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EDEXCEL INTERNATIONAL A LEVEL MATHS: QUESTIONS BY TOPIC

Forces & Newton's Laws (M1.2)

International A Level Mathematics · M1: Mechanics 1 (WME01)

27 questions · 311 marks · Mark schemes included

Past papers January 2020 - June 2025 · 3 sub-topics

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HOW TO USE THIS BOOKLET

Questions are grouped by sub-topic and run from the lowest to the highest mark tariff, then oldest paper first.

Click any row below to jump straight to that sub-topic or question.

On every question page, click ANSWER in the top-right corner to jump to its mark scheme; < QUESTION brings you back.

A gold bar in the left margin marks exactly where the question sits on the original page.

Diagrams, graphs, grids and tables are printed exactly as they appear in the original papers.

Each question is filed under its main topic; longer questions may also test skills from other topics.

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QUESTIONS

27 questions · 311 marks · 3 sub-topics

SUB-TOPIC M1.2a

NEWTON'S LAWS & RESOLVING FORCES

Sub-topic M1.2a · 5 questions · 34 marks · lowest tariff first



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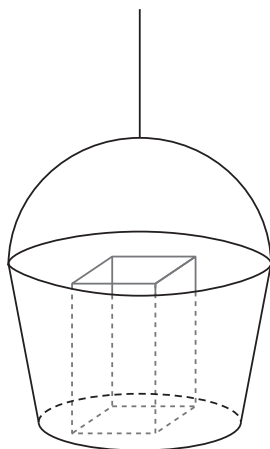
Leave
blank**Figure 1**

Figure 1 shows a large bucket used by a crane on a building site to move materials between the ground and the top of the building. The mass of the bucket is 15 kg.

The bucket is attached to a vertical cable with the bottom of the bucket horizontal. The cable is modelled as light and inextensible.

When the bucket is on the ground, a bag of cement of mass 25 kg is placed in the bucket.

The bucket with the bag of cement moves vertically upwards with constant acceleration 0.2 ms^{-2} . Air resistance is modelled as being negligible.

(a) Find the tension in the cable.

(3)

At the top of the building, the bag of cement is removed. A box of tools of mass 12 kg is now placed in the bucket.

Later on the bucket with the box of tools is moving vertically downwards with constant deceleration 0.1 ms^{-2} . Air resistance is again modelled as being negligible.

(b) Find the magnitude of the normal reaction between the bucket and the box of tools.

(3)

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Q4



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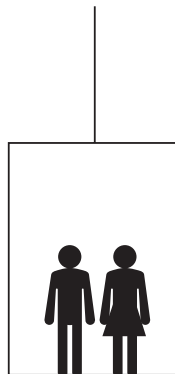


Figure 3

Two children, Alan and Bhavana, are standing on the horizontal floor of a lift, as shown in Figure 3.

The lift has mass 250 kg. The lift is raised vertically upwards with constant acceleration by a vertical cable which is attached to the top of the lift. The cable is modelled as being light and inextensible. While the lift is accelerating upwards, the tension in the cable is 3616 N.

As the lift accelerates upwards, the floor of the lift exerts a force of magnitude 565 N on Alan and a force of magnitude 226 N on Bhavana.

Air resistance is modelled as being negligible and Alan and Bhavana are modelled as particles.

- (a) By considering the forces acting on the lift only, find the acceleration of the lift. (3)
- (b) Find the mass of Alan. (3)

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Question 4 continued

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Question 4 continued

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Q4

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Question 3 continued

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Q3



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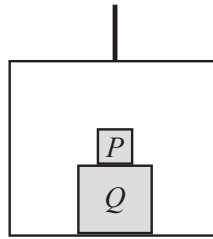


Figure 4

A simple lift operates by means of a vertical cable which is attached to the top of the lift.

The lift has mass m

A box Q is placed on the floor of the lift.

A box P is placed directly on top of box Q , as shown in Figure 4.

The cable is modelled as being light and inextensible and air resistance is modelled as being negligible.

The tension in the cable is $\frac{42mg}{5}$

The lift and its contents move vertically upwards with acceleration $\frac{2g}{5}$

Using the model,

(a) find, in terms of m , the combined mass of boxes P and Q

(4)

During the motion of the lift, the force exerted on box P by box Q is $\frac{14mg}{5}$

Using the model,

(b) find, in terms of m , the mass of box P

(3)

Question 7 continued

(Total for Question 7 is 7 marks)



Question 6 continued

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Question 6 continued

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Question 6 continued

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Q6

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SUB-TOPIC M1.2b

CONNECTED PARTICLES & PULLEYS

Sub-topic M1.2b · 14 questions · 186 marks · lowest tariff first



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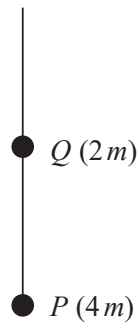


Figure 1

Two particles, P and Q , have masses $4m$ and $2m$ respectively. The particles are connected by a light inextensible string. A second light inextensible string has one end attached to Q . Both strings are taut and vertical, as shown in Figure 1.

The particles are **accelerating** vertically **downwards**.

Given that the tension in the string connecting the two particles is $3mg$, find, in terms of m and g , the tension in the upper string.

(6)



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Q7

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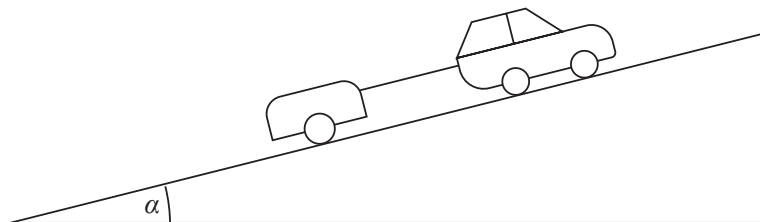


Figure 4

A car of mass 1200 kg is towing a trailer of mass 600 kg up a straight road, as shown in Figure 4.

The road is inclined at an angle α to the horizontal, where $\sin \alpha = \frac{1}{12}$

The driving force produced by the engine of the car is 3000 N.

The car moves with acceleration 0.75 m s^{-2}

The non-gravitational resistance to motion of

- the **car** is modelled as a constant force of magnitude $2R$ newtons
- the **trailer** is modelled as a constant force of magnitude R newtons

The car and the trailer are modelled as particles.

The tow bar between the car and trailer is modelled as a light rod that is parallel to the direction of motion.

Using the model,

- (a) show that the value of R is 60

(4)

- (b) find the tension in the tow bar.

(3)

When the car and trailer are moving at a speed of 12 m s^{-1} , the tow bar breaks.

Given that the non-gravitational resistance to motion of the trailer remains unchanged,

- (c) use the model to find the further distance moved by the trailer before it first comes to rest.

(4)

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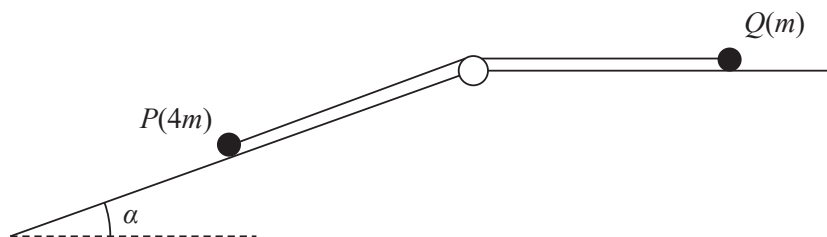




TOTAL FOR PAPER IS 75 MARKS



7.

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A particle P of mass $4m$ lies on the surface of a fixed rough inclined plane.

The plane is inclined to the horizontal at an angle α where $\tan \alpha = \frac{3}{4}$

The particle P is attached to one end of a light inextensible string.

The string passes over a small smooth pulley that is fixed at the top of the plane. The other end of the string is attached to a particle Q of mass m which lies on a smooth horizontal plane.

The string lies along the horizontal plane and in the vertical plane that contains the pulley and a line of greatest slope of the inclined plane.

The system is released from rest with the string taut, as shown in Figure 4, and P moves down the plane.

The coefficient of friction between P and the plane is $\frac{1}{4}$

For the motion before Q reaches the pulley

(a) write down an equation of motion for Q , (1)

(b) find, in terms of m and g , the tension in the string, (7)

(c) find the magnitude of the force exerted on the pulley by the string. (4)

(d) State where in your working you have used the information that the string is light. (1)

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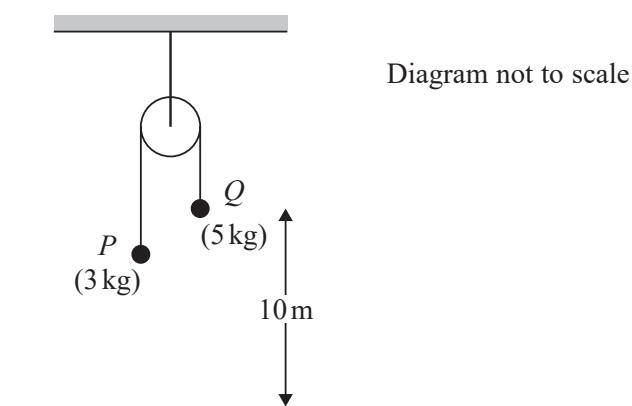
Question 7 continued

(Total for Question 7 is 13 marks)

TOTAL FOR PAPER IS 75 MARKS



5.

**Figure 3**

Two particles, P and Q , have masses 3 kg and 5 kg respectively. The particles are connected by a light inextensible string which passes over a small smooth fixed pulley.

The particles are released from rest with the string taut and the hanging parts of the string vertical, as shown in Figure 3.

