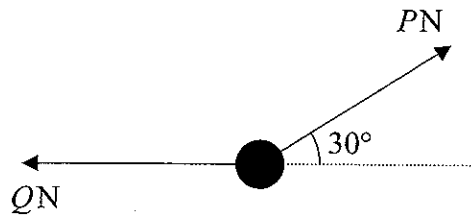




1.

Figure 1



A particle of weight  $24 \text{ N}$  is held in equilibrium by two light inextensible strings. One string is horizontal. The other string is inclined at an angle of  $30^\circ$  to the horizontal, as shown in Figure 1. The tension in the horizontal string is  $Q$  newtons and the tension in the other string is  $P$  newtons. Find

(a) the value of  $P$ , (3)

(b) the value of  $Q$ . (3)

*(Handwritten solution area with horizontal lines)*

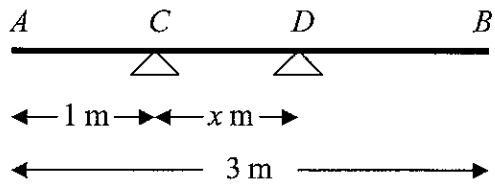


January 2007  
6677 Mechanics M1  
Mark Scheme

Question Number	Scheme	Marks
1.	<p>(a) <math>P \sin 30^\circ = 24</math> <math>P = 48</math></p> <p>(b) <math>Q = P \cos 30^\circ</math> <math>\approx 41.6</math>      accept <math>24\sqrt{3}</math>, awrt 42</p>	<p>M1 A1 A1    <u>3</u></p> <p>M1 A1 A1    <u>3</u>    <b>6</b></p>
2.	<p>(a) <math>M(C) \quad 80 \times x = 120 \times 0.5</math> <math>x = 0.75</math> *      cso</p> <p>(b) Using reaction at <math>C = 0</math> <math>M(D) \quad 120 \times 0.25 = W \times 1.25</math>      ft their <math>x</math> <math>W = 24</math> (N)</p> <p>(c) i      <math>X = 24 + 120 = 144</math> (N)      ft their <math>W</math></p> <p>(d) The weight of the rock acts precisely at <math>B</math>.</p>	<p>M1 A1 A1    <u>3</u></p> <p>B1 M1 A1 A1    <u>4</u></p> <p>M1 A1ft       <u>2</u></p> <p>B1    <u>1</u>    <b>10</b></p>
3.	<p>(a) <math>\mathbf{a} = \frac{(15\mathbf{i} - 4\mathbf{j}) - (3\mathbf{i} + 2\mathbf{j})}{4} = 3\mathbf{i} - 1.5\mathbf{j}</math></p> <p>(b) N2L    <math>\mathbf{F} = m\mathbf{a} = 6\mathbf{i} - 3\mathbf{j}</math>      ft their <math>\mathbf{a}</math> <math> \mathbf{F}  = \sqrt{(6^2 + 3^2)} \approx 6.71</math> (N)      accept <math>\sqrt{45}</math>, awrt 6.7</p> <p>(c) <math>\mathbf{v}_6 = (3\mathbf{i} + 2\mathbf{j}) + (3\mathbf{i} - 1.5\mathbf{j})6</math>      ft their <math>\mathbf{a}</math> <math>= 21\mathbf{i} - 7\mathbf{j}</math> (<math>\text{ms}^{-1}</math>)</p>	<p>M1 A1 <u>2</u></p> <p>M1 A1 M1 A1 <u>4</u></p> <p>M1 A1ft A1    <u>1</u>    <b>9</b></p>

2.

