

Please check the examination details below before entering your candidate information

|                                                                                                      |  |  |  |  |                                                                                                          |  |  |             |  |                                                                                                          |  |  |  |  |
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| Candidate surname                                                                                    |  |  |  |  | Other names                                                                                              |  |  |             |  |                                                                                                          |  |  |  |  |
| <b>Pearson Edexcel</b><br><b>International</b><br><b>Advanced Level</b>                              |  |  |  |  | Centre Number                                                                                            |  |  |             |  | Candidate Number                                                                                         |  |  |  |  |
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| <b>Monday 3 June 2019</b>                                                                            |  |  |  |  |                                                                                                          |  |  |             |  |                                                                                                          |  |  |  |  |
| Afternoon (Time: 1 hour 30 minutes)                                                                  |  |  |  |  | Paper Reference <b>WME01/01</b>                                                                          |  |  |             |  |                                                                                                          |  |  |  |  |
| <b>Mathematics</b><br><b>International Advanced Subsidiary/Advanced Level</b><br><b>Mechanics M1</b> |  |  |  |  |                                                                                                          |  |  |             |  |                                                                                                          |  |  |  |  |
| <b>You must have:</b><br>Mathematical Formulae and Statistical Tables (Blue), calculator             |  |  |  |  |                                                                                                          |  |  | Total Marks |  |                                                                                                          |  |  |  |  |

**Candidates may use any calculator permitted by Pearson regulations. 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).
- **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  $g = 9.8 \text{ m s}^{-2}$ , and give your answer to either two significant figures or three significant figures.
- Inexact answers should be given to three significant figures unless otherwise stated.

### Information

- A booklet 'Mathematical Formulae and Statistical Tables' is provided.
- There are 8 questions in this question paper. 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.
- If you change your mind about an answer, cross it out and put your new answer and any working underneath.

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Answer ALL questions. Write your answers in the spaces provided.

1. Two particles,  $P$  and  $Q$ , have masses  $3m$  and  $2m$  respectively. They are moving in a straight line in opposite directions towards each other on a smooth horizontal plane and collide directly. The speeds of  $P$  and  $Q$  immediately before the collision are  $2u$  and  $4u$  respectively. As a result of the collision, the speed of  $P$  is halved and its direction of motion is reversed.

- (a) Find the speed of  $Q$  immediately after the collision. (3)
- (b) Find the magnitude of the impulse exerted on  $Q$  by  $P$  in the collision. (2)



LM

$$3m(2u) + 2m(-4u) = 3m(-u) + 2mx$$

$$6u - 8u = -3u + 2x$$

$$u = 2x$$

$$x = \frac{u}{2} \text{ m s}^{-1}$$

(b)  $3m(u - -2u)$

$$= \underline{\underline{9m4Ns}}$$

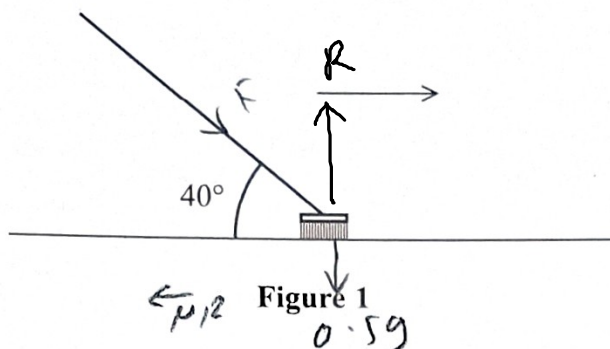


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2.



A broom is being used to sweep a rough horizontal floor. The handle of the broom makes a constant angle of  $40^\circ$  with the horizontal, as shown in Figure 1. The broom head is modelled as a particle of mass  $0.5\text{ kg}$  and the handle of the broom is modelled as a light rod. The coefficient of friction between the broom head and the floor is  $\frac{1}{4}$ . The broom head is pushed along the floor in a straight line at constant speed. Find the magnitude of the force that is being applied along the handle of the broom to the broom head.

