)$	M1 A1
	OR: e.g. $0 = 24^2 - 2gh$ and $V^2 = 2g(h + 2.5)$ oe	
	$V = 25$	A1
		(3)
6(b)	Some possible equations in t: $25 = -24 + gt$ $2.5 = \frac{(25 + (-24))t}{2}$ $2.5 = -24t + \frac{1}{2}gt^2$ $2.5 = 25t - \frac{1}{2}gt^2$ Or they may find t_{UP} $\left(\frac{24}{g}\right)$ and t_{DOWN} $\left(\frac{25}{g}\right)$ AND add	M1 A1
	$t = 5$ (s)	A1
		(3)
6(c)	From A to C: $10 = 24t + \frac{1}{2}(-g)t^2$	M1 A1
Complete method to find the required time: e.g. solving the above quadratic and finding the positive difference in the roots **N.B.** Allow this mark if they solve their quadratic, and give the answer as a range of values: $t_1 \leqslant t \leqslant t_2$		M1
	4, 4.0 or 3.98 (s)	A1
	ALT 1: From A to C: $W^2 = 24^2 - 2\times 10g$	M1A1
	$0 = W - g(\frac{1}{2}t)$	M1
	4.0 or 3.98 (s)	A1
	ALT 2: From A to C: $W^2 = 24^2 - 2\times 10g$	M1A1
	$0 = Wt + \frac{1}{2}(-g)t^2$	M1
	4.0 or 3.98 (s)	A1
		(4)
6(d)		B1 shape B1 ft labels
		(2)
		(12)

	Notes for question 6	
(a)		
M1	Complete method to find an equation in V only. Condone sign errors.	
A1	Correct equation in V only using g. Note the sign of 2.5 and g should be the same.	
A1	cao	
(b)		
M1	Complete method to find an equation in t only. Condone sign errors.	
A1	Correct equation in t only using g.	
A1	cao	
(c)		
M1	Forming an equation or equations which could lead to a relevant time. Condone sign errors.	
A1	Correct equation(s)	
M1	Complete method to find the required time.	
A1	cao	
(d)		
B1	Correct shape. It should appear symmetrical with regards to gradients but the end point should be higher than the start point. Vertex on horizontal axis.	
B1ft	Correct labels (24, 25 and 5), ft on their answers to (a) and (b), provided they are positive. **N.B.** ignore an incorrect time when $v = 0$. **Neither mark available if using a velocity-time graph**.	

QUESTION NUMBER	SCHEME	MARKS
N.B. Column vectors acceptable throughout apart from the answer to (b).		
7(a)	$\sqrt{12^2+16^2}=20\,(\text{km h}^{-1})$	M1 A1
		(2)
7(b)	$(19\mathbf{i}+22\mathbf{j})+t(12\mathbf{i}-16\mathbf{j})$	M1 A1
		(2)
7(c) **(i)**	Displacement vector $\overrightarrow{LS}=(19+12t-26)\mathbf{i}+(22-16t-15)\mathbf{j}$ or $\overrightarrow{SL}=(26-19-12t)\mathbf{i}+(15-22+16t)\mathbf{j}$	M1
	Correct with **i** and **j** collected $\overrightarrow{LS}=(12t-7)\mathbf{i}+(7-16t)\mathbf{j}$ or $\overrightarrow{SL}=(7-12t)\mathbf{i}+(16t-7)\mathbf{j}$	A1
	Use of Pythagoras to find the distance $\left\lvert\overrightarrow{LS}\right\rvert=\sqrt{(12t-7)^2+(7-16t)^2}$	M1
	Correct 3TQ $400t^2-392t+98$	A1
	Min occurs when $t = 0.49$	A1
	Alternative for last 3 marks: Closest when relative pv is perpendicular to relative velocity i.e $\left[(12t-7)\mathbf{i}+(7-16t)\mathbf{j}\right].(12\mathbf{i}-16\mathbf{j})=0$ $400t-196=0$ Min occurs when $t = 0.49$	M1 A1 A1
(ii)	$\sqrt{1.96}=1.4$ (km)	M1
	$1.4>1.3$ so it is safe for *S* to continue its course.	A1 **cso**
		(7)
	Alternative for (c)(i) and (ii):	
7(c)		
(i)	Path of *S*: $y-22=\frac{-16}{12}(x-19)$	M1
	Normal through *L*: $y-15=\frac{12}{16}(x-26)$	A1
	Solve for either *x* OR *y*	M1
	$x = 24.88$ OR $y = 14.16$	A1
	$24.88 = 12t + 19$ OR $14.16 = 22 - 16t$ => $t = 0.49$	A1
(ii)	$\sqrt{(26-24.88)^2+(15-14.16)^2}=1.4$	M1
	$1.4>1.3$ so it is safe for *S* to continue its course.	A1 **cso**
		(7)
	Alternative for (c)(i):	
	Path of *S*: $(19\mathbf{i}+22\mathbf{j})+t(12\mathbf{i}-16\mathbf{j})$	
	Normal through *L*: $(26\mathbf{i}+15\mathbf{j})+k(16\mathbf{i}+12\mathbf{j})$ oe	M1 A1
	Solve for *t*	M1
	$t = 0.49$	A2
		(5)
		(11)

