Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Mechanics M1

Advanced/Advanced Subsidiary

Monday 23 January 2017 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
WME01/01

You must have:
Mathematical Formulae and Statistical Tables (Blue)

Total Marks

Candidates may use any calculator allowed by the regulations of the Joint Council for Qualifications. Calculators must not have the facility for symbolic algebra manipulation, differentiation and integration, or have retrievable mathematical formulae stored in them.

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B). Coloured pencils and highlighter pens must not be used.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions and ensure that your answers to parts of questions are clearly labelled.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*
- You should show sufficient working to make your methods clear. Answers without working may not gain full credit.
- Whenever a numerical value of g is required, take $g = 9.8$ m s^{-2}, and give your answer to either two significant figures or three significant figures.
- When a calculator is used, the answer should be given to an appropriate degree of accuracy.

Information

- The total mark for this paper is 75.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 8 3 2 6 A 0 1 2 8

Pearson

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1. A train moves along a straight horizontal track between two stations R and S. Initially the train is at rest at R. The train accelerates uniformly at $\frac{1}{2}$ m s^{-2} from rest at R until it is moving with speed 15 m s^{-1}. For the next 200 seconds the train maintains a constant speed of 15 m s^{-1}. The train then decelerates uniformly at $\frac{1}{4}$ m s^{-2} until it comes to rest at S.

Find

(a) the time taken by the train to travel from R to S,

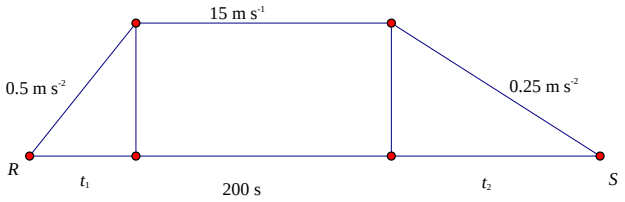
(3)

(b) the distance from R to S,

(4)

(c) the average speed of the train during the journey from R to S.

(2)

Question Number	Scheme	Marks
1a		
	Use of $v = u + at$ to find t_1 or t_2	M1
	$t_1 = 15 \div 0.5 = 30$ (s) **OR** $t_2 = 15 \div 0.25 = 60$	A1
	Total time $= 30 + 200 + 60 = 290$ (s)	A1 **cso**
		(3)
1b	Use area/ *suvat* to find distance: $\text{distance} = \frac{1}{2} \times 30 \times 15 + 200 \times 15 + \frac{1}{2} \times 60 \times 15$ Follow their t_1 & t_2	M1A2 **ft**
	$= 3675$ (m) (3.675 km)	A1
		(4)
1c	Ave. speed $= \frac{\text{their(b)}}{\text{their(a)}}$	M1
	$= \frac{3675}{290}$ oe (m s^{-1}) (12.6724..)	A1
		(2)
		[9]
	Notes	
1a	M1 for use of $v = u + at$ or gradient or any other complete method to find a value for t_1 or t_2 (condone sign errors)	
	First A1 for either 30 or 60 (A0 if negative)	
	Second A1 for 290 with no errors seen	
1b	M1 for a complete method to find distance (must have a ½) either by using trapezium rule or by using 2 triangles and a rectangle	
	A2 **ft** on their t_1 & t_2 (-1 each error)	
	A1 for 3675 (m) or 3.675 km	
1c	M1 for $= \frac{\text{their(b)}}{\text{their(a)}}$	
	A1 for 13 or better	

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2. A particle P of mass 0.5 kg moves under the action of a single constant force $(2\mathbf{i} + 3\mathbf{j})$N.

(a) Find the acceleration of P.

(2)

At time t seconds, P has velocity $\mathbf{v}$ m s^{-1}. When $t = 0$, $\mathbf{v} = 4\mathbf{i}$

(b) Find the speed of P when $t = 3$

(4)

Given that P is moving parallel to the vector $2\mathbf{i} + \mathbf{j}$ at time $t = T$

(c) find the value of T.