(6)

$$F \cos 40 = \mu R \quad (\leftarrow)$$

R

$$(\uparrow) 0.5g + F \sin 40 = R.$$

$$F \cos 40 = \frac{1}{4} (0.5g + F \sin 40)$$

$$4 F \cos 40 = 0.5g + F \sin 40.$$

$$4 F \cos 40 - F \sin 40 = 0.5g.$$

$$F (4 \cos 40 - \sin 40) = 0.5g.$$

$$F = \underline{\underline{2.02\text{ N}}}$$



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3.

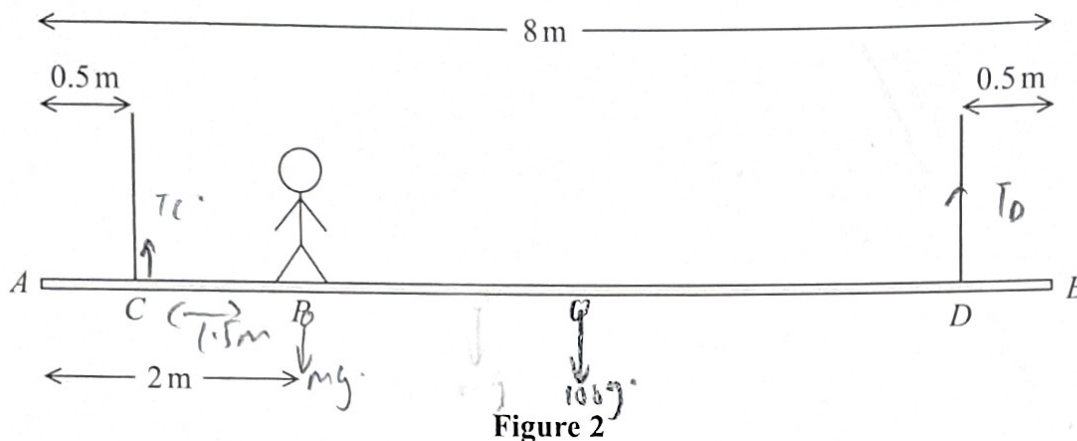


Figure 2

A beam  $AB$  has mass  $100\text{ kg}$  and length  $8\text{ m}$ . The beam is held in equilibrium in a horizontal position by two vertical ropes attached to the beam at  $C$  and  $D$ , where  $AC = 0.5\text{ m}$  and  $BD = 0.5\text{ m}$ . A gymnast of mass  $M\text{ kg}$  stands on the beam at the point  $P$ , where  $AP = 2\text{ m}$ , as shown in Figure 2. The beam remains horizontal and in equilibrium. The tension in the rope attached to the beam at  $D$  is  $637\text{ N}$ . The gymnast is modelled as a particle, the beam as a uniform rod and the ropes as light inextensible strings.

(a) Find

(i) the value of  $M$ ,

(ii) the tension in the rope attached to the beam at  $C$ .

(6)

(b) State how you have used the fact that the beam is modelled as a rod.

(1)

The gymnast at  $P$  now gets off the beam and is replaced by two gymnasts. One gymnast, of mass  $60\text{ kg}$ , stands on the beam at  $P$  and the other gymnast, of mass  $48\text{ kg}$ , stands on the beam at  $X$ , where  $AX = x$  metres. The beam remains horizontal and in equilibrium but the tensions in the two ropes are now equal. The two gymnasts are modelled as particles.

(c) Find the value of  $x$ .

(6)

$$a) mg + 100g = T_C + T_D \quad (\uparrow)$$

$$M(C)$$

$$= 1.5(Mg) + 3.5(100g) = 7(637)$$

$$M = \underline{70\text{ kg}}$$

$$170g = T_C + 637$$

$$T_C = \underline{1029\text{ N}} \approx 1030\text{ N}$$

(b) We assume that the rod doesn't bend and remains straight.