	Notes for question 7	
(a)		
M1	Use of Pythagoras to find the speed. Since this is a 3,4,5 triangle the correct answer may appear without working.	
A1	cao	
(b)		
M1	Correct structure	
A1	Correct answer o.e. with **i**'s and **j**'s	
(c) (i)		
M1	Subtraction used to find the displacement vector $\overrightarrow{LS}$ or $\overrightarrow{SL}$	
A1	Correct components for $\overrightarrow{LS}$ or $\overrightarrow{SL}$ with **i**'s and **j**'s collected, seen or implied.	
M1	Use of Pythagoras with their components, which must have come from attempt at subtracting or adding **s** and **l**, to form a 3TQ for distance or distance squared.	
A1	Correct 3TQ, seen or implied, e.g allow $400t^2 - 392t + 96.31$	
A1	**cao** Note: The correct value $t = 0.49$ may appear without working as a result of the quadratic solver on a calculator. Other methods may include completing the square or differentiation. **N.B.** Correct 3TQ = 1.3^2 oe can score max M1A1M1A1	
(ii)		
M1	Use of their t value, which must have come from an attempt to minimise the distance LS, to find the shortest distance between S and L. Note: The correct value 1.4 may appear without working since the quadratic solver on a calculator will give a min value for d^2 as 1.96.	
A1cso	Correct conclusion by comparing 1.4 and 1.3. **N.B**. Accept e.g. '1.4 therefore it is safe'.	

QUESTION NUMBER	SCHEME	MARKS
8(a)	Perp. to plane for P: $R = mg\cos a$	M1A1
	P: $T = mg\sin\alpha + F$ Q: $T = 0.5mg$ **N.B**. $mg\sin\alpha + F = 0.5mg$ scores M1A1 (LHS) B1 RHS)	M1 A1 B1
	Use of $F = \mu R$	B1
	$0.5mg = \frac{5mg}{13} + \mu\frac{12mg}{13}$	dM1
	$\mu = \frac{1}{8}$	A1
		(8)
8(b)	$mg\sin\alpha - F = ma$ $\left(a = \frac{7g}{26} \quad (\text{ms}^{-2})\right)$	M1 A1
	$V^2 = 0^2 + 2\left(\frac{7g}{26}\right)0.8$	M1
	V = 2.1 or 2.05	A1
		(4)
		(12)
	Notes for question 8	
(a)		
M1	Resolve perpendicular to find an expression for R in terms of m, condone sin/cos confusion and sign errors.	
A1	Correct unsimplified equation.	
M1	Form an equilibrium equation for P. Correct no. of terms, dimensionally correct. If $F=ma$ is used then a must be zero.	
A1	Correct unsimplified equation.	
B1	Correct equation	
B1	Use of $F = \mu R$, seen or implied, in an equation.	
dM1	Dependent on previous M mark, replace trig and form an equation in μ only.	
A1	Correct answer. Accept 0.125, 0.13	
(b)		
M1	Use of $F=ma$ for P. Correct no. of terms, dimensionally correct, ignore sin/cos confusion.	
A1	Correct equation, trig and F do not need to be substituted.	
M1	Use their calculated acceleration to form an equation in V. M0 if they use g.	
A1	Correct answer 2/3sf	