Immediately after the particles are released from rest, P moves upwards with acceleration $a\text{ ms}^{-2}$ and the tension in the string is T newtons.

(a) Write down an equation of motion for P .

(2)

(b) Find the value of T .

(4)

The total force acting on the pulley due to the string has magnitude F newtons.

(c) Find the value of F .

(2)

Initially, Q is 10 m above horizontal ground and P is more than 2 m below the pulley.

At the instant when Q has descended a distance of 2 m , the string breaks and Q falls to the ground.

(d) Find the speed of Q at the instant it hits the ground.

(5)





(Total for Question 3 is 15 marks)



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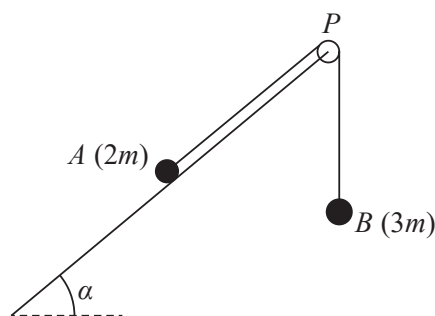
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Figure 4

One end of a light inextensible string is attached to a particle A of mass $2m$. The other end of the string is attached to a particle B of mass $3m$. The string passes over a small, smooth, light pulley P which is fixed at the top of a rough inclined plane. The plane is inclined to the horizontal at an angle α , where $\tan \alpha = \frac{3}{4}$

Particle A is held at rest on the plane with the string taut and B hanging freely below P , as shown in Figure 4. The section of the string AP is parallel to a line of greatest slope of the plane.

The coefficient of friction between A and the plane is $\frac{1}{2}$

Particle A is released and begins to move up the plane.

For the motion before A reaches the pulley,

- (a) (i) write down an equation of motion for A ,
 - (ii) write down an equation of motion for B ,
- (4)
- (b) find, in terms of g , the acceleration of A ,
- (5)
- (c) find the magnitude of the force exerted on the pulley by the string.
- (4)
- (d) State how you have used the information that P is a smooth pulley.
- (1)

Question 7 continued

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Q7



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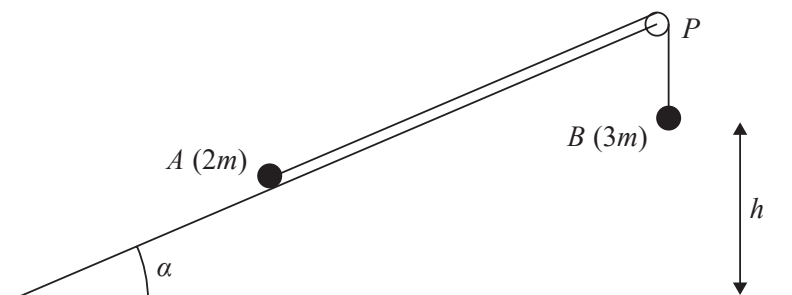


Figure 4

One end of a light inextensible string is attached to a particle A of mass $2m$. The other end of the string is attached to a particle B of mass $3m$. Particle A is held at rest on a rough plane which is inclined to horizontal ground at an angle α , where $\tan \alpha = \frac{5}{12}$.

The string passes over a small smooth pulley P which is fixed at the top of the plane. Particle B hangs vertically below P with the string taut, at a height h above the ground, as shown in Figure 4.

The part of the string between A and P lies along a line of greatest slope of the plane. The two particles, the string and the pulley all lie in the same vertical plane.

The coefficient of friction between A and the plane is $\frac{11}{36}$.

The particle A is released from rest and begins to move up the plane.

(a) Show that the frictional force acting on A as it moves up the plane is $\frac{22mg}{39}$ (3)

(b) Write down an equation of motion for B . (2)

(c) Show that the acceleration of A immediately after its release is $\frac{1}{3}g$ (4)

In the subsequent motion, A comes to rest before it reaches the pulley.

(d) Find, in terms of h , the total distance travelled by A from when it was released from rest to when it first comes to rest again. (6)

Question 8 continued

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Question 8 continued

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Question 8 continued

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Question 8 continued

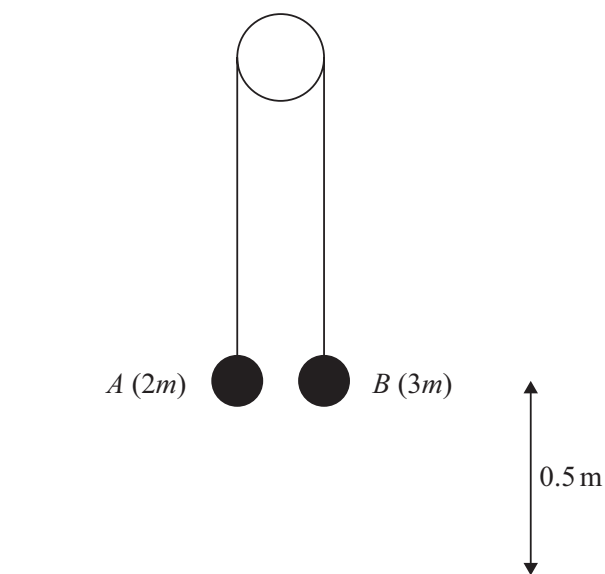
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TOTAL FOR PAPER IS 75 MARKS



7.

**Figure 4**

One end of a light inextensible string is attached to a particle A of mass $2m$.
 The other end is attached to a particle B of mass $3m$.
 The string passes over a small smooth fixed pulley.
 The string is taut and both straight parts of the string are vertical.
 Both particles are held at a distance 0.5 m above a horizontal surface, as shown in Figure 4.

The system is released from rest and B moves downwards.

- (a) Find the tension in the string in terms of m and g .

(5)

- (b) Find the speed of B at the instant it strikes the surface.

(4)

In the subsequent motion, A does not reach the pulley and B does not rebound after it strikes the surface.

- (c) Find the time from the instant when the system is released from rest to the instant when A first reaches a height of 1.06 m above the surface.

(6)

Question 7 continued

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TOTAL FOR PAPER IS 75 MARKS



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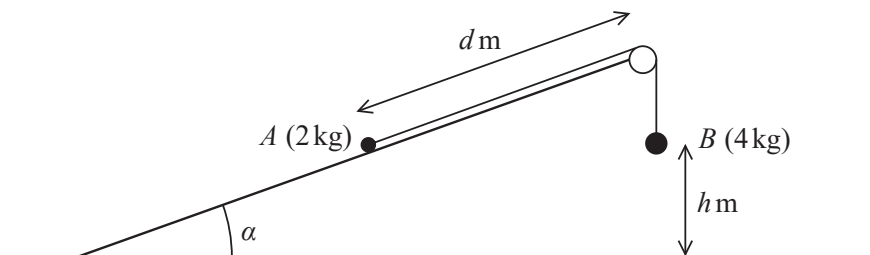
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Figure 3

Two particles, A and B , have masses 2 kg and 4 kg respectively. The particles are connected by a light inextensible string. The string passes over a small smooth pulley which is fixed at the top of a rough plane. The plane is inclined to the horizontal ground at an angle α where $\tan \alpha = \frac{3}{4}$. The particle A is held at rest on the plane at a distance d metres from the pulley. The particle B hangs freely at rest, vertically below the pulley, at a distance h metres above the ground, as shown in Figure 3. The part of the string between A and the pulley is parallel to a line of greatest slope of the plane. The coefficient of friction between A and the plane is $\frac{1}{4}$.

The system is released from rest with the string taut and B descends.

- (a) Find the tension in the string as B descends.

(9)

On hitting the ground, B immediately comes to rest.

Given that A comes to rest before reaching the pulley,

- (b) find, in terms of h , the range of possible values of d .

(7)

- (c) State one physical factor, other than air resistance, that could be taken into account to make the model described above more realistic.

(1)

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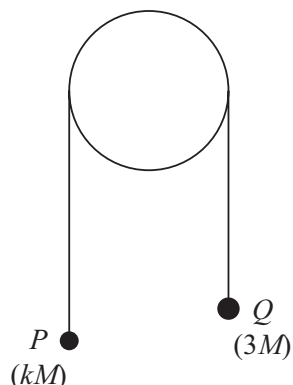


Figure 5

Two small balls, P and Q , have masses kM and $3M$ respectively, where $k < 3$

The balls are attached to the ends of a light inextensible string that passes over a fixed light smooth pulley.

The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 5.

The system is released from rest and, in the subsequent motion, P moves with an acceleration of magnitude $\frac{1}{5}g$

The balls are modelled as particles.

(a) Write down an equation of motion for P . (2)

(b) Find the value of k . (3)

Given that $M = 0.5$ kg,

(c) find the magnitude of the force exerted on the pulley by the string while Q is moving downwards. (3)

At the instant when the system is released, P is more than 2.5 m from the pulley and Q is 2.5 m above horizontal ground.

After hitting the ground, Q rebounds with a speed of 0.4 m s^{-1}

(d) Find the magnitude of the impulse received by Q when it hits the ground. (5)

In the subsequent motion, P does not hit the pulley.