(3)

Question Number	Scheme	Marks
	Accept column vectors throughout	
2a	Use of $\mathbf{F} = m\mathbf{a}$: $2\mathbf{i} + 3\mathbf{j} = 0.5\mathbf{a}$	M1
	$\mathbf{a} = 4\mathbf{i} + 6\mathbf{j}$ (m s^{-2})	A1
		(2)
2b	Use of $\mathbf{v} = \mathbf{u} + 3\mathbf{a}$ with their $\mathbf{a}$	M1
	$= 16\mathbf{i} + 18\mathbf{j}$	A1
	Use of Pythagoras: speed $= \sqrt{16^2 + 18^2}$	M1
	$= \sqrt{580}$ or 24 (m s^{-1}) or better	A1
		(4)
2c	In component form: $\mathbf{v} = 4\mathbf{i} + t(4\mathbf{i} + 6\mathbf{j})$	M1
	$4 + 4T = 2 \times 6T$	M1
	$T = \frac{1}{2}$	A1
		(3)
		[9]
	Notes	
2a	M1 for use for $\mathbf{F} = m\mathbf{a}$:	
	A1 for $4\mathbf{i} + 6\mathbf{j}$ (m s^{-2}) isw if magnitude found.	
2b	First M1 for $\mathbf{v} = 4\mathbf{i} + 3(4\mathbf{i} + 6\mathbf{j})$ with their $\mathbf{a}$ (but M0 if they use 2**i** + 3**j** (the force) instead of **a**)	
	First A1 for $16\mathbf{i} + 18\mathbf{j}$ seen or implied	
	Second M1 for finding magnitude of their **v**	
	Second A1 for 24 or better (24.0831…) or $\sqrt{580}$	
2c	First M1 for $\mathbf{v} = 4\mathbf{i} + t(4\mathbf{i} + 6\mathbf{j})$ with their $\mathbf{a}$ (but M0 if they use 2**i** + 3**j** (the force) instead of **a**)	
	Second independent M1 for a correct method to give an equation in T *(t) only* using their **v**	
	A1 for (T) = ½	

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3.

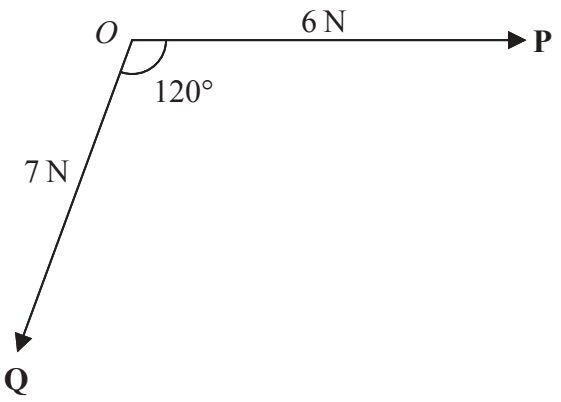


Figure 1

Two forces **P** and **Q** act on a particle at a point *O*. Force **P** has magnitude 6 N and force **Q** has magnitude 7 N. The angle between the line of action of **P** and the line of action of **Q** is 120°, as shown in Figure 1.

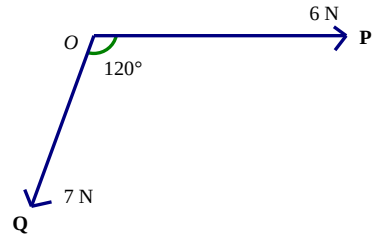
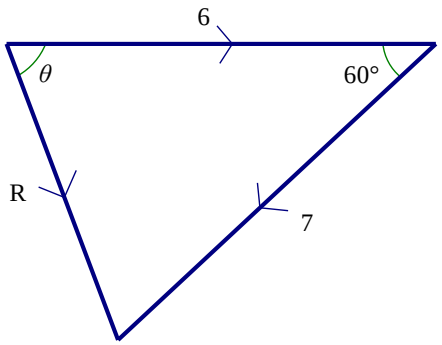
The resultant of **P** and **Q** is **R**.

Find

(i) the magnitude of **R**,

(ii) the angle between the line of action of **R** and the line of action of **P**.