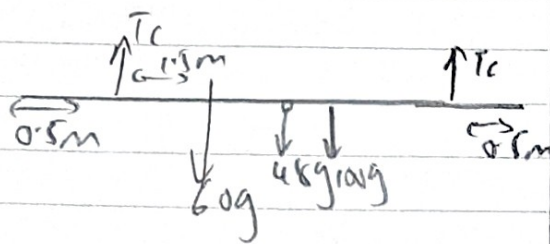
$$(c) 60g + 48g + 100g = 2T_C \quad (\uparrow)$$

$$208g = 2T_C$$

$$T_C = 104g$$



## Question 3 continued



MCA)

$$0.5(104g) + 7.5(104g) =$$

$$60g(2) + 100g(4) + 48gx$$

$$52 + 780 = 120 + 400 + 48x$$

$$x = \underline{\underline{6.5m}}$$



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4.

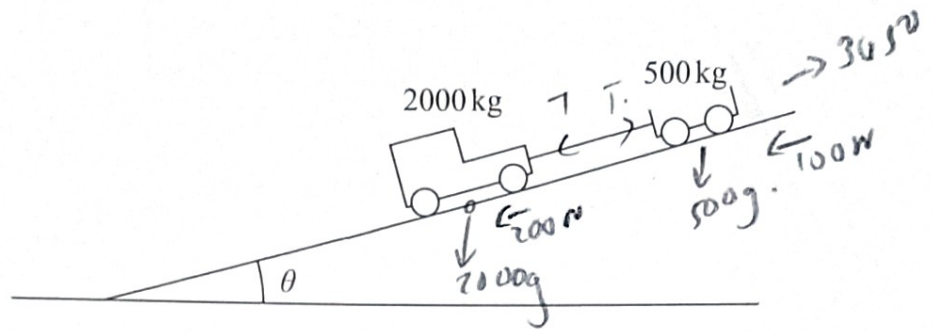


Figure 3

A railway truck of mass 500 kg is pushed up a straight track by a railway engine of mass 2000 kg. The track is inclined to the horizontal at an angle  $\theta$ , where  $\sin \theta = \frac{1}{14}$ , as shown in Figure 3. The engine produces a constant driving force of magnitude 3050 N. The truck experiences a constant resistance to motion of magnitude 100 N and the engine experiences a constant resistance to motion of magnitude 200 N. The engine and the truck are connected by a coupling which is modelled as a light rod that is parallel to the track.

Find

- (i) the acceleration of the system,
- (ii) the magnitude of the force exerted on the truck by the coupling.

(8)

i) For the whole system

$$3050 - 200 - 100 - \frac{2500g}{14} = 2500a$$

$$a = \underline{0.4 \text{ ms}^{-2}}$$

(ii) For engine.

$$3050 - T - 200 - \frac{2000g}{14} = 2000 \times 0.4$$

$$T = 650 \text{ N}$$

$$\therefore |F| = \underline{650 \text{ N}}$$

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5. Two forces  $F_1$  and  $F_2$  act on a particle. The resultant of the two forces is  $R$ .

Given that  $R$  has the same direction as the vector  $(3i - 2j)$ ,

(a) find the size of the angle between  $R$  and the vector  $j$ .

(2)

Given that  $F_1 = (ai + 3j)N$  and  $F_2 = (-4i + bj)N$ ,

(b) show that  $2a + 3b + 1 = 0$

(4)

$$(a) \quad k \begin{pmatrix} 3 \\ -2 \end{pmatrix}$$

$$= \begin{pmatrix} 3k \\ -2k \end{pmatrix}$$

$$\tan^{-1} \left( \frac{2}{3} \right)$$

$$\theta = 33.7$$

$$90 + 33.7 = \underline{\underline{123.7^\circ}}$$

$$(b) \quad F_1 + F_2 = R$$

$$\begin{pmatrix} a \\ 3 \end{pmatrix} + \begin{pmatrix} -4 \\ b \end{pmatrix} = \begin{pmatrix} 3k \\ -2k \end{pmatrix}$$