(e) Find the total time from when the balls are released until P first comes to rest. (4)

Question 8 continued

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Question 8 continued

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Question 8 continued

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TOTAL FOR PAPER IS 75 MARKS



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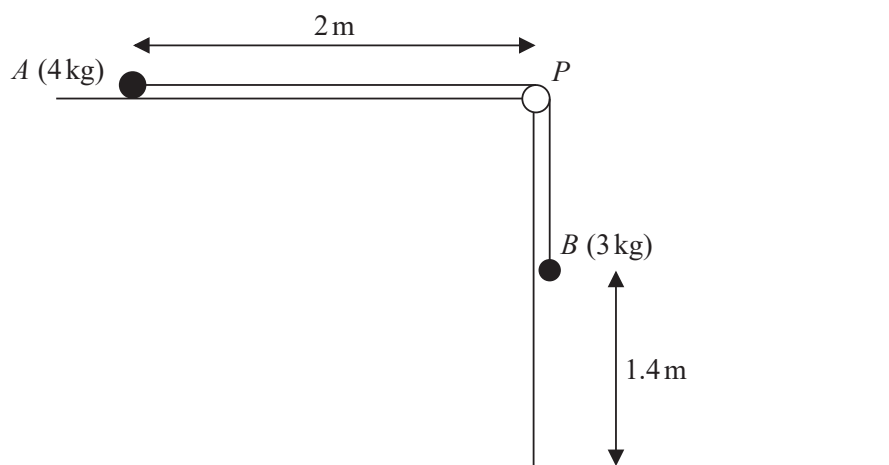


Figure 3

A particle A of mass 4 kg is held at rest on a rough horizontal table. Particle A is attached to one end of a string that passes over a pulley P . The pulley is fixed at the edge of the table. The other end of the string is attached to a particle B , of mass 3 kg, which hangs freely below P .

The part of the string from A to P is perpendicular to the edge of the table and A , P and B all lie in the same vertical plane.

The string is modelled as being light and inextensible and the pulley is modelled as being small, smooth and light.

The system is released from rest with the string taut. At the instant of release, A is 2 m from the edge of the table and B is 1.4 m above a horizontal floor, as shown in Figure 3.

After descending with constant acceleration for 2 seconds, B hits the floor and does not rebound.

(a) Show that the acceleration of A before B hits the floor is 0.7 m s^{-2} (2)

(b) State which of the modelling assumptions you have used in order to answer part (a). (1)

(c) Find the magnitude of the resultant force exerted on the pulley by the string. (4)

The coefficient of friction between A and the table is μ .

(d) Find the value of μ . (6)

(e) Determine, by calculation, whether or not A reaches the pulley. (5)

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SUB-TOPIC M1.2c

INCLINED PLANES & FRICTION (DYNAMICS)

Sub-topic M1.2c · 8 questions · 91 marks · lowest tariff first



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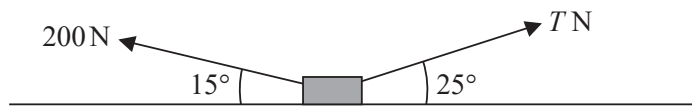


Figure 1

A parcel of mass 20 kg is at rest on a rough horizontal floor. The coefficient of friction between the parcel and the floor is 0.3

Two forces, both acting in the same vertical plane, of magnitudes 200 N and $T\text{ N}$ are applied to the parcel. The line of action of the 200 N force makes an angle of 15° with the horizontal and the line of action of the $T\text{ N}$ force makes an angle of 25° with the horizontal, as shown in Figure 1. The parcel is modelled as a particle P .

Find the smallest value of T for which P remains in equilibrium.

(9)

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Question 6 continued

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Question 6 continued

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Question 4 continued

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Q4



Question 6 continued





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Q6



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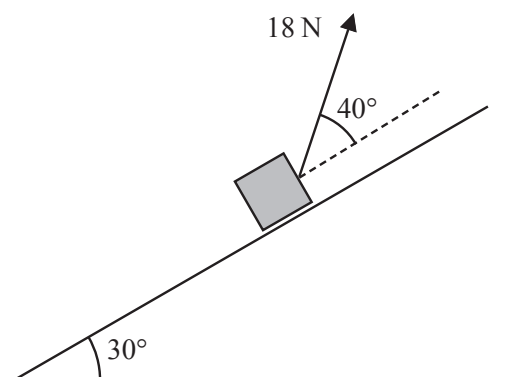


Figure 5

A parcel of mass 2 kg is pulled up a rough inclined plane by the action of a constant force.

The force has magnitude 18 N and acts at an angle of 40° to the plane.

The line of action of the force lies in a vertical plane containing a line of greatest slope of the inclined plane.

The plane is inclined at an angle of 30° to the horizontal, as shown in Figure 5.

The coefficient of friction between the plane and the parcel is 0.3

The parcel is modelled as a particle P

- (a) Find the acceleration of P (8)

The points A and B lie on a line of greatest slope of the plane, where $AB = 5$ m and B is above A . Particle P passes through A with speed 2 m s^{-1} in the direction AB .

- (b) Find the speed of P as it passes through B . (3)

The force of 18 N is removed at the instant P passes through B . As a result, P comes to rest at the point C .

- (c) Determine whether P will remain at rest at C . You must show all stages of your working clearly. (4)



Question 8 continued





TOTAL FOR PAPER: 75 MARKS

MARK SCHEMES

official mark schemes, in the same order as the questions



2.	Use of $s = ut + \frac{1}{2}at^2$	M1	Form equation in u and a . N.B. Marks are available if they use two other unknowns, rather than u and a
	$20 = 3u + \frac{9a}{2}$	A1	Correct unsimplified equation
	Use of $suvat$	M1	Form second equation in u and a . N.B. Marks are available if they use the same two other unknowns, rather than u and a
	$10 = (u + 3a) + \frac{a}{2}$ or $30 = 4u + 8a$	A1	Correct unsimplified equation
	$30 = 3u + \frac{21a}{2} \Rightarrow 10 = 6a, a = \frac{5}{3}$	M1	Solve for u or a Or for one of their unknowns.
	$u = \frac{25}{6}$	A1	u and a both correct or both their unknowns correct. Accept equivalent forms. 1.7, 4.2 or better
	Use of $v = u + at$, $20 = \frac{25}{6} + \frac{5}{3}t$	M1	Complete method using $suvat$ to find t . Correct unsimplified for their u, a .
	$t = 9.5$ (s)	A1	cao
		[8]	

	Allow use of column vectors		
3a	$(5\mathbf{i} + 2\mathbf{j}) + (-3\mathbf{i} + \mathbf{j}) + \mathbf{F}_3 = \mathbf{0}$ oe	M1	Use equilibrium to find $\mathbf{F}_3$
	$\mathbf{F}_3 = -2\mathbf{i} - 3\mathbf{j} (\Rightarrow a = -2, b = -3)$	A1	Correct $\mathbf{F}_3$
	$\tan \theta = \frac{2}{3}$	M1	For an equation in a relevant angle using their a and b
	$\theta = 33.7^\circ$	A1	34° or better. 0.588 (0.59) rads
		(4)	
3b	Resultant force $= (2 + \lambda)\mathbf{i} + (3 + 3\lambda)\mathbf{j}$	B1	Seen or implied. They must collect the $\mathbf{i}$'s and $\mathbf{j}$'s.
	$\mathbf{F} = 4\mathbf{a}$ oe, where $\mathbf{F}$ is their resultant, seen or implied (could be implied by $ \mathbf{F} = 13$)	M1	Must have attempted to add all 3 forces. N.B. $3.25 = \frac{1}{4}[(2 + \lambda)\mathbf{i} + (3 + 3\lambda)\mathbf{j}]$ oe Scores B1M1M0M0A0 but allow recovery.
	Finding magnitude of their $\mathbf{a}$ or $\mathbf{F}$ $\sqrt{\left(\frac{2 + \lambda}{4}\right)^2 + \left(\frac{3 + 3\lambda}{4}\right)^2}$ or $\sqrt{(2 + \lambda)^2 + (3 + 3\lambda)^2}$	M1	
	Use of $ \mathbf{a} = 3.25$ or $ \mathbf{F} = 13$ to form (3 term quadratic in λ) = 0 ($10\lambda^2 + 22\lambda - 156 = 0$)	M1	
	$\lambda = 3$	A1	A0 if they give 2 values.
		(5)	
		[9]	



4a	$\uparrow T - (15g + 25g) = (15 + 25) \times 0.2$	M1	All terms required. Must be in T only. Condone sign errors
		A1	Correct unsimplified equation in T
	$T = 400 \text{ (N)}$	A1	Must be positive
		(3)	
4b	$\uparrow 12g - R = -0.1 \times 12$	M1	All terms required. Condone sign errors
		A1	Correct unsimplified equation in R only. Allow $+R$ at this stage
	$R = 119 \text{ (N) } (120)$	A1	Must be positive
		(3)	
		[6]	

Question Number	Scheme	Marks
4(a)	$3616 - 250g - 565 - 226 = 250a$	M1 A1
	$a = 1.5 \text{ (m s}^{-2}\text{)}$	A1
		(3)
4(b)	$565 - mg = m \times 1.5$	M1A1ft
	$m = 50 \text{ (kg)}$	A1
		(3)
		(6)
	Notes for question 4	
4(a)	M1 Equation in a only , correct no. of terms, condone sign errors	
	A1 Correct equation	
	A1 oe	
4(b)	M1 Equation in m (mass of A) only , correct terms, condone sign errors	
	A1ft Correct equation ft on their a	
	A1 cao	

Question Number	Scheme	Marks
3(a)	$7400 - 200 - 6000 = 6000a$ $7400 - 200 - R = 8000a$ Any two of these three equations $6000 - R = 2000a$ N.B. 6000 (N) must be used as the tension to earn an M mark.	M1A1 M1A1
	$R = 5600$	DM1A1
	N.B. If they consistently use tonnes in their equations treat as a MR i.e. max M1A0M1A0M1A1 Wrong figs. for mass, e.g. 6000000 etc or just m , can score M mark in that equation.	
		(6)
3(b)	Same acceleration for the tractor and the block	B1
		(1)
		(7)
	Notes for question 3	
	N.B. Enter marks on ePen in the order in which the equations appear.	
3(a)	M1 Correct no. of terms, condone sign errors (use mass to determine which equation is being attempted)	
	A1 Correct equation	
	M1 Correct no. of terms, condone sign errors	
	A1 Correct equation	
	DM1 Solve for R , dependent on both M marks	
	A1 cao	
3(b)	B1 Any equivalent statement e.g 'both have the same acceleration' but not just 'same acceleration'. Need to say 'both' or mention the tractor and the block. Allow 'they have the same acceleration'. Allow 'same acceleration throughout the system' and 'both particles have the same acceleration'. N.B. B0 if extra wrong answers are included.	