(8)

Question Number	Scheme	Marks
3		
Method 1	Horizontal component $= 6 - 7\cos 60$ (N)	M1A1
	Vertical component (N) $= 7\cos 30$	M1A1
	Use Pythagoras: $\sqrt{2.5^2 + 6.06^2} = \sqrt{43} = 6.6$(N) or better	M1A1
	Use trig: angle = $\tan^{-1}(\frac{7\cos 30}{2.5}) = 68^o$(below **P**) or better Also allow 112^0, 292^0 or 248^0	M1A1
		(8)
Alt		
	Cosine rule to find $\|\mathbf{R}\|$: $R^2 = 36 + 49 - 2\times 6\times 7\times\cos 60 (= 43)$	M2 A2
	R = 6.6 (N) or better	M1 A1
	Solve Sine rule for θ: $\sin^{-1}(\frac{7\sin 60}{R})$	M1
	= 68^o or better Also allow 112^0 or 292^0 or 248^0	A1
		[8]
	Notes	
Method 1	First M1 for attempt, allow sin/cos confusion, to find component parallel to **P**	
	First A1 for a correct expression	
	Second M1 for attempt, allow sin/cos confusion to find component perp to **P**	
	First A1 for a correct expression	
	Third M1 for using Pythag to find magnitude of **R**	
	Third A1 for $\sqrt{43}$, 6.6 (N) or better	
	Fourth M1 for complete method to find angle (M0 if 6 used for 'horiz' cpt) Fourth A1 for 68^o or better (67.589089…) 112^0 or 292^0 or 248^0	

Question Number	Scheme	Marks
Alt	**Notes** First M2 for use of cosine rule with correct structure but allow $\cos 120^o$ and allow R^2 First A2 for a correct equation. (<u>A0 if 120^o used</u>) Third M1 for solving for R Third A1 for $\sqrt{43}$, 6.6 (N) or better Fourth M1 for complete method (e.g. sine rule) to find angle between their **R** and **P** Fourth A1 for 68^o or better	

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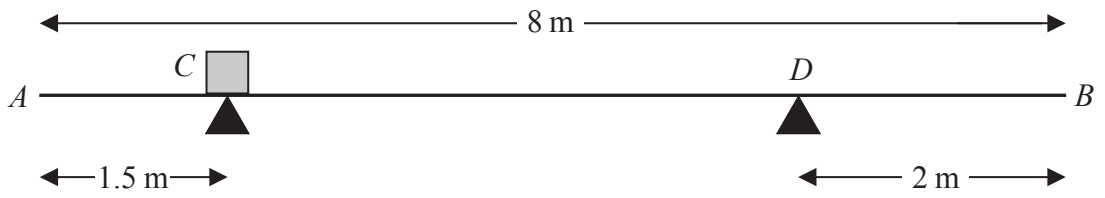


Figure 2

A plank AB of mass 20 kg and length 8 m is resting in a horizontal position on two supports at C and D, where $AC = 1.5$ m and $DB = 2$ m. A package of mass 8 kg is placed on the plank at C, as shown in Figure 2. The plank remains horizontal and in equilibrium. The plank is modelled as a uniform rod and the package is modelled as a particle.

(a) Find the magnitude of the normal reaction

(i) between the plank and the support at C,

(ii) between the plank and the support at D.

(6)

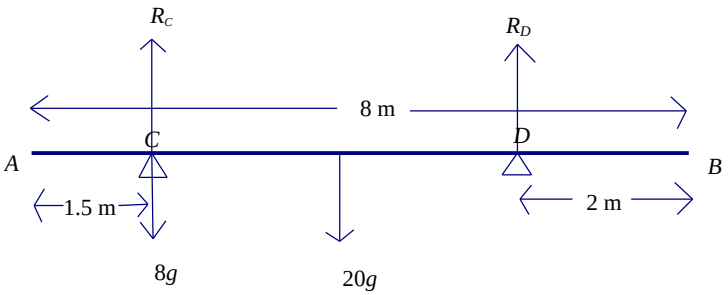
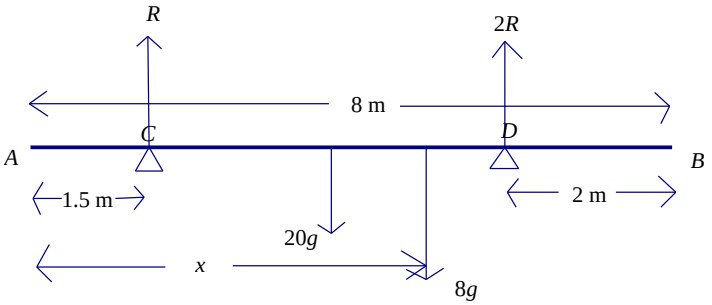
The package is now moved along the plank to the point E. When the package is at E, the magnitude of the normal reaction between the plank and the support at C is R newtons and the magnitude of the normal reaction between the plank and the support at D is $2R$ newtons.