$$a - 4 = 3k \quad k = \frac{a-4}{3}$$

$$3 + b = -2k$$

$$3 + b = \frac{-2}{3}(a-4) \quad \text{from } \uparrow$$

$$a + 3b = -2a + 8$$

$$2a + 3b + 1 = 0 \text{ as req.}$$



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6. A small ball is projected vertically upwards with speed  $U \text{ m s}^{-1}$  from a point  $A$  that is  $12.5 \text{ m}$  above horizontal ground. The ball moves freely under gravity until it hits the ground  $\frac{25}{7} \text{ s}$  later. By modelling the ball as a particle,

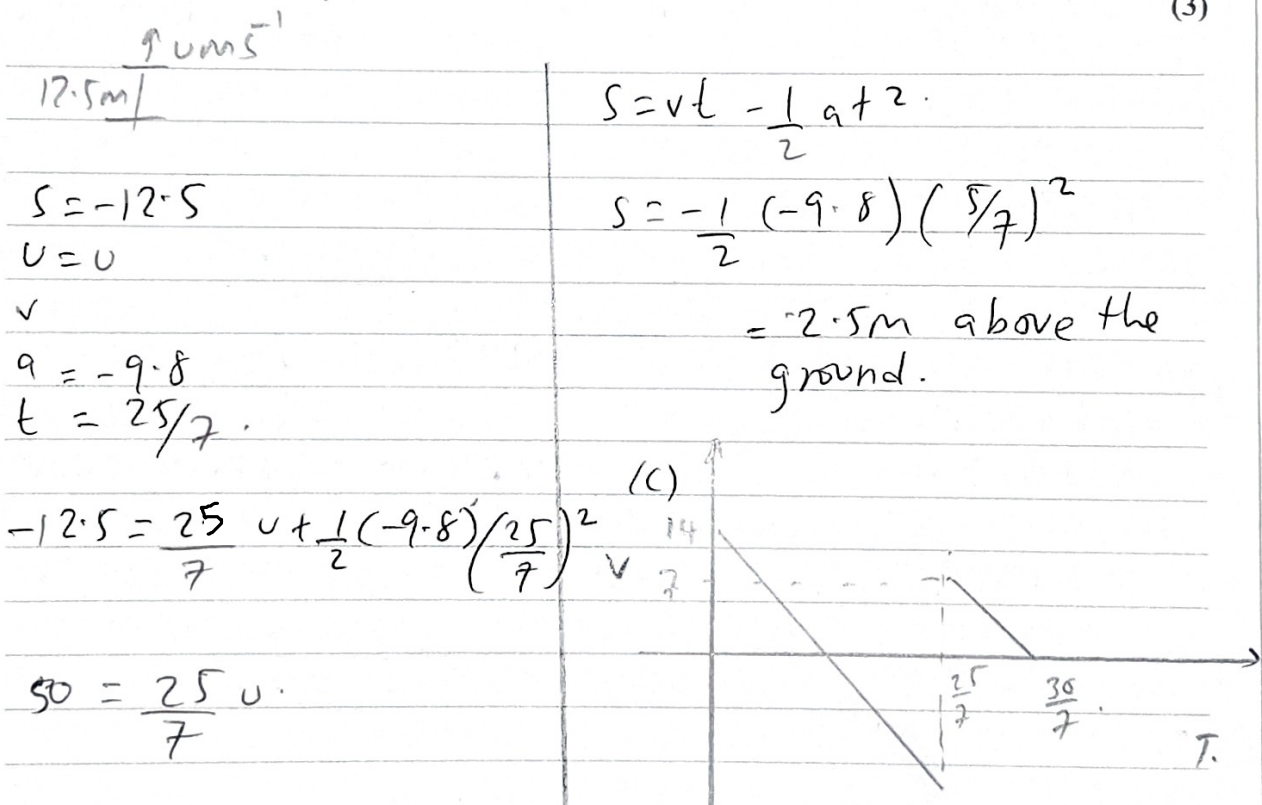
(a) find the value of  $U$ . (3)

After hitting the ground the ball rebounds vertically and comes to instantaneous rest at the point  $B$ ,  $\frac{5}{7} \text{ s}$  after hitting the ground.