Question Number	Scheme	Marks
7(a)	$\frac{42mg}{5} - (m + M)g = (m + M)\frac{2g}{5}$ where $M = (p + q)$	M1 A1
	OR : $\frac{42mg}{5} - Mg = M\frac{2g}{5}$ where $M = p + q + m$	
	$(p + q) = 5m$	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	
A1	eliminate R Correct equation in M and m for their M	
dM1	N.B. Award marks for a correct equation only if no wrong working seen.	
A1	Rearrange to find an expression for the combined mass of P and Q . Must be a multiple of m Cao	
(b) M1	Form an equation of motion for box P . Correct terms, condone sign errors.	
A1	Fully correct equation. Cao	

Question Number	Scheme	Marks
6(a)	$2000 - 500 - 500g \sin \alpha = 500a$ (truck)	M1 A2
	$a = 0.256$ or $0.26 \text{ (m s}^{-2}\text{)}$ (32/125 is A0)	A1
		(4)
(b)	$D - 1200 - 500 - 1500g \sin \alpha - 500g \sin \alpha = 2000a$ (system)	M1 A2
	OR: $D - 1200 - 1500g \sin \alpha - 2000 = 1500a$ (engine)	
	$D = 7700$	A1
	N.B. They may write down the system and engine equations and then: (a) solve them for a (b) solve them for D .	
		(4)
		(8)
	Notes for Question 6	
6(a)	M1 Using equation(s) of motion to give <u>an equation in a only</u> , with correct number of terms and $500g$ resolved, condone sign errors	
	A1 Equation with at most one error	
	A1 Correct equation	
	A1 Correct answer	
6(b)	M1 Using an equation of motion to give an equation in D and a only, with correct number of terms and $500g$ (or $1500g$) resolved, condone sign errors	
	A1 Equation with at most one error (a does not need to be substituted) Treat omission of g as one error	
	A1 Correct equation	
	A1 Correct answer	

Question Number	Scheme	Marks
3.	For P: $4mg - 3mg = 4ma$ For both: $4mg + 2mg - T = (4+2)ma = 6ma$ Any two of these For Q: $2mg + 3mg - T = 2ma$	M1A1 M1A1
	Solve for T	DM1
	$\frac{9mg}{2}$, $4.5mg$ oe	A1 (6)
		(6)
	Notes	
	N.B. Use the mass in the ‘ma’ term in each equation of motion to determine to which part of the system the equation refers. Allow a replaced by $-a$ in both equations. Enter marks on ePEN in the order in which equations appear.	
	M1: Equation of motion with correct terms, condone sign errors	
	A1: Correct equation	
	M1: Equation of motion with correct terms, condone sign errors	
	A1: Correct equation	
	DM1: Dependent on both M’s, for solving for T (must be in terms of mg)	
	A1: Any equivalent expression of the form kmg .	
	N.B. For the P and Q equations, allow M1 if they have T instead of $3mg$ and it’s VERY clear that T is the tension in the connecting string and not the tension they are trying to find.	

Question Number	Scheme	Marks
7(a)	$5mg - T = 5ma$ OR $5mg - T = -5ma$	M1 A1
	$T - 3mg = 3ma$ $T - 3mg = -3ma$	M1 A1
	Solve for T	DM1
	$T = \frac{15mg}{4}$ oe (allow unsimplified and not in terms of mg at this stage)	A1
	Force on pulley = $2T$	M1
	$\frac{15mg}{2}$ oe (must be a single positive term)	A1
		(8)
(b)	The tension is the same on both sides of the pulley.	B1
	Tension is same across the pulley	(1)
		(9)
	Notes for Question 7	
7.(a)	M1 Correct number of terms, condone sign errors (M0 if m 's missing)	
	A1 Correct equation	
	M1 Correct number of terms, condone sign errors (M0 if m 's missing)	
	A1 Correct equation	
	DM1 Solve for T , dependent on previous two M marks, and must be in terms of m .	
	A1 Correct expression for T	
	M1 Correct method	
	A1 Correct answer	
(b)	B1 Any equivalent statement. B0 if any incorrect extras B0 if pulley not mentioned.	

Question Number	Scheme	Marks
7(a)	Whole system: $3000 - 1200g \sin \alpha - 600g \sin \alpha - 2R - R = 1800(0.75)$	M1 A1 A1
	From exact working $R = 60 *$	A1* cso
		(4)
7(b)	Trailer: $T - 600g \sin \alpha - 60 = 600(0.75)$ OR Car: $3000 - 1200g \sin \alpha - 2(60) - T = 1200(0.75)$ (T could be replaced by $(-T)$ in either equation, leading to $T = -1000$, so tension is 1000)	M1 A1
	$T = 1000(\text{N})$	A1
		(3)
7(c)	Equation of motion $-60 - 600g \sin \alpha = 600a$ (or $-600a$) $\left[a = -\frac{11}{12} = -0.9166... \right]$	M1 A1
	$0 = 12^2 + 2\left(-\frac{11}{12}\right)d$	M1
	$d = 78.5, 79 \text{ (m)}$	A1
		(4)
		(11)
Notes for question 7		
(a)	Equation of motion for the whole system (or for car AND trailer with T eliminated) to give an equation in R only.	
M1	$\sin \alpha$ does not need to be substituted Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.	
A1	Correct equation with at most one error. $\sin \alpha$ does not need to be substituted	
A1	Correct equation. $\sin \alpha$ does not need to be substituted	
A1*	Reach the GIVEN answer with at least one intermediate line of working and must come from exact working.	
(b)	Equation of motion for the trailer or for the car. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.	
M1	$\sin \alpha$ does not need to be substituted but $R = 60$ does	
A1	Correct unsimplified equation. $\sin \alpha$ does not need to be substituted	
A1	Correct answer for T	
(c)	Form an equation of motion for the trailer to find the new acceleration. Correct number of terms, forces resolved where appropriate, condone sign errors and sin/cos confusion.	
M1	$\sin \alpha$ does not need to be substituted but $R = 60$ does	
A1	Correct unsimplified equation. $\sin \alpha$ does not need to be substituted	
M1	Complete method, with a calculated acceleration that is not g , to find the distance travelled.	
A1	Cao 2 or 3sf Must be positive. N.B. Allow a negative value of d and made positive for the distance.	



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)	$mg \sin \alpha - F = ma$ $\left(a = \frac{7g}{26} \text{ (ms}^{-2}\text{)} \right)$	M1 A1
	$V^2 = 0^2 + 2 \left(\frac{7g}{26} \right) 0.8$	M1
	$V = 2.1 \text{ or } 2.05$	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	

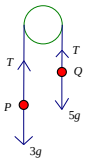
Question Number	Scheme	Marks
7(a)	$T = ma$ (allow $-a$)	B1
		(1)
7(b)	$4mg \sin \alpha - T - F = 4ma$ OR $4mg \sin \alpha - F = 5ma$ (allow $-a$) (allow $-a$)	M1A1
	$F = \frac{1}{4}R$	B1
	$R = 4mg \cos \alpha$	M1A1
	Solve for T in terms of mg only	DM1
	$T = \frac{8mg}{25}$ oe	A1
		(7)
7(c)	$2T \sin \frac{1}{2}\alpha$ oe e.g. $\sqrt{T^2 + T^2 - 2T^2 \cos \alpha}$ using cos rule Or $\frac{T \sin \alpha}{\sin(90^\circ - \frac{1}{2}\alpha)}$ using sine rule Or $\sqrt{(T - T \cos \alpha)^2 + (T \sin \alpha)^2}$ using components and Pythag.	M1 A1
	Substitute for T and trig	M1
	$\frac{8mg\sqrt{10}}{125}$ oe, $2m$ or $2.0m$ or $1.98m$ or $0.2mg$ or better	A1
		(4)
7(d)	e.g. Tension will be the same <u>throughout a section</u> of the string.	B1 (1)
		(13)
Notes for question 7		
7(a)	B1 cao The equation must appear in (a) to earn the B1.	
7(b)	M1 Equation of motion for P parallel to the plane, correct no. of terms, condone sign errors and sin/cos confusion	
	A1 Correct equation	
	B1 $F = \frac{1}{4}R$ seen – could just be on the diagram	
	M1 Resolve perpendicular to the plane for P , correct no. of terms, condone sign errors and sin/cos confusion	
	A1 Correct equation	
	DM1 Dependent on both M marks, for solving for T – must be in terms of mg only (must be of form kmg)	
	A1 cao	
7(c)	M1 If using resolving, condone cos/sin confusion and sign errors but must have correct angle	
	A1 Any correct unsimplified expression in terms of T and α	
	M1 For substituting in their T (must be of form kmg) and correct values for their trig	
	A1 cao	
7(d)	B1 B0 for ‘tension is the same throughout the string’ B0 if incorrect extras	