Figure 2



A uniform plank  $AB$  has weight  $120$  N and length  $3$  m. The plank rests horizontally in equilibrium on two smooth supports  $C$  and  $D$ , where  $AC = 1$  m and  $CD = x$  m, as shown in Figure 2. The reaction of the support on the plank at  $D$  has magnitude  $80$  N. Modelling the plank as a rod,

- (a) show that  $x = 0.75$  (3)

A rock is now placed at  $B$  and the plank is on the point of tilting about  $D$ . Modelling the rock as a particle, find

- (b) the weight of the rock, (4)
- (c) the magnitude of the reaction of the support on the plank at  $D$ . (2)
- (d) State how you have used the model of the rock as a particle. (1)

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Question Number	Scheme	Marks
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3.	<p>(a) <math>\mathbf{a} = \frac{(15\mathbf{i} - 4\mathbf{j}) - (3\mathbf{i} + 2\mathbf{j})}{4} = 3\mathbf{i} - 1.5\mathbf{j}</math></p> <p>(b) N2L    <math>\mathbf{F} = m\mathbf{a} = 6\mathbf{i} - 3\mathbf{j}</math>      ft their <math>\mathbf{a}</math> <math> \mathbf{F}  = \sqrt{(6^2 + 3^2)} \approx 6.71</math> (N)      accept <math>\sqrt{45}</math>, awrt 6.7</p> <p>(c) <math>\mathbf{v}_6 = (3\mathbf{i} + 2\mathbf{j}) + (3\mathbf{i} - 1.5\mathbf{j})6</math>      ft their <math>\mathbf{a}</math> <math>= 21\mathbf{i} - 7\mathbf{j}</math> (<math>\text{ms}^{-1}</math>)</p>	<p>M1 A1 <u>2</u></p> <p>M1 A1 M1 A1 <u>4</u></p> <p>M1 A1ft A1    <u>1</u>    <b>9</b></p>



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4. A particle  $P$  of mass  $0.3 \text{ kg}$  is moving with speed  $u \text{ m s}^{-1}$  in a straight line on a smooth horizontal table. The particle  $P$  collides directly with a particle  $Q$  of mass  $0.6 \text{ kg}$ , which is at rest on the table. Immediately after the particles collide,  $P$  has speed  $2 \text{ m s}^{-1}$  and  $Q$  has speed  $5 \text{ m s}^{-1}$ . The direction of motion of  $P$  is reversed by the collision. Find

(a) the value of  $u$ , (4)

(b) the magnitude of the impulse exerted by  $P$  on  $Q$ . (2)

Immediately after the collision, a constant force of magnitude  $R$  newtons is applied to  $Q$  in the direction directly opposite to the direction of motion of  $Q$ . As a result  $Q$  is brought to rest in  $1.5 \text{ s}$ .

(c) Find the value of  $R$ . (4)

Lined area for writing answers.





Question Number	Scheme	Marks
4.	<p>(a) CLM <math>0.3u = 0.3 \times (-2) + 0.6 \times 5</math> <math>u = 8</math></p> <p>(b) <math>I = 0.6 \times 5 = 3</math> (Ns)</p> <p>(c) <math>v = u + at \Rightarrow 5 = a \times 1.5</math> (<math>a = \frac{10}{3}</math>) N2L <math>R = 0.6 \times \frac{10}{3} = 2</math></p>	<p>M1 A1 M1 A1 <u>4</u></p> <p>M1 A1 <u>2</u></p> <p>M1 A1 M1 A1 <u>4</u> <b>10</b></p>
5.	<p>(a) <math>v^2 = u^2 + 2as \Rightarrow 0^2 = 21^2 - 2 \times 9.8 \times h</math> <math>h = 22.5</math> (m)</p> <p>(b) <math>v^2 = u^2 + 2as \Rightarrow v^2 = 0^2 + 2 \times 9.8 \times 24</math> or equivalent (= 470.4) <math>v \approx 22</math> (<math>\text{ms}^{-1}</math>) accept 21.7</p> <p>(c) <math>v = u + at \Rightarrow -\sqrt{470.4} = 21 - 9.8t</math> or equivalent - 1 each error <math>t \approx 4.4</math> (s) accept 4.36</p>	<p>M1 A1 A1 <u>3</u></p> <p>M1 A1 A1 <u>3</u></p> <p>M1 A2 (1, 0) A1 <u>4</u> <b>10</b></p>

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5. A ball is projected vertically upwards with speed  $21 \text{ m s}^{-1}$  from a point  $A$ , which is  $1.5 \text{ m}$  above the ground. After projection, the ball moves freely under gravity until it reaches the ground. Modelling the ball as a particle, find

(a) the greatest height above  $A$  reached by the ball, (3)

(b) the speed of the ball as it reaches the ground, (3)

(c) the time between the instant when the ball is projected from  $A$  and the instant when the ball reaches the ground. (4)

Ruled area for writing answers.

