

June 2009
6677 Mechanics M1
Mark Scheme

Question Number	Scheme	Marks
Q1	$45 = 2u + \frac{1}{2}a2^2 \Rightarrow 45 = 2u + 2a$ $165 = 6u + \frac{1}{2}a6^2 \Rightarrow 165 = 6u + 18a$ <p>eliminating either u or a</p> $u = 20 \text{ and } a = 2.5$	<p>M1 A1</p> <p>M1 A1</p> <p>M1</p> <p>A1 A1</p> <p>[7]</p>
Q2 (a) (b)	$\tan \theta = \frac{p}{2p} \Rightarrow \theta = 26.6^\circ$ $\mathbf{R} = (\mathbf{i} - 3\mathbf{j}) + (p\mathbf{i} + 2p\mathbf{j}) = (1 + p)\mathbf{i} + (-3 + 2p)\mathbf{j}$ <p>\mathbf{R} is parallel to $\mathbf{i} \Rightarrow (-3 + 2p) = 0$</p> $\Rightarrow p = \frac{3}{2}$	<p>M1 A1 (2)</p> <p>M1 A1</p> <p>DM1</p> <p>A1 (4)</p> <p>[6]</p>
Q3 (a) (b)	<p>For A:</p> $-\frac{7mu}{2} = 2m(v_A - 2u)$ $v_A = \frac{u}{4}$ <p>For B:</p> $\frac{7mu}{2} = m(v_B - -3u)$ $v_B = \frac{u}{2}$ <p>OR CLM:</p> $4mu - 3mu = 2m\frac{u}{4} + mv_B$ $v_B = \frac{u}{2}$	<p>M1 A1</p> <p>A1 (3)</p> <p>M1 A1</p> <p>A1 (3)</p> <p>OR</p> <p>M1 A1</p> <p>A1 (3)</p> <p>[6]</p>

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Question Number	Scheme	Marks
Q4	$0.5g \sin \theta - F = 0.5a$ $F = \frac{1}{3}R \text{ seen}$ $R = 0.5g \cos \theta$ <p>Use of $\sin \theta = \frac{4}{5}$ or $\cos \theta = \frac{3}{5}$ or decimal equiv or decimal angle e.g 53.1° or 53°</p> $a = \frac{3g}{5} \text{ or } 5.88 \text{ m s}^{-2} \text{ or } 5.9 \text{ m s}^{-2}$	<p>M1 A1 A1</p> <p>B1</p> <p>M1 A1</p> <p>B1</p> <p>DM1 A1</p> <p>[9]</p>
Q5	$F = P \cos 50^\circ$ $F = 0.2R \text{ seen or implied.}$ $P \sin 50^\circ + R = 15g$ <p>Eliminating R; Solving for P ; $P = 37 \text{ (2 SF)}$</p>	<p>M1 A1</p> <p>B1</p> <p>M1 A1 A1</p> <p>DM1; D M1; A1</p> <p>[9]</p>
Q6	<p>(a) For whole system: $1200 - 400 - 200 = 1000a$</p> $a = 0.6 \text{ m s}^{-2}$ <p>(b) For trailer: $T - 200 = 200 \times 0.6$</p> $T = 320 \text{ N}$ <p>OR: For car: $1200 - 400 - T = 800 \times 0.6$</p> $T = 320 \text{ N}$ <p>(c) For trailer: $200 + 100 = 200f$ or $-200f$</p> $f = 1.5 \text{ m s}^{-2} \text{ (-1.5)}$ <p>For car: $400 + F - 100 = 800f$ or $-800f$</p> $F = 900$ <p>(N.B. For both: $400 + 200 + F = 1000f$)</p>	<p>M1 A1</p> <p>A1 (3)</p> <p>M1 A1 ft</p> <p>A1</p> <p>OR:</p> <p>M1 A1 ft</p> <p>A1 (3)</p> <p>M1 A1</p> <p>A1</p> <p>M1 A2</p> <p>A1 (7)</p> <p>[13]</p>

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Q5	$F = P \cos 50^\circ$ $F = 0.2R \text{ seen or implied.}$ $P \sin 50^\circ + R = 15g$ <p>Eliminating R; Solving for P ; $P = 37 \text{ (2 SF)}$</p>	M1 A1 B1 M1 A1 A1 DM1; D M1; A1 [9]
Q6 (a) (b) OR: (c)	<p>For whole system: $1200 - 400 - 200 = 1000a$</p> $a = 0.6 \text{ m s}^{-2}$ <p>For trailer: $T - 200 = 200 \times 0.6$</p> $T = 320 \text{ N}$ <p>OR: For car: $1200 - 400 - T = 800 \times 0.6$</p> $T = 320 \text{ N}$ <p>For trailer: $200 + 100 = 200f \text{ or } -200f$</p> $f = 1.5 \text{ m s}^{-2} \text{ (-1.5)}$ <p>For car: $400 + F - 100 = 800f \text{ or } -800f$</p> $F = 900$ <p>(N.B. For both: $400 + 200 + F = 1000f$)</p>	M1 A1 A1 (3) M1 A1 ft A1 OR: M1 A1 ft A1 (3) M1 A1 A1 M1 A2 A1 (7) [13]