Question Number	Scheme	Marks
7(a)	$F = \mu mg$	B1
	For P: $mg - kmg = ma$ Allow $mg - T = ma$	M1A1
	For Q: $kmg - F = ma$ Allow $T - F = ma$	M1A1
	Either of these may be replaced by : $mg - F = 2ma$ (whole system)	
	Produce an equation in k and μ only using $T = kmg$	M1
	$k = \frac{1}{2}(1 + \mu)$	A1
		(7)
7(b)	Attempt to find the acceleration. [Note that some possible correct forms are: $a = \frac{1}{2}g(1 - \mu)$ or $g(1 - k)$ or $g(k - \mu)$]	M1
	$d = \frac{1}{2} \times \frac{1}{2} g(1 - \mu)t^2$	M1A1
	$t = \sqrt{\frac{4d}{g(1 - \mu)}}$	A1
		(4)
7(c)	P or Q (or the system) would not move	B1
	Accept any of $T = mg$, $T > mg$, $T \geq mg$, $a = 0$, $a < 0$, $a \leq 0$ $F = T$, $F > T$, $F \geq T$, $F > mg$. Allow F replaced by μR N.B. Forces referred to must be clearly defined so e.g. use of vague terms like ‘forward force’, ‘opposite force’, ‘force to the left or right’ is B0.	DB1
		(2)
		(13)

	Notes for question 7	
7(a)	B1 for $F = \mu mg$ seen e.g. on a diagram	
	M1 Equation of motion for P with correct no. of terms, condone sign errors	
	A1 Correct equation (allow $-a$)	
	M1 Equation of motion for Q with correct no. of terms, condone sign errors	
	A1 Correct equation (allow $-a$)	
	N.B. $(-a)$ must be used in both equations	
	M1 for producing an equation in k and μ only	
	A1 oe Must appear in (a)	
7(b)	M1 Attempt to find the acceleration in terms of g and μ or g and k or g , k and μ	
	M1 Complete method to find an equation in d , g , t and μ only, condone a sign error.	
	A1 Correct equation in d , g , t and μ only	
	A1 Any equivalent form	
7(c)	B1 Correct statement. B0 if incorrect extras.	
	DB1 Correct reason	

QUESTION NUMBER	SCHEME	MARKS
7(a)(i)	For A: $\frac{4mg}{3} - mg \sin \alpha - F = ma$	M1A1
	$R = mg \cos \alpha$	M1 A1
	Use of $F = \frac{1}{3} R$ in an equation.	M1
	$a = \frac{11g}{15}$ or $0.73g$ or better	A1
(ii)	For B: $kmg - \frac{4mg}{3} = kma$	M1 A1
	$k = 5$	A1
	N.B. Either equation of motion could be replaced by a whole system equation: $kmg - mg \sin \alpha - F = (k+1)ma$	
		(9)
7(b)	Complete method to find resultant force $2T \cos\left(\frac{90^\circ - \alpha}{2}\right)$	M1 A1
	Substitute $T = \frac{4mg}{3}$ and trig	dM1
	$\frac{32mg}{15}$ or $2.1mg$ or better.	A1
ALT 1	Use of cosine rule: $\sqrt{T^2 + T^2 - 2(T)(T) \cos(90 + \alpha)}$	M1 A1
ALT 2	Use of vert and horiz components to find the resultant: $\sqrt{(T \cos \alpha)^2 + (T + T \sin \alpha)^2}$	M1 A1
		(4)
		(13)
	Notes for question 7	
(a) M1	For A use $F=ma$ parallel to the plane. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion.	
A1	N.B. If they use T in this equation and never replace it, allow M1.	
M1	Correct unsimplified equation.	
A1	N.B. a could be replaced by $-a$	
M1	Resolve perpendicular to the plane Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion.	
A1	Correct equation	
M1	Use of $F = \frac{1}{3} R$	
A1	Correct answer	
M1	For B use $F=ma$ vertically. Must be dimensionally correct and have correct no of terms. Condone sin/cos confusion.	
A1	N.B. Must have km on <i>both</i> sides for this mark.	
A1	N.B. If they use T in this equation and never replace it, allow M1.	
A1	Correct unsimplified equation	
A1	N.B. a could be replaced by $-a$, but must be consistent with the equation for A.	
A1	correct answer	

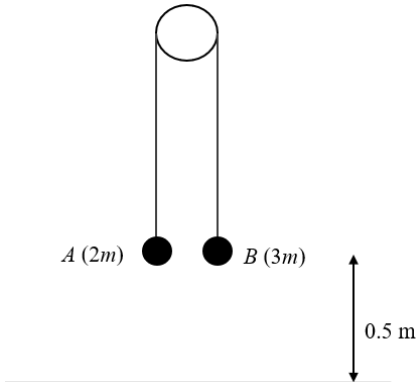
(b) M1	Complete method to find resultant force on pulley , allow sin/cos confusion
A1	Correct expression
dM1	Substitute $T = \frac{4mg}{3}$ and trig, dependent on previous M mark
A1	Correct answer.
(b) ALT1	
M1	Complete method – must involve α or its numerical value
A1	Correct expression
dM1	Substitute $T = \frac{4mg}{3}$ and trig, dependent on previous M mark
A1	Correct answer. Allow $\sqrt{\frac{1024m^2g^2}{225}}$ or similar.
(b) ALT2	
M1	Complete method, allow sin/cos confusion
A1	Correct expression
dM1	Substitute $T = \frac{4mg}{3}$ and trig, dependent on previous M mark
A1	Correct answer. Allow $\sqrt{\frac{1024m^2g^2}{225}}$ or similar.

Q	Scheme	Marks	Notes
5a			N.B. If they use $3m$ AND $5m$ consistently, can score for (a), (b) and (c), Max M1A0 in (a) Max M1A0 DM1 A0 in (b) Max M1A0 in (c). Max B1M1A1ftM1A0 in (d).
	Equation of motion for P	M1	Require all terms. Condone sign errors
	$T - 3g = 3a$ oe	A1	Correct unsimplified equation
		[2]	
5b	Equation of motion for Q	M1	Require all terms. Condone sign errors
	$Q : 5g - T = 5a$ oe	A1	Second correct equation.
			Condone combined equation $5g - 3g = (5 + 3)a$ in place of one of the above
	Solve for T	DM1	Dependent on both previous M marks, for solving for T . N.B. They could solve using a calculator, in which case this DM could be implied by a correct answer.
	$T = 36.8$	A1	Accept $\frac{15g}{4}$ oe or 37 N.B. Must be a numerical value.
		[4]	
5c	Force on pulley = $2T$	M1	Correct for their T , provided $T \neq 0$
	$F = 73.5$	A1ft	Accept $\frac{15g}{2}$ or 74 (not 73.6), ft on their T value. N.B. Must be a numerical value.
		[2]	
5d	Use of $a = \frac{g}{4}$ oe	B1	Must be used in (d).
	Complete method to find v or v^2 with $a \neq g$	M1	M0 if $s = 8$ is used
	$v^2 = 2 \times a \times 2 \left(v^2 = 2 \times \frac{g}{4} \times 2 \right)$	A1ft	Correct unsimplified equation in v or v^2 . ft on their $a \neq \pm g$
	Speed at ground	M1	Complete method with $a = \pm g$, $s = 8$, and a calculated v^2 at $s = 2$, condone sign errors.
	$w^2 = v^2 + 2 \times g \times 8$ $w = 12.9(13) (\text{ms}^{-1})$	A1	3 sf or 2 sf N.B. Only penalise overaccuracy after $g = 9.8$, ONCE for the whole question.
		[5]	
		(13)	

Question Number	Scheme	Marks
7(a) (i)	$T - 2mg \sin \alpha - F = 2ma$	M1A1
(ii)	$3mg - T = 3ma$	M1A1
	N.B. Ignore the labelling (i) and (ii)	(4)
7(b)	$R = 2mg \cos \alpha$ Allow if this appears in (a).	M1A1
	$F = \frac{1}{2} R$	B1
	Substitute for trig. and solve for a ,	DM1
	$a = \frac{1}{5} g$	A1
		(5)
7(c)	$T = \frac{12mg}{5}$ (23.52m)	DM1
	$2T \cos\left(\frac{90^\circ - \alpha}{2}\right)$ OR $\sqrt{T^2 + T^2 - 2T^2 \cos(90^\circ + \alpha)}$ OR $\sqrt{(T \cos \alpha)^2 + (T + T \sin \alpha)^2}$	M1
	Substitute for trig and T to obtain an expression in m or mg	DM1
	$\frac{48\sqrt{5}mg}{25}$; Accept $4.3mg$ or better, $42m$ or $42.1m$	A1
		(4)
7(d)	Tension is the same on either side of the pulley , tension across the pulley is the same.	B1
	B0 for tension is same for A and B or is the same for both strings etc	(1)
		(14)
Notes for question 7		
	N.B. If m 's are consistently missing, mark (a) and (b) as a MR	
7(a)	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation	
	M1 Correct no. of terms, condone sign errors	
	A1 Correct equation	
	N.B. Could have a replaced by $(-a)$ in both	
7(b)	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation	
	B1 Seen, possibly on a diagram or in (a)	
	DM1, dependent on the two M's in (a), for solving 2 simultaneous equations or using a whole system equation to find a	
	A1 cao	
7(c)	DM1, dependent on the relevant 1 st or 2 nd M1 in (a), for <u>attempt</u> to find their T , must be of form km or kmg . Apply isw if they 'cancel' m 's.	
	M1 for a correct expression in terms of T and α only; α does not need to be substituted	
	DM1, dependent on previous M, for substituting in their T and for trig, to give an expression of form km or kmg	
	A1 cao	
7(d)	B1 for any equivalent statement. B0 for incorrect extras.	