(b) Find the distance AE.

(6)

(c) State how you have used the fact that the package is modelled as a particle.

(1)

Question Number	Scheme	Marks
4a		
	Moments about D: $20g\times 2+8g\times 4.5=R_C\times 4.5$ **OR** Resolve: $R_C+R_D=28g$	M1A1
(i)	$R_C=\frac{152}{9}g\,(=166 \text{ or } 170)$	A1
	Moments about C: $20g\times 2.5=R_D\times 4.5$ **OR** Resolve: $R_C+R_D=28g$	M1A1
(ii)	$R_D=\frac{100}{9}g\,(=109 \text{ or } 110)$	A1
		(6)
4b		
	Moments about A: $R\times 1.5+2R\times 6=20g\times 4+8g\times x$	M1A1
	Resolve: $3R=28g$, $\left(R=\frac{28}{3}g\,(=91.5)\right)$	M1A1
	Substitute for R and solve for x: $\frac{27}{2}\times\frac{28}{3}g=80g+8g\times x$	M1
	$126=80+8x$, $8x=46$, $x=5.75\,(\text{m})$	A1
		(6)
4c	The weight of the package acts at point C (or E)	B1 (1)
		[13]
	Notes **N.B.** In both parts, enter marks on ePen for the *equations* as they appear **BUT** in part (a) second A1 is for R_C and fourth A1 is for R_D Remember to only penalise overaccuracy, after use of g, ONCE per whole question	

Question Number	Scheme	Marks
4a	**Omission of g is an A error in this part.** If answers are given as decimal multiples of g, penalise once If answers given as (fraction x g), fraction must be ratio of two integers First M1 for any moments equation (even if it contains both reactions) or vertical resolution First A1 for a correct equation Second A1 for $R_C = \frac{152}{9}g \left(= 166 \text{ or } 170\right)$ Second M1 for another moments equation (even if it contains both reactions) or vert resolution Third A1 for a correct equation Fourth A1 for $R_D = \frac{100}{9}g \left(= 109 \text{ or } 110\right)$	
4b **4c**	**Notes** **N.B. Consistent omission of g can score full marks in this part.** **If they use the values of the reactions from part(a), no marks for part b.** If *R* and 2*R* reversed, can score max M1A1 (vert res) M1A0 (mom about C or D) M1A0 First M1 for a moments equation in *R* and *x* only (*x* may not be *AE*) First A1 for a correct equation e.g. M(A) $R \times 1.5 + 2R \times 6 = 20g \times 4 + 8g \times x$ Second M1 for another moments equation in *R* and *x* only or vert resolution in *R* only Second A1 for a correct equation Third M1 for solving for *AE* Third A1 for 5.75 (m) (Must be EXACT) Mass or wt of package is or acts at (point) *C* (or *E*)	

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5. Two particles P and Q have masses $4m$ and km respectively. They are moving towards each other in opposite directions along the same straight line on a smooth horizontal table when they collide directly. Immediately before the collision the speed of P is $3u$ and the speed of Q is u. Immediately after the collision both particles have speed $2u$ and the direction of motion of Q has been reversed.

(a) Find, in terms of k, m and u, the magnitude of the impulse received by Q in the collision.

(3)

(b) Find the two possible values of k.