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6. A car of mass 800 kg pulls a trailer of mass 200 kg along a straight horizontal road using a light towbar which is parallel to the road. The horizontal resistances to motion of the car and the trailer have magnitudes 400 N and 200 N respectively. The engine of the car produces a constant horizontal driving force on the car of magnitude 1200 N. Find

(a) the acceleration of the car and trailer, (3)

(b) the magnitude of the tension in the towbar. (3)

The car is moving along the road when the driver sees a hazard ahead. He reduces the force produced by the engine to zero and applies the brakes. The brakes produce a force on the car of magnitude F newtons and the car and trailer decelerate. Given that the resistances to motion are unchanged and the magnitude of the thrust in the towbar is 100 N,

(c) find the value of F . (7)



Question Number	Scheme	Marks
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Q5	$F = P \cos 50^\circ$ $F = 0.2R \text{ seen or implied.}$ $P \sin 50^\circ + R = 15g$ <p>Eliminating R; Solving for P ; $P = 37 \text{ (2 SF)}$</p>	M1 A1 B1 M1 A1 A1 DM1; D M1; A1 [9]
Q6	<p>(a) For whole system: $1200 - 400 - 200 = 1000a$</p> $a = 0.6 \text{ m s}^{-2}$ <p>(b) For trailer: $T - 200 = 200 \times 0.6$</p> $T = 320 \text{ N}$ <p>OR: For car: $1200 - 400 - T = 800 \times 0.6$</p> $T = 320 \text{ N}$ <p>(c) For trailer: $200 + 100 = 200f \text{ or } -200f$</p> $f = 1.5 \text{ m s}^{-2} \text{ (-1.5)}$ <p>For car: $400 + F - 100 = 800f \text{ or } -800f$</p> $F = 900$ <p>(N.B. For both: $400 + 200 + F = 1000f$)</p>	M1 A1 A1 (3) M1 A1 ft A1 OR: M1 A1 ft A1 (3) M1 A1 A1 M1 A2 A1 (7) [13]

7.

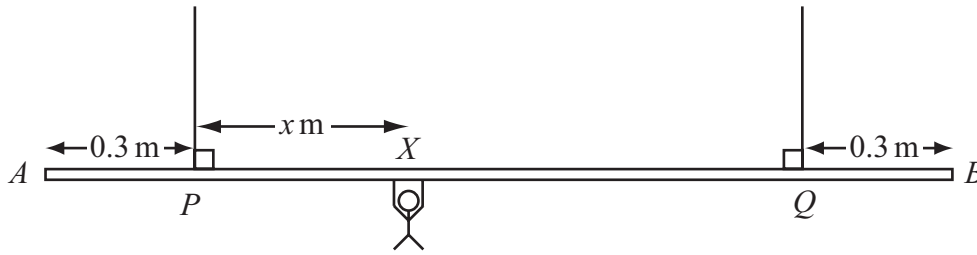


Figure 2

A beam AB is supported by two vertical ropes, which are attached to the beam at points P and Q , where $AP = 0.3$ m and $BQ = 0.3$ m. The beam is modelled as a uniform rod, of length 2 m and mass 20 kg. The ropes are modelled as light inextensible strings. A gymnast of mass 50 kg hangs on the beam between P and Q . The gymnast is modelled as a particle attached to the beam at the point X , where $PX = x$ m, $0 < x < 1.4$ as shown in Figure 2. The beam rests in equilibrium in a horizontal position.

(a) Show that the tension in the rope attached to the beam at P is $(588 - 350x)$ N. (3)

(b) Find, in terms of x , the tension in the rope attached to the beam at Q . (3)

(c) Hence find, justifying your answer carefully, the range of values of the tension which could occur in each rope. (3)

Given that the tension in the rope attached at Q is three times the tension in the rope attached at P ,

(d) find the value of x . (3)