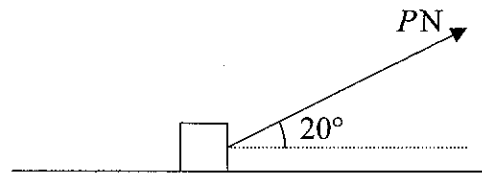


Question Number	Scheme	Marks
4.	<p>(a) CLM <math>0.3u = 0.3 \times (-2) + 0.6 \times 5</math> <math>u = 8</math></p> <p>(b) <math>I = 0.6 \times 5 = 3</math> (Ns)</p> <p>(c) <math>v = u + at \Rightarrow 5 = a \times 1.5</math> (<math>a = \frac{10}{3}</math>) N2L <math>R = 0.6 \times \frac{10}{3} = 2</math></p>	<p>M1 A1 M1 A1 <u>4</u></p> <p>M1 A1 <u>2</u></p> <p>M1 A1 M1 A1 <u>4</u> <b>10</b></p>
5.	<p>(a) <math>v^2 = u^2 + 2as \Rightarrow 0^2 = 21^2 - 2 \times 9.8 \times h</math> <math>h = 22.5</math> (m)</p> <p>(b) <math>v^2 = u^2 + 2as \Rightarrow v^2 = 0^2 + 2 \times 9.8 \times 24</math> or equivalent (= 470.4) <math>v \approx 22</math> (<math>\text{ms}^{-1}</math>) accept 21.7</p> <p>(c) <math>v = u + at \Rightarrow -\sqrt{470.4} = 21 - 9.8t</math> or equivalent - 1 each error <math>t \approx 4.4</math> (s) accept 4.36</p>	<p>M1 A1 A1 <u>3</u></p> <p>M1 A1 A1 <u>3</u></p> <p>M1 A2 (1, 0) A1 <u>4</u> <b>10</b></p>

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6.

Figure 3



A box of mass 30 kg is being pulled along rough horizontal ground at a constant speed using a rope. The rope makes an angle of  $20^\circ$  with the ground, as shown in Figure 3. The coefficient of friction between the box and the ground is 0.4. The box is modelled as a particle and the rope as a light, inextensible string. The tension in the rope is  $P$  newtons.

(a) Find the value of  $P$ . (8)

The tension in the rope is now increased to 150 N.

(b) Find the acceleration of the box. (6)

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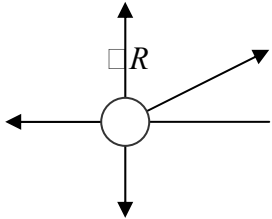
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Question Number	Scheme	Marks
6.	<p>(a) </p> <p style="margin-left: 150px;"><math>R</math>                      <math>P</math></p> <p style="margin-left: 150px;"><math>20^\circ</math></p> <p style="margin-left: 150px;"><math>30g</math></p> <p style="margin-left: 150px;">Use of <math>F = \mu R</math></p> <p style="margin-left: 100px;"><math>\bar{\Phi}</math> <math>P \cos 20^\circ = \mu R</math></p> <p style="margin-left: 100px;">i <math>R + P \sin 20^\circ = 30g</math></p> <p style="margin-left: 150px;"><math>P \cos 20^\circ = \mu(30g - P \sin 20^\circ)</math></p> <p style="margin-left: 150px;"><math>P = \frac{0.4 \times 30g}{\cos 20^\circ + 0.4 \sin 20^\circ}</math></p> <p style="margin-left: 150px;"><math>\approx 110 \text{ (N)}</math>                      accept 109</p> <p>(b)                      i <math>R + 150 \sin 20^\circ = 30g</math></p> <p style="margin-left: 150px;"><math>(R \approx 242.7)</math></p> <p>N2L                      <math>\bar{\Phi}</math> <math>150 \cos 20^\circ - \mu R = 30a</math></p> <p style="margin-left: 150px;"><math>a \approx \frac{150 \cos 20^\circ - 0.4 \times 242.7}{30}</math></p> <p style="margin-left: 150px;"><math>= 1.5 \text{ (ms}^{-2}\text{)}</math>                      accept 1.46</p>	<p>B1</p> <p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>M1</p> <p>A1 <u>8</u></p> <p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>A1 <u>6</u> <b>14</b></p>

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7.