Question Number	Scheme	Marks
8.	N.B. In parts (a) and (c), $g = 9.8$ could appear in the working but final answers must be using g. In (b), $g = 9.8$ could be used in their answer. In (d), $g = 9.8$ could appear throughout in the working. N.B. For any equation of motion, if they use an incorrect mass in the 'ma' term, award M0 for the equation. However, if the correct mass has been used in (c), treat an error in the 'ma' term in (d) as a slip.	
8(a)	$R = 2mg \cos \alpha$	M1A1
	$F = \frac{11}{36} \times 2mg \times \frac{12}{13} = \frac{22mg}{39} *$	A1* (3)
8(b)	$3mg - T = 3ma$	M1A1 (2)
8(c)	$T - \frac{22mg}{39} - 2mg \sin \alpha = 2ma \quad \left(T - \frac{4mg}{3} = 2ma \right)$ OR: $3mg - \frac{22mg}{39} - 2mg \sin \alpha = 5ma$	M1A1
	Solve for a in terms of g N.B. Must reach $a = kg$ from their equations	M1
	$a = \frac{1}{3}g *$	A1* (4)
8(d)	$v^2 = \frac{2gh}{3}$	B1
	$-\frac{22mg}{39} - 2mg \sin \alpha = \pm 2ma \quad \text{OR} \quad \text{PE Gain} = 2mgd \sin \alpha$	M1
	$\pm \frac{2g}{3} = a \quad \quad \quad = \frac{10mgd}{13}$	A1
	$0 = \frac{2gh}{3} - 2 \times \frac{2g}{3} \times d$ $\frac{22mgd}{39} = \frac{1}{2} \times 2m \times \frac{2gh}{3} - \frac{10mgd}{13}$	M1
	$d = \frac{1}{2}h \quad \quad \quad d = \frac{1}{2}h$	A1
	Total distance = $\frac{1}{2}h + h = \frac{3}{2}h$	A1 ft (6)
		(15)

	Notes	
	N.B. For (a) and (c), if fractions for the trig ratios are not seen or implied, only penalise once.	
8(a)	M1: Resolve perp to the plane, correct terms, condone cos/sin confusion and sign errors. Allow if they use $\cos(\frac{12}{13})$ or similar.	
	A1: Correct equation	
	A1*: Correct given answer correctly obtained, must see $\frac{12}{13}$	
8(b)	M1: Equation of motion for <i>B</i> , correct terms, condone sign errors	
	A1: Correct equation	
8(c)	M1: Equation of motion for <i>A</i> OR whole system, correct terms but allow <i>F</i> , condone sign errors and sin/cos confusion. Allow if they use $\sin(\frac{5}{13})$ or similar.	
	A1: Correct equation	
	M1: Solve for <i>a</i> in terms of <i>g</i> , need to see trig substituted and must be solving 2 equations in <i>T</i> and <i>a</i> OR using a whole system equation with correct terms.	
	A1*: Correct given answer correctly obtained, must see $\frac{5}{13}$	
	N.B. Allow a full verification, using the equations of motion for <i>A</i> and <i>B</i> OR the whole system equation.	
8(d)	B1: seen or implied	
	M1: Equation of motion for <i>A</i> , correct terms, condone sign errors and sin/cos confusion	
	A1: Correct acceleration or deceleration of <i>A</i>	
	M1: Complete method to find an equation in <i>d</i> , <i>g</i> and <i>h</i> only, using a new calculated <i>a</i>	
	A1: cao	
	A1ft: Their <i>d</i> (which must be a multiple of <i>h</i>) + <i>h</i> . N.B. This mark is only dependent on the previous M.	
	OR: Using Work-energy	
	B1: cao	
	M1: PE gain of <i>A</i> , condone sign errors and sin/cos confusion	
	A1: Correct PE gain	
	M1: Use of work-energy principle to obtain an equation in <i>m</i> , <i>d</i> , <i>g</i> and <i>h</i> only, using their PE expression	
	A1: cao	
	A1ft: Their <i>d</i> (which must be a multiple of <i>h</i>) + <i>h</i> , with the final answer of the form <i>kh</i> .	

QUESTION NUMBER	SCHEME	MARKS
7		
7(a)	First equation of motion for either particle or whole system. For A : $T - 2mg = 2ma$ For B : $3mg - T = 3ma$ For system: $3mg - 2mg = 5ma$	M1 A1
	Second equation of motion for either particle or whole system.	M1 A1
	$T = \frac{12mg}{5}$ or $2.4mg$	A1
		(5)
7(b)	Acceleration = $\frac{g}{5}$ oe (must be used in (b))	B1
	$v^2 = 0^2 + 2 \times \text{their } a \times (0.5)$	M1
	$v^2 = 2 \times \frac{g}{5} \times 0.5$ (=1.96)	A1
	$v = 1.4$ (m s^{-1})	A1
		(4)
7(c)	Equation for time to travel the first 0.5m e.g. $0.5 = 0 + \frac{1}{2} \left(\frac{g}{5} \right) t^2$ OR $0.5 = \left(\frac{0 + 1.4}{2} \right) t$	M1 A1
	Equation for time for which A is moving under gravity $0.06 = 1.4t + \frac{1}{2}(-g)t^2$	M1 A1ft

	$t = 0.0525069... \left(\frac{5 - \sqrt{10}}{35} \right)$	A1
	Total time = 0.05250. + 0.71428.. = 0.77 or 0.767 (s)	A1
		(6)
		(15)
	Notes for Question 7	
7(a)	N.B. If m 's consistently missing, award M marks only.	
M1	Form an equation of motion for a particle or the whole system. Correct no. of terms, dimensionally correct, condone sign errors. For A : $T - 2mg = 2ma$ For B : $3mg - T = 3ma$ For system: $3mg - 2mg = 5ma$	
A1	Correct equation.	
M1	Form second equation of motion. Correct no. of terms, dimensionally correct, condone sign errors.	
A1	Correct equation.	
A1	Correct expression for tension N.B. must be kmg	
7(b)		
B1	Correct acceleration.	
M1	Complete method to find an equation in v only. Must use their acceleration. M0 if they assume that $a = 9.8$	
A1	Correct equation in v only.	
A1	Cao N.B. 7/5 is A0.	
7(c)		
M1	Complete method to find an equation for the time taken to travel first 0.5m. Must use their acceleration for the pulley system.	
A1	Correct equation in t only. Note that solving this equation gives $t = 0.71$ or 0.714 (5/7)	
M1	Complete method to find an equation in t (time to move a distance 0.06 m) only, using g for acceleration. Allow M1 if 0.56 m used but M0 for any other distance or if they use $u = 0$ or $v = 0$.	
A1ft	Correct equation in t only, ft on answer to (b).	
A1	If they stop here, then it must be $t = 0.053$ or 0.0525 (If seen, 0.233 should be rejected.) However, this A mark can be implied by a correct final answer.	
A1	Complete the solution to find the correct total time 2/3 sf	

Question Number	Scheme	Marks
8(a)	$R = 2g \cos \alpha$ (Could be earned in (b) if used there)	M1A1
	$T - 2g \sin \alpha - F = 2a$	M1A1
	$4g - T = 4a$	M1A1
	OR $4g - 2g \sin \alpha - F = 6a$ (whole system) M1A1	
	$F = 0.25R$ seen anywhere e.g. on a diagram or in (b)	B1
	Solve for T	M1
	$T = 2.4g = \frac{12g}{5} = 24 \text{ or } 23.5 \text{ (N)}$	A1 (9)
8(b)	$2.4g - 2g \sin \alpha - 0.4g = 2a$ OR $4g - 2.4g = 4a$	M1
	$a = 0.4g$	A1
	$v^2 = \frac{4gh}{5}$	M1
	$-\frac{6g}{5} - \frac{2g}{5} = 2a'$ (a' is new acceleration of A up the slope) Allow +ve terms on LHS	B1
	$0 = \frac{4gh}{5} - \frac{8g}{5}s$	M1
	$s = \frac{1}{2}h$	A1
	$d > 1.5h$	A1 (7)
8(c)	Weight of string; extensibility of the string; friction at pulley	B1 (1)
	N.B. Simply restating what's in the question is B0.	(17)
	Notes for question 8	
8(a)	M1 Resolving perpendicular to the plane, correct no. of terms, condone sign errors and sin/cos confusion	
	A1 Correct equation	
	M1 Equation of motion parallel to the plane, correct no. of terms, condone sign errors and sin/cos confusion	
	A1 Correct equation	
	M1 Equation of motion vertically, correct no. of terms, condone sign errors.	
	A1 Correct equation	
	N.B. Either equation of motion may be replaced by a whole system equation with usual rules.	
	B1 $F = 0.25R$ seen anywhere e.g. on diagram	
	M1 Solve for T (Must have <i>two</i> equations of <i>motion</i> with a in each)	
	A1 cao	
8(b)	M1 Eliminate T from their equations of motion to give an equation in a only. (N.B. May be done in (a) but must be used in (b))	



Question Number	Scheme	Marks
	(Must have <i>two</i> equations of <i>motion</i> with a in each)	
	A1 $a = 0.4g$ oe (N.B. May be found in (a) but must be used in (b))	
	M1 Complete method to give an equation in v and h only using their a , which must have been found. (M0 if $0.4g$ or g used)	
	B1 Correct equation of motion, with forces in numerical form or in terms of g , for A after B hits the ground in a' only	
	M1 for an equation in s and h only, using their a' (M0 if no a' found)	
	A1 For a correct expression for s in terms of h .	
	A1 cao	
8(c)	B1 Any correct answer. B0 if any incorrect extras included.	