Question Number	Scheme	Marks
Q7 (a)	$M(Q), 50g(1.4 - x) + 20g \times 0.7 = T_p \times 1.4$ $T_p = 588 - 350x \quad \text{Printed answer}$	M1 A1 A1 (3)
(b)	$M(P), 50gx + 20g \times 0.7 = T_Q \times 1.4 \quad \text{or} \quad R(\uparrow), T_p + T_Q = 70g$ $T_Q = 98 + 350x$	M1 A1 A1 (3)
(c)	<p>Since $0 < x < 1.4$, $98 < T_p < 588$ and $98 < T_Q < 588$</p>	M1 A1 A1 (3)
(d)	$98 + 350x = 3(588 - 350x)$ $x = 1.19$	M1 DM1 A1 (3) [12]
Q8 (a)	$ \mathbf{v} = \sqrt{1.2^2 + (-0.9)^2} = 1.5 \text{ m s}^{-1}$	M1 A1 (2)
(b)	$(\mathbf{r}_H =) 100\mathbf{j} + t(1.2\mathbf{i} - 0.9\mathbf{j}) \text{ m}$	M1 A1 (2)
(c)	$(\mathbf{r}_K =) 9\mathbf{i} + 46\mathbf{j} + t(0.75\mathbf{i} + 1.8\mathbf{j}) \text{ m}$	M1 A1
(d)	$\overrightarrow{HK} = \mathbf{r}_K - \mathbf{r}_H = (9 - 0.45t)\mathbf{i} + (2.7t - 54)\mathbf{j} \text{ m} \quad \text{Printed Answer}$ <p>Meet when $\overrightarrow{HK} = \mathbf{0}$</p> $(9 - 0.45t) = 0 \quad \text{and} \quad (2.7t - 54) = 0$ $t = 20 \text{ from both equations}$ $\mathbf{r}_K = \mathbf{r}_H = (24\mathbf{i} + 82\mathbf{j}) \text{ m}$	M1 A1 A1 DM1 A1 cso (5) [13]

8. [In this question \mathbf{i} and \mathbf{j} are horizontal unit vectors due east and due north respectively.]

A hiker H is walking with constant velocity $(1.2\mathbf{i} - 0.9\mathbf{j}) \text{ m s}^{-1}$.

(a) Find the speed of H .

(2)

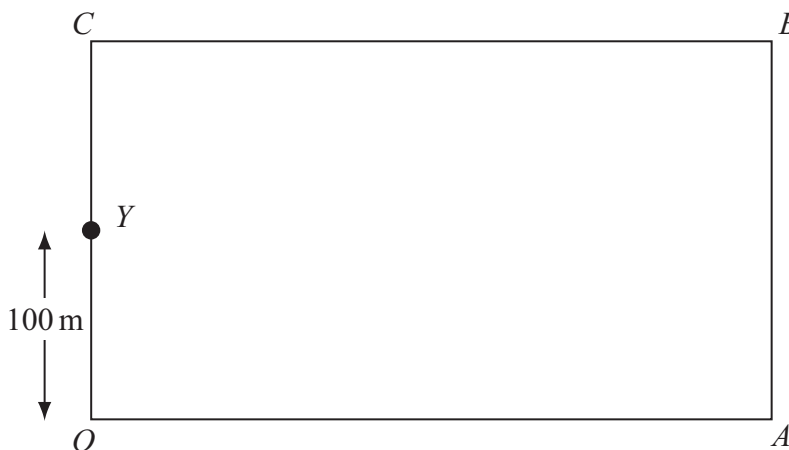


Figure 3

A horizontal field $OABC$ is rectangular with OA due east and OC due north, as shown in Figure 3. At twelve noon hiker H is at the point Y with position vector $100\mathbf{j}$ m, relative to the fixed origin O .

(b) Write down the position vector of H at time t seconds after noon.

(2)

At noon, another hiker K is at the point with position vector $(9\mathbf{i} + 46\mathbf{j})$ m. Hiker K is moving with constant velocity $(0.75\mathbf{i} + 1.8\mathbf{j}) \text{ m s}^{-1}$.

(c) Show that, at time t seconds after noon,

$$\overrightarrow{HK} = [(9 - 0.45t)\mathbf{i} + (2.7t - 54)\mathbf{j}] \text{ metres.}$$

(4)

Hence,

(d) show that the two hikers meet and find the position vector of the point where they meet.

(5)



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(c)	<p>Since $0 < x < 1.4$, $98 < T_p < 588$ and $98 < T_Q < 588$</p>	M1 A1 A1 (3)
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(d)	$\overrightarrow{HK} = \mathbf{r}_K - \mathbf{r}_H = (9 - 0.45t)\mathbf{i} + (2.7t - 54)\mathbf{j} \text{ m} \quad \text{Printed Answer}$ <p>Meet when $\overrightarrow{HK} = \mathbf{0}$</p> $(9 - 0.45t) = 0 \quad \text{and} \quad (2.7t - 54) = 0$ $t = 20 \text{ from both equations}$ $\mathbf{r}_K = \mathbf{r}_H = (24\mathbf{i} + 82\mathbf{j}) \text{ m}$	M1 A1 A1 DM1 A1 cso (5) [13]