(5)

Question Number	Scheme	Marks
5a		
	Attempt at difference in momenta for Q	M1
	$= \pm km(2u--u)$	A1
	Magnitude $= 3kmu$	A1
		(3)
5b		
	First case e.g. P continues in the same direction CLM: $4m\times 3u - km\times u = 4m\times 2u + km\times 2u$ **OR** $-3kmu = 4m(2u-3u)$	M1A1
	$k = \frac{4}{3}$, 1.33 (3 SF or better)	A1
		
	Second case e.g. P changes direction CLM: $4m\times 3u - km\times u = -4m\times 2u + km\times 2u$ **OR** $3kmu = 4m(2u--3u)$	M1
	$k = \frac{20}{3}$, 6.67 (3 SF or better)	A1
		(5)
		[8]

Question Number	Scheme	Marks
	Notes	
5a	M1 for clear attempt at *difference* in momenta for *Q* only (M0 if mass omitted or if g's included or if clearly adding) in terms of *k*, *m* and *u* only.	
	First A1 for $\pm km(2u--u)$	
	Second A1 for 3*kmu*	
5b	**N.B.** Mark the 'better' equation out of 3	
	First M1 for an equation in *k*, *m* and *u only*, dim. correct with correct no. of terms (4 if using CLM, or 3 if using impulse from part (a)) condone sign errors	
	First A1 for a correct equation	
	Second A1 for a correct value of *k*	
	Second M1 for another equation (**N.B**. Must clearly have *P* now moving in the opposite direction to that already considered) in *k*, *m* and *u only*, dim. correct with correct terms (4 if using CLM, or 3 if using impulse from part (a)) condone sign errors	
	Third A1 for the other correct value of *k*	

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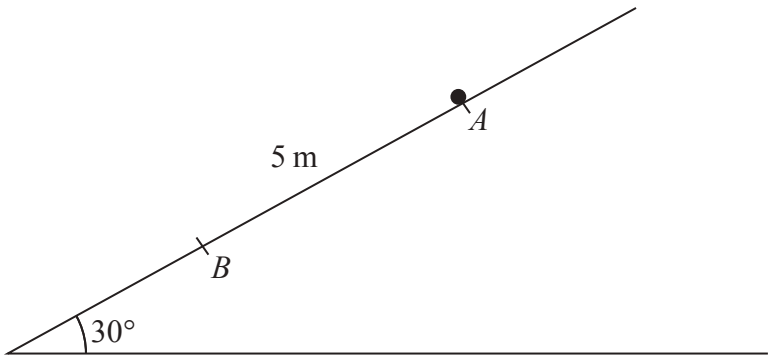


Figure 3

A particle P of mass 4 kg is held at rest at the point A on a rough plane which is inclined at 30° to the horizontal. The point B lies on the line of greatest slope of the plane that passes through A. The point B is 5 m down the plane from A, as shown in Figure 3. The coefficient of friction between the plane and P is 0.3

The particle is released from rest at A and slides down the plane.

(a) Find the speed of P at the instant it reaches B.

(7)

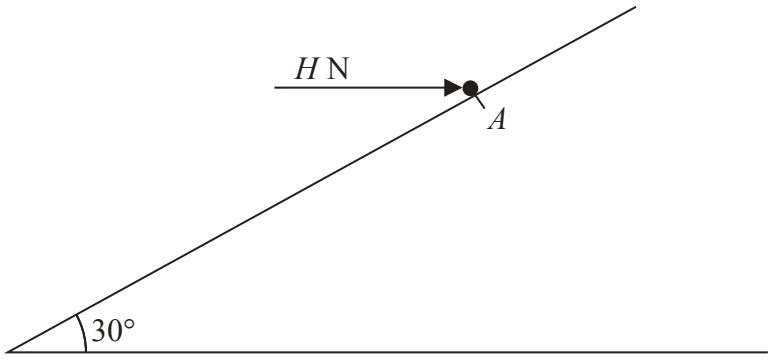
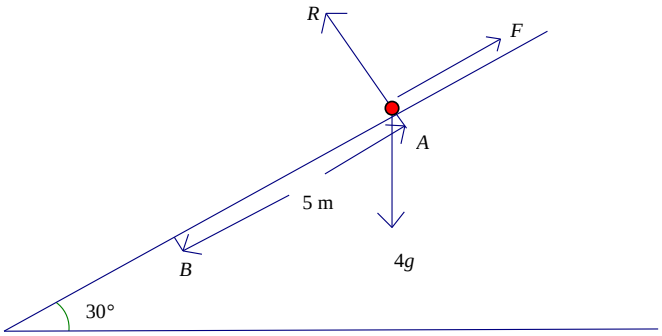
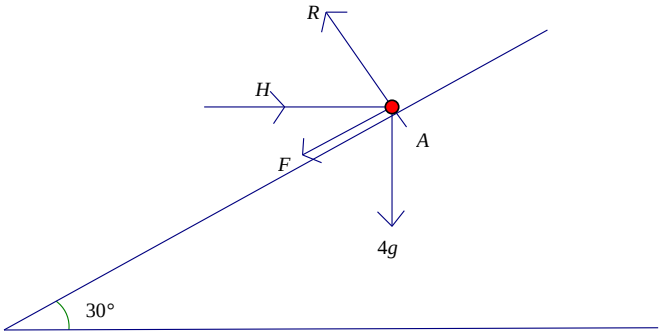