8a	Equation of motion for P N.B. In (a) and (b), for both equations of motion, must be using the correct mass to score the M mark.	M1	Dimensionally correct. Need all terms. Condone sign errors. N.B. Allow if a is used instead of $\frac{1}{5}g$
	$T - kMg = \frac{1}{5}kMg$	A1	Correct only. N.B. A0 if a is used here unless subsequently is replaced by $\frac{1}{5}g$ at any stage in the question.
		(2)	
8b	Another equation of motion	M1	Condone whole system equation. N.B. Allow if a is used instead of $\frac{1}{5}g$
	For Q: $3Mg - T = \frac{3}{5}Mg$ OR For system: $3Mg - kMg = \frac{1}{5}(kM + 3M)g$	A1	or equivalent in either case. N.B. A0 if a is used here unless subsequently is replaced by $\frac{1}{5}g$ at any stage.
	Obtain $k = 2$	A1	Correct only
		(3)	
8c	Complete method to obtain equation in T only e.g. $T - g = \frac{1}{5}g$ OR $1.5g - T = \frac{3}{5} \times 0.5g$	M1	Use of their $k = 2$ and/or $M = 0.5$ in their equation of motion for P or Q Condone sign errors.
	Use of force $= 2T$	M1	Their T must be substituted. Independent M mark.
	$\frac{12}{5}g = 24$ or $23.5(\text{N})$	A1	2 sf or 3 sf only Allow $\frac{12}{5}g$ oe
		(3)	
8d	Complete method to obtain the speed of Q when it hits the ground, must be using $a = \frac{1}{5}g$ and $s = 2.5$ e.g. $v = \sqrt{2 \times \frac{1}{5}g \times 2.5}$	M1	Condone sign errors.

	$v = \sqrt{g} = \frac{7}{\sqrt{5}} = 3.13049\dots$	A1	Any of these but allow 3.1 or better
	$\pm 1.5(0.4 - (-v))$	M1	Condone sign errors, v does not need to be substituted. N.B. Allow use of $3M$, M or 0.5 for mass.
	$= \pm 1.5(0.4 + \sqrt{g})$ oe	A1	Or with $\sqrt{g} = 3.1$ or better
	Obtain 5.3 or 5.30 (Ns)	A1	2 sf or 3 sf only
		(5)	
8e	Use of <i>suvat</i> with correct acceleration to find an equation in t_1 OR t_2 only. e.g. For t_1, any of : $\sqrt{g} = \frac{1}{5}gt_1$ $2.5 = \frac{1}{2} \times \frac{1}{5}gt_1^2$ $2.5 = \frac{1}{2}(0 + \sqrt{g})t_1$ $2.5 = \sqrt{g}t_1 - \frac{1}{2} \times \frac{1}{5}gt_1^2$ OR e.g. For t_2 $0 = \sqrt{g} - gt_2$ or any other complete method e.g. find s (0.5) and use it to find t_2	M1	Complete <i>suvat</i> method to find an equation in a relevant time. Condone sign errors. N.B. If using their v ($\sqrt{g}$) from part (d), it must have come from a correct method. N.B. t_1 may have been found in (d) but must be used in (e) to gain credit.
	Obtain $t_1 = \frac{5}{\sqrt{g}} = \frac{5\sqrt{5}}{7} = 1.5971\dots$ OR $t_2 = \frac{1}{\sqrt{g}} = \frac{\sqrt{5}}{7} = 0.319438\dots$	A1	Any of these but allow $t_1 = 1.6$ or better OR Any of these but allow $t_2 = 0.3$ or better
	Complete correct method for total time = $t_1 + t_2$	M1	Correct use of <i>suvat</i> and correct accelerations
	1.9(s) or 1.92(s)	A1	2 sf or 3 sf only
		(4)	
		(17)	

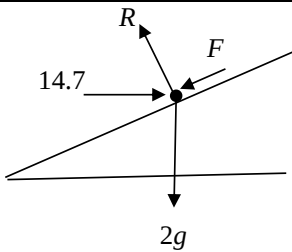
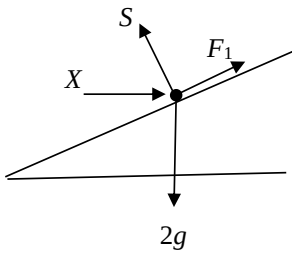
Question Number	Scheme	Marks
7(a)	$1.4 = \frac{1}{2}a \times 2^2$	M1
	$a = 0.7 \text{ (m s}^{-2}\text{)} *$ GIVEN ANSWER	A1*
		(2)
7(b)	Inextensibility of string	B1
		(1)
7(c)	$3g - T = 3 \times 0.7$ (for B)	M1 A1
	Resultant = $2T \cos 45^\circ$ OR $= \sqrt{T^2 + T^2}$ OR $= \frac{T}{\cos 45^\circ}$	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 $3g - \mu \times 4g = 7 \times 0.7$	DM1
	$\mu = 0.625$ 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
	$0.16 + 1.4 < 2 \Rightarrow$ 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. <i>Allow verification</i>	
	A1* Given answer correctly obtained or <i>verification completed correctly</i> .	
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	



Question Number	Scheme	Marks
3(a)	$R = 10g \cos \alpha$	M1
	$= 78.4 \text{ or } 78 \text{ (N)}$	A1
		(2)
(b)	$F = 0.5R$	B1
	$P = 10g \sin \alpha + F$	M1A1
	$= 98$	A1
		(4)
(c)	$P = 10g \sin \alpha - F$	M1
	$= 19.6 \text{ or } 20$	A1
		(2)
		(8)
	Notes for Question 3	
3(a)	M1 Allow sin/cos confusion	
	A1 Correct answer. Allow 8g.	
3(b)	B1 $F = 0.5R$ seen anywhere	
	M1 Correct number of terms, with 10g resolved	
	A1 Correct equation or inequality	
	A1 Correct answer. Allow 10g.	
	For any inequality which never becomes an equation, usual rules: Max M1A1A0 for $P \leq 10g \sin \alpha + F$	
3(c)	M1 Correct number of terms, with 10g resolved	
	A1 Correct answer. Allow 2g	
	For any inequality which never becomes an equation, usual rules: Max M1A0	

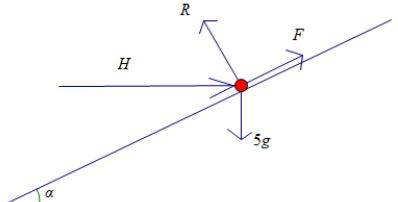
Question Number	Scheme	Marks
3(a)		
	(□), $14.7 \cos \alpha = 2g \sin \alpha + F$ (could be $-F$) (→), $14.7 + F \cos \alpha = R \sin \alpha$ OR: (↑), $R \cos \alpha + F \sin \alpha = 2g$ AND eliminate R to give an equation in F only. <u>Verificaton methods</u> $14.7 \cos \alpha = (11.76) = 2g \sin \alpha$ (i.e. verification that $X = 14.7 \Rightarrow F = 0$) OR: $X \cos \alpha = 2g \sin \alpha \Rightarrow X = 14.7$ (i.e. verification that $F = 0 \Rightarrow X = 14.7$)	M1 A1
	so $F = 0^*$ oe	A1*
		(3)
		
3(b)	$F_1 = 0.5S$	B1
	Two equations taken from: (□), $X \cos \alpha + F_1 = 2g \sin \alpha$ (□), $S = X \sin \alpha + 2g \cos \alpha$ (→), $X + F_1 \cos \alpha = S \sin \alpha$ (↑), $S \cos \alpha + F_1 \sin \alpha = 2g$	M1A2 M1A2

	N.B. M0 for both equations if they put $X = 14.7$ anywhere	
	$X = 4g/11$, 3.6 or 3.56 or 3.57	A1
	N.B. Enter marks for the equations on ePen in the order in which they appear above.	
		(8)
		(11)
	Notes for question 3	
3(a)	M1 Equation in F only, correct no of terms, condone sign errors and sin/cos confusion (M0 if they use $F = 0.5R$) N.B. Allow the equation without F Allow use of m instead of 2 for the Mmark	
	A1 Correct equation	
	A1* cao Must state a conclusion or , if verifying, must state clearly $X = 14.7 \Rightarrow F = 0$ OR $F = 0 \Rightarrow X = 14.7$	
3(b)	B1 $F_1 = 0.5S$ seen e.g. on a diagram (even if wrong direction)	
	M1 A resolution, correct no of terms, condone sign errors and sin/cos confusion Allow use of m instead of 2 for the A mark	
	A2 Correct equation, -1 each error	
	M1 A resolution, correct no of terms, condone sign errors and sin/cos confusion Allow use of m instead of 2 for the A mark	
	A2 Correct equation, -1 each error	
	A1 cao	