(b) Find the height of  $B$  above the ground. (3)

(c) Sketch a velocity-time graph for the motion of the ball from the instant when it was first projected from  $A$  to the instant when it comes to instantaneous rest at  $B$ .

[No further calculations are needed in order to draw this sketch.] (3)



$50 = \frac{25}{7}u$

$u = 14 \text{ m s}^{-1}$

(b)  $s = ?$

$u$   
 $v = 0$   
 $a = -9.8$   
 $t = \frac{5}{7}$

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7. [In this question  $\mathbf{i}$  and  $\mathbf{j}$  are horizontal unit vectors due east and due north respectively and position vectors are given relative to a fixed origin  $O$ .]

A ship  $A$  is moving with constant velocity  $(2\mathbf{i} - 14\mathbf{j})\text{ km h}^{-1}$ . At 2 pm the position vector of ship  $A$  is  $(8\mathbf{i} + 7\mathbf{j})\text{ km}$ .

A ship  $B$  is moving with constant velocity  $(12\mathbf{i} - 4\mathbf{j})\text{ km h}^{-1}$ . At 2 pm the position vector of ship  $B$  is  $(\mathbf{i} + 2\mathbf{j})\text{ km}$ .

(a) Show that at time  $t$  hours after 2 pm,

$$\vec{BA} = [(7 - 10t)\mathbf{i} + (5 - 10t)\mathbf{j}]\text{ km} \tag{5}$$

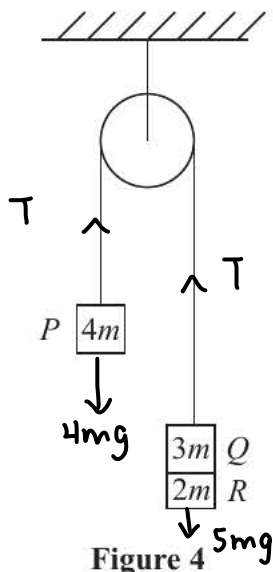
(b) Hence find the length of time for which the ships are within 2 km of each other. (7)

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>(a) <math>r_{OA} = \begin{pmatrix} 8 \\ 7 \end{pmatrix}</math>    <math>v_A = \begin{pmatrix} 2 \\ -14 \end{pmatrix}</math></p> <p><math>r_{OB} = \begin{pmatrix} 1 \\ 2 \end{pmatrix}</math>    <math>v_B = \begin{pmatrix} 12 \\ -4 \end{pmatrix}</math></p> <p><math>r_A = \begin{pmatrix} 8 \\ 7 \end{pmatrix} + t \begin{pmatrix} 2 \\ -14 \end{pmatrix} \rightarrow \vec{OA}</math></p> <p><math>= \begin{pmatrix} 8 + 2t \\ 7 - 14t \end{pmatrix}</math></p> <p><math>r_B = \begin{pmatrix} 1 \\ 2 \end{pmatrix} + t \begin{pmatrix} 12 \\ -4 \end{pmatrix}</math></p> <p><math>r_B = \begin{pmatrix} 1 + 12t \\ 2 - 4t \end{pmatrix} \rightarrow \vec{OB}</math></p> <p><math>\vec{OB} + \vec{OA} = \vec{BA}</math></p> <p><math>\begin{pmatrix} -1 - 12t \\ -2 + 4t \end{pmatrix} + \begin{pmatrix} 8 + 2t \\ 7 - 14t \end{pmatrix}</math></p> <p><math>\vec{BA} = \begin{pmatrix} 7 - 10t \\ 5 - 10t \end{pmatrix}</math></p> <p><math>\therefore \vec{BA} = (7 - 10t)\mathbf{i} + (5 - 10t)\mathbf{j}</math><br/>as req.</p> | <p>(b) <math> \vec{BA}  = 2</math></p> <p><math>\begin{pmatrix} 7 - 10t \\ 5 - 10t \end{pmatrix}</math></p> <p><math>\sqrt{(7 - 10t)^2 + (5 - 10t)^2} = 2</math></p> <p><math>(7 - 10t)^2 + (5 - 10t)^2 = 4</math></p> <p><math>49 - 140t + 100t^2 + 25 - 100t + 100t^2 = 4</math></p> <p><math>200t^2 - 240t + 70 = 0</math></p> <p><math>240 \pm \sqrt{(240)^2 - 4(200 \times 70)}</math><br/><math>2 \times 200</math></p> <p><math>t = \frac{1}{2} \quad t = \frac{7}{10}</math></p> <p>2:30 pm <math>\rightarrow</math> 2:42 pm</p> <p><math>\therefore</math> length of time = <u>12 min</u></p> |
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8.