Figure 4

The particle is now returned to A and is held in equilibrium by a horizontal force of magnitude H newtons, as shown in Figure 4. The line of action of the force lies in the vertical plane containing the line of greatest slope of the plane through A. The particle is on the point of moving up the plane.

(b) Find the value of H.

(7)

Question Number	Scheme	Marks
6a		
	Resolve perpendicular to plane: $R = 4g\cos 30$	B1
	$F = 0.3R$ seen	B1
	Use of $F = ma$ parallel to plane: $4a = 4g\sin 30 - F$	M1A1
	$4a = 4g\sin 30 - 0.3\times 4g\cos 30$	A1
	Use of $v^2 = (u^2 +)2as$: $v = \sqrt{(10a)}$	M1
	v = 4.9 or 4.85(m s^{-1})	A1
		(7)
6b		
	Resolve perpendicular to the plane: $R = 4g\cos 30 + H\cos 60$	M1A1
	Resolve parallel to the plane: $H\cos 30 = F + 4g\sin 30$	M1A1
	Use of $F = 0.3R$	M1
	Solve for H: $H = \dfrac{g(1.2\cos 30 + 4\sin 30)}{\cos 30 - 0.3\cos 60}$	**DM**1
	= 42 or 41.6	A1
		(7)
6b alt	Resolve vertically: $R\cos 30 = 4g + F\cos 60$	M1A1
	Resolve horizontally: $H = R\cos 60 + F\cos 30$	M1A1
	Use of $F = 0.3R$	M1
	Solve for H:	**DM**1
	H = 42 or 41.6	A1 (7)
	N.B. Enter marks on ePen for equations as they appear.	[14]

Question Number	Scheme	Marks
6a	**Notes** First B1 for $R = 4g\cos 30$ Second B1 for $F = 0.3R$ seen (could just be on diagram) First M1 for equation of motion, with usual rules, condone sign errors First A1 for a correct equation (F not substituted) Second A1 for a correct equation in a only, without trig ratios substituted Second M1 for a complete method for finding v (must have found an a value) Third A1 for 4.9 or 4.85	
6b	First M1 for a resolution, with usual rules, condone sign errors First A1 for a correct equation Second M1 for another resolution, with usual rules, condone sign errors Second A1 for a correct equation Third M1 for use of (i.e. it must appear in an equation) $F = 0.3R$ (**N.B.** M0 if using R from part **a**) Fourth M1 **dependent** on first, second and third M's, for eliminating F and R and solving for H Third A1 for 42 or 41.6	

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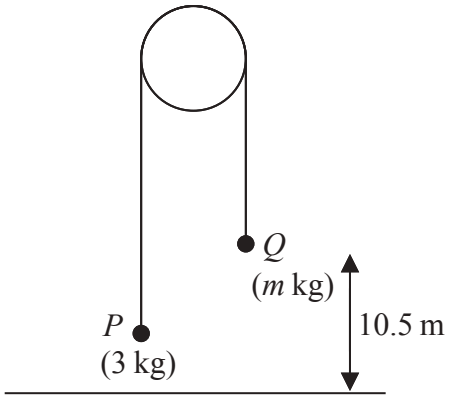


Figure 5

Two particles P and Q have masses 3 kg and m kg respectively ($m > 3$). The particles are connected by a light inextensible string which passes over a smooth light fixed pulley. The system is held at rest with the string taut and the hanging parts of the string vertical. The particle Q is at a height of 10.5 m above the horizontal ground, as shown in Figure 5. The system is released from rest and Q moves downwards. In the subsequent motion P does not reach the pulley. After the system is released, the tension in the string is 33.6 N.