Figure 4

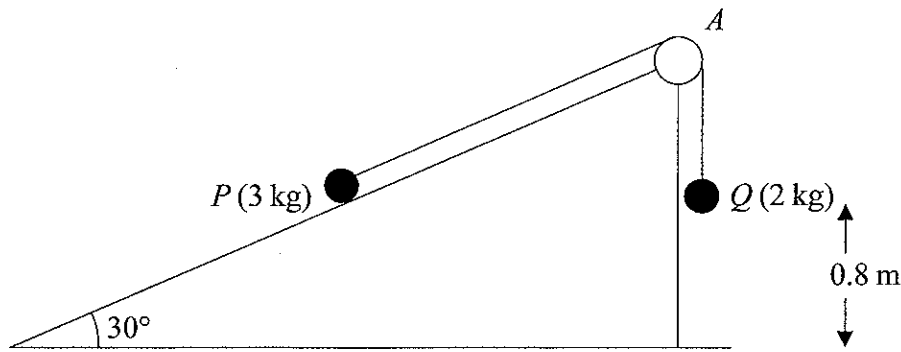


Figure 4 shows two particles  $P$  and  $Q$ , of mass 3 kg and 2 kg respectively, connected by a light inextensible string. Initially  $P$  is held at rest on a fixed smooth plane inclined at  $30^\circ$  to the horizontal. The string passes over a small smooth light pulley  $A$  fixed at the top of the plane. The part of the string from  $P$  to  $A$  is parallel to a line of greatest slope of the plane. The particle  $Q$  hangs freely below  $A$ . The system is released from rest with the string taut.

- (a) Write down an equation of motion for  $P$  and an equation of motion for  $Q$ . (4)
- (b) Hence show that the acceleration of  $Q$  is  $0.98 \text{ m s}^{-2}$ . (2)
- (c) Find the tension in the string. (2)
- (d) State where in your calculations you have used the information that the string is inextensible. (1)

On release,  $Q$  is at a height of 0.8 m above the ground. When  $Q$  reaches the ground, it is brought to rest immediately by the impact with the ground and does not rebound. The initial distance of  $P$  from  $A$  is such that in the subsequent motion  $P$  does not reach  $A$ . Find

- (e) the speed of  $Q$  as it reaches the ground, (2)
- (f) the time between the instant when  $Q$  reaches the ground and the instant when the string becomes taut again. (5)

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Question Number	Scheme	Marks
7.	(a) N2L $Q$ $2g - T = 2a$ N2L $P$ $T - 3g \sin 30^\circ = 3a$	M1 A1 M1 A1 <u>4</u>
	(b) $2g - 3g \sin 30^\circ = 5a$ $a = 0.98 \text{ (ms}^{-2}\text{)} \star$ cso	M1 A1 <u>2</u>
	(c) $T = 2(g - a)$ or equivalent $\approx 18 \text{ (N)}$ accept 17.6	M1 A1 <u>2</u>
	(d) The (magnitudes of the) accelerations of $P$ and $Q$ are equal	B1 <u>1</u>
	(e) $v^2 = u^2 + 2as \Rightarrow v^2 = 2 \times 0.98 \times 0.8 \text{ (=1.568)}$ $v \approx 1.3 \text{ (ms}^{-1}\text{)}$ accept 1.25	M1 A1 <u>2</u>
	(f) N2L for $P$ $-3g \sin 30^\circ = 3a$ $a = (-)\frac{1}{2}g$ $s = ut + \frac{1}{2}at^2 \Rightarrow 0 = \sqrt{1.568}t - \frac{1}{2}4.9t^2$ or equivalent $t = 0.51 \text{ (s)}$ accept 0.511	M1 A1 M1 A1 A1 <u>5</u> <b>16</b>
<p><i>A maximum of one mark can be lost for giving too great accuracy.</i></p>		