Three particles,  $P$ ,  $Q$  and  $R$ , have masses  $4m$ ,  $3m$  and  $2m$  respectively. Particles  $P$  and  $Q$  are connected by a light inextensible string that passes over a smooth light fixed pulley. Particle  $R$  is attached to particle  $Q$ . The system is held at rest with the string taut and the hanging parts of the string vertical, as shown in Figure 4. The system is released from rest.

- (a) Find
- (i) the acceleration of particle  $P$ ,
  - (ii) the tension in the string.
- (7)

- (b) State how you have used the fact that the string is inextensible.
- (1)

At the instant when particle  $P$  has moved a distance  $d$  upwards from its initial position, particle  $R$  separates from particle  $Q$  and falls away. In the subsequent motion, particles  $P$  and  $Q$  continue to move and particle  $P$  does not reach the pulley.

At the instant when particles  $R$  and  $Q$  separate, particle  $Q$  is at the point  $A$ , and it continues to move downwards. Particle  $Q$  then comes to instantaneous rest at the point  $B$ .

- (c) Find, in terms of  $d$ , the distance  $AB$ .
- (8)

ai)  $F = ma$  b) Particles have the same acceleration

$$3mg + 2mg - 4mg = (3+2+4)ma$$

$$g = 9a$$

$$a = \frac{g}{9}$$

ii)  $T - 4mg = 4ma$

$$T = 4m\left(\frac{g}{9}\right) + 4mg$$

$$= \frac{40mg}{9}$$

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## Question 8 continued

$$(c) \quad r = d$$

$$u = 0$$

$$v = ?$$

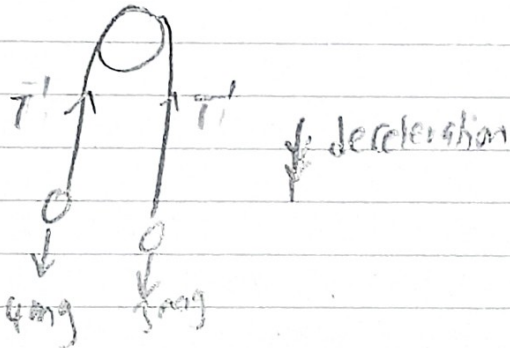
$$a = g/7$$

$$t$$

$$v^2 = u^2 + 2as$$

$$v^2 = 2\left(\frac{g}{7}\right)d$$

$$v = \sqrt{\frac{2gd}{7}}$$



$$T' - 4mg = 4ma$$

$$3mg - T' = 3ma$$

$$-mg = 7ma$$

$$a = -g/7$$

$$s = ?$$

$$u = \sqrt{\frac{2gd}{7}}$$

$$v = 0$$

$$a = -g/7$$

$$t$$

$$0 = \frac{2gd}{7} + 2\left(\frac{-g}{7}\right)s$$

$$\frac{2s}{7} = \frac{2d}{7}$$

$$s = \frac{14d}{18}$$

$$s = \frac{7d}{9}$$

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