6a	Resolve perpendicular to the slope: $R = mg \cos \theta \left(= \frac{4}{5} mg \right)$ OR $R = W \cos \theta \left(= \frac{4}{5} W \right)$	M1	Condone sine / cosine confusion and use of α , or similar, for θ
	Use of $F = \frac{1}{4} R$	M1	R does not need to be substituted.
	Friction = $\frac{1}{4} \times mg \cos \theta$	A1	Seen or implied.
	Equation of motion	M1	Need all 3 terms. Condone sign errors and sine / cosine confusion
	$F + mg \sin \theta = ma$ OR $F + W \sin \theta = \frac{W}{g} a$	A1	Correct unsimplified equation. Allow with $-a$
	$(a =) \frac{4}{5} g$ *	A1*	Given answer A0 for 0.8g If using $-a$, allow $-a = \frac{4}{5} g$ but not $a = -\frac{4}{5} g$ as the final answer.
			N.B. Full marks available if m replaced with 2 throughout.
			N.B. The first 3 marks are for finding the friction and just stating that $F = \frac{1}{5} mg$, scores M0M0A0. N.B. Since this is a 'Show that...' question the final A1* can only be scored for a fully correct solution, including use of $\cos \theta = \frac{4}{5}$ and $\sin \theta = \frac{3}{5}$,
		(6)	
6b	Use of <i>suvat</i> to form an equation in U only	M1	e.g. $0 = U^2 - 2 \times \frac{4}{5} g \times 1.5$ N.B. Must use $a = \pm \frac{4}{5} g$
	Obtain $U = 4.8$ or $U = 4.85$	A1	2 sf or 3 sf only Not $\sqrt{\frac{12}{5}} g$ nor $\frac{14\sqrt{3}}{5}$
		(2)	

6c	Resolve parallel to the slope: $X + F = 2g \sin \theta$	M1	Correct terms. M0 if using R in their equation. Condone sign errors and sine / cosine confusion. N.B. Allow m for the mass.
	$X + \frac{1}{4}2g \cos \theta = 2g \sin \theta$	A1	Correct unsimplified equation in X and θ
	$X = \frac{4}{5}g = 7.8 \quad \text{or} \quad 7.84$	A1	2 sf or 3 sf only Allow $\frac{4}{5}g$ or $0.8g$
		(3)	
		(11)	

Question Number	Scheme	Marks
4(a)	(↑) $R = 5g - 14\sin 30^\circ$	M1 A1
	$R = 42 \text{ (N)}$	A1
	(Max Friction $\Rightarrow \frac{3}{7} \times 42 = 18 \text{ (N)}$ (18 only, with no working can score this M mark)	M1
	Horiz cpt of $P = 14\cos 30^\circ = 12.124\dots$ and $12 < 18$ (their max friction) They must be comparing with a maximum friction i.e. the word ' maximum ' or must have been clearly stated somewhere. N.B. M0 if they state or imply that the friction acting on the block is 18 N.	M1
	Friction = 12 or better (N) and block doesn't move	A1
		(6)
4(b)	(↑) $P\sin 30^\circ + S = 5g$	M1A1
	(→) $P\cos 30^\circ = \frac{3}{7}S$ (Allow M1A0 if they use the max friction from (a) or $\frac{3}{7} \times$ wrong value for S) (allow M1A0 for $P\cos 30^\circ = F$)	M1A1
	Solve for P	DM1
	$P = 19 \text{ or } 19.4 \text{ (N)}$	A1
		(6)
		(12)
	Notes for question 4	
4(a)	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation in R only .	
	A1 Correct value (seen or implied)	
	M1 Use of $F = \frac{3}{7}R$ with their R substituted.	
	M1 Condone sin/cos confusion	
	A1 cao and any equivalent correct statement and justification	
4(b)	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation	
	M1 Correct no. of terms, condone sin/cos confusion and sign errors	
	A1 Correct equation	
	DM1 Dependent on both M marks; must be solving two equations in P and one other unknown	
	A1 cao	

Q	Scheme	Marks	Notes
6a			$\tan \alpha = 0.75$ N.B. If they use $5m$ consistently, can score Max M1A0M1A0 B1A0 in (a) Max B0B1M1A0M1A0 in (b)
	First equation e.g. resolve perpendicular to the slope	M1	Need all terms. Condone sign errors and sin/cos confusion.
	$R = 5g \cos \alpha + H \sin \alpha$	A1	Correct unsimplified equation
	Second equation e.g. resolve parallel to the slope	M1	Need all terms. Condone sign errors and sin/cos confusion.
	$H \cos \alpha + F = 5g \sin \alpha$	A1	Correct unsimplified equation
	N.B. Consistent omission of g from both equations, penalise ONCE so can score max: M1A0M1A1B1A0		
	Alternative equations: Resolve horizontally: $H + F \cos \alpha (= H + \mu R \cos \alpha) = R \sin \alpha$ Resolve vertically: $5g = R \cos \alpha + F \sin \alpha (= R \cos \alpha + \mu R \sin \alpha)$		
	N.B. If they use the wrong values for $\sin \alpha$ and $\cos \alpha$, still allow the A marks for the equations, provided it's clear that the correct ratios have been used.		
	$F = \frac{1}{4} R$	B1	Seen or implied. Allow $F \leq \frac{1}{4} R$
	$H = 20.6 \text{ or } 20.7 \text{ or } 21 \text{ or } \frac{40g}{19}$	A1	Must be 3 sf or 2 sf or exact multiple of g . A0 for $\frac{392}{19}$
		[6]	
			N.B. No marks available in (b) if they use R and F from (a).
6b	N.B. If they use the wrong values for $\sin \alpha$ and $\cos \alpha$, still allow the A marks for the equations, provided it's clear that the correct ratios have been used. N.B. If g is omitted consistently, can score max : B0B1M1A1M1A0		
	$S = 5g \cos \alpha (= 4g)$	B1	Seen or implied
	$F = \frac{1}{4} S$	B1	Used with a new value for the reaction.
	Equation of motion for P : $5g \sin \alpha - g (= 3g - g) = 5a$ oe	M1	Need all terms. Condone sign errors and sin/cos confusion.

	$a = \frac{2g}{5}$ or 3.92	A1	Correct value for a N.B. Allow -ve value provided it's clear that their a was up the plane.
	$1.5 = \frac{1}{2} \times \frac{2g}{5} \times T^2$	M1	Complete method to form an equation in T only. Follow their $a \neq g$.
	$(T) = 0.875$ or 0.87	A1	3 sf or 2 sf N.B. Only penalise overaccuracy after $g = 9.8$, ONCE for the whole question.
		[6]	
		(12)	

6a	Resolve perpendicular to the plane	M1	Condone sin/cos confusion
	$R = 6g \cos \theta$	A1	Correct resolution
	$F = \frac{1}{4}R = \frac{18g}{13} = 13.6(\text{N})$ or $14(\text{N})$	A1	2 sf or 3 sf for decimal answer
		(3)	
6b	Equation of motion parallel to the plane	M1	Need all terms and dimensionally correct. Condone sign errors and sin/cos confusion.
	$-F - 6g \sin \theta = 6a$	A1	Correct unsimplified equation in F Allow $-6a$ on RHS
	$0 = 5^2 + 2 \times as$	M1	Complete method using <i>suvat</i> and calculated a ($a \neq g$) to find s This is independent of previous M mark but they must have found a value for a .
	$0 = 5^2 - 2 \times \frac{8g}{13}s$	A1	Correct unsimplified equation. Allow $(-s)$
	$s = 2.07(\text{m})$ or $2.1(\text{m})$	A1	Must be positive.
		(5)	
6c	Equation of motion parallel to the plane	M1	Need all terms and dimensionally correct. Condone sign errors and sin/cos confusion.
	$6g \sin \theta - F = 6a'$	A1	Correct unsimplified equation in F
	$5^2 = 0 + 2a's$	M1	Complete method using <i>suvat</i> , with $a' \neq a$ and $a' \neq g$ to find s
	$5^2 = 0 + 2 \times \frac{2g}{13} \times s$	A1	Correct unsimplified equation
	$8.29(\text{m})$ or $8.3(\text{m})$	A1	
		(5)	
		[13]	

A1	N.B. They may find q (M1A1) and subtract from $5m$	
Question Number	Scheme	Marks
8(a)	Perpendicular to the plane: $R + 18\sin 40^\circ = 2g \cos 30^\circ$	M1 A1
	Equation of motion parallel to the plane: $18\cos 40^\circ - F - 2g \sin 30^\circ = 2a$ (or $-2a$)	M1 A1 A1
	$F = 0.3R$	B1
	$18\cos 40^\circ - 0.3(2g \cos 30^\circ - 18\sin 40^\circ) - 2g \sin 30^\circ = 2a$	dM1
	$a = 1.18$ or 1.2 (m s^{-2})	A1 cao
		(8)
8(b)	$v^2 = 2^2 + 2(1.18)5$	M1 A1ft
	$v = 3.98$ 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)	$R = 2g \cos 30^\circ (= g\sqrt{3})$	B1
	Friction = $0.3 \times 2g \cos 30^\circ$ OR $0.3 \times 2g \sin 30^\circ$	M1
	Compares Friction with weight component parallel to plane Eg Consider: $2g \sin 30^\circ - 0.3(2g \cos 30^\circ) (= 2a)$ OR $0.3(2g \cos 30^\circ) - 2g \sin 30^\circ (= 2a)$	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 <i>perp to the plane</i> 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 A1ft A1	Complete method to form an equation in v or v^2 Correct unsimplified equation. Follow through on their value for a. Cao. Must be positive. Note that $a = 1.2$ leads to $v = 4$.	
(c) B1 M1 dM1 A1	Correct expression or value for new R Find the max friction. M0 if the previous R is used. Correct comparison between max friction value and weight component (force parallel to slope), dependent on previous M Correct statement from fully correct working. Concludes that P will not remain at rest.	