(a) Show that the magnitude of the acceleration of P is 1.4 m s^{-2}.

(3)

(b) Find the value of m.

(3)

The system is released from rest at time $t = 0$. At time T_1 seconds after release, Q strikes the ground and does not rebound. The string goes slack and P continues to move upwards.

(c) Find the value of T_1

(3)

At time T_2 seconds after release, P comes to instantaneous rest.

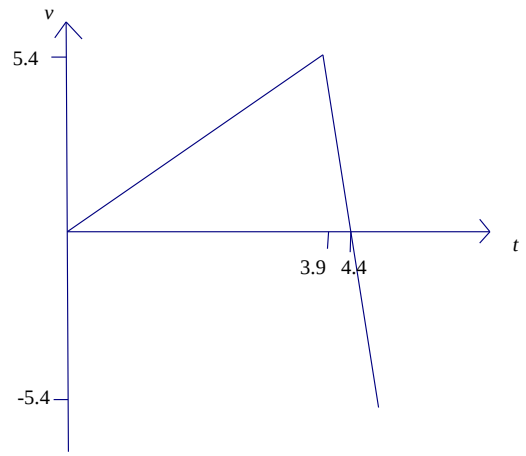
(d) Find the value of T_2

(3)

At time T_3 seconds after release ($T_3 > T_1$) the string becomes taut again.

(e) Sketch a velocity-time graph for the motion of P in the interval $0 \leqslant t \leqslant T_3$

(2)

Question Number	Scheme	Marks
7a	Motion of P: $T - 3g = 3a$	M1
	$33.6 - 3g = 3a$	A1
	$a = 1.4\ (\text{m s}^{-2})$ ***Given Answer***	A1
		(3)
7b	Motion of Q: $mg - T = ma$	M1
	$mg - 33.6 = 1.4m$	A1
	$m = 4$	A1
		(3)
7c	Use of $s = (ut +)\frac{1}{2}at^2$: $10.5 = \frac{1}{2} \times 1.4 \times t^2$	M1A1
	$T_1 = \sqrt{15} = 3.9$ or better	A1
		(3)
7d	Use $v^2 = (u^2 +)2as$ to find speed of particles when Q hits ground: $v = \sqrt{2 \times 1.4 \times 10.5}\ (= \sqrt{29.4})$	M1
	Use $v = u + at$ to find additional time for P to come to rest: $0 = \sqrt{29.4} - gt$	**DM**1
	Total time : $T_2 = \sqrt{15} + \frac{\sqrt{29.4}}{9.8} = 4.4$ or 4.43	A1
		(3)
7e		B1 Shape **DB**1 **ft** their values for 5.4, -5.4, 3.9, 4.4 (or T_1 T_2) (2)
		[14]

Question Number	Scheme	Marks
	Notes	
7a	M1 for equation of motion for P with T not substituted, condone sign errors First A1 for a correct equation in a only (allow $\pm a$) Second A1 for **given answer** (units not needed)	
7b	M1 for equation of motion for Q with neither T nor a substituted, condone sign errors First A1 for a correct equation in m only Second A1 for $m = 4$ **N.B.** Whole system equn: $mg - 3g = a(m + 3)$ may be used	
7c	M1 for a complete method to find T_1 (M0 if g used) First A1 for a correct equation (or equations) Second A1 for $\sqrt{15}$, 3.9 or better $v = \sqrt{29.4}$ (5.4) may be found in this part but only gets credit if it appears in part (d)	
7d	First M1 for a complete method to find the speed of particles when Q hits the ground (M0 if using g) Second M1 **dependent** on first M1for a complete method to find the additional time for P to come to rest (must be using g) A1 for 4.4 or 4.43	
7e	First B1 (generous) for shape. Graph does not need to go down as far as it goes up and ignore gradients. (B0 if it goes outside the range $0 \leq t \leq T_3$ or if a continuous vertical line is included) Second **B**1, **dependent** on first B1, **ft** on their $\sqrt{29.4}$, T_1 and T_2 Allow T_1 and T_2 entered on the graph (rather than their numerical values)	