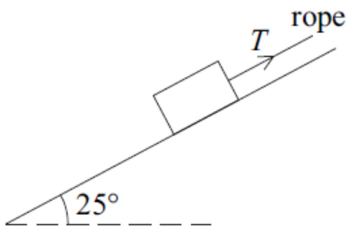
Resolving Forces Questions

8 A rough slope is inclined at an angle of $25°$ to the horizontal. A box of weight 80 newtons is on the slope. A rope is attached to the box and is parallel to the slope. The tension in the rope is of magnitude T newtons. The diagram shows the slope, the box and the rope.



(a) The box is held in equilibrium by the rope.

(i) Show that the normal reaction force between the box and the slope is 72.5 newtons, correct to three significant figures. *(3 marks)*

(ii) The coefficient of friction between the box and the slope is 0.32. Find the magnitude of the maximum value of the frictional force which can act on the box. *(2 marks)*

(iii) Find the least possible tension in the rope to prevent the box from moving down the slope. *(4 marks)*

(iv) Find the greatest possible tension in the rope. *(3 marks)*

(v) Show that the mass of the box is approximately 8.16 kg. *(1 mark)*

(b) The rope is now released and the box slides down the slope. Find the acceleration of the box. *(3 marks)*

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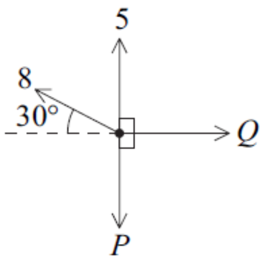
2 A particle is in equilibrium under the action of four horizontal forces of magnitudes 5 newtons, 8 newtons, P newtons and Q newtons, as shown in the diagram.

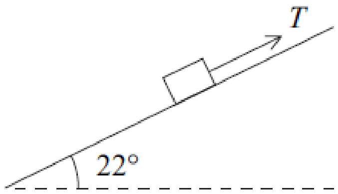


(a) Show that $P = 9$. *(3 marks)*

(b) Find the value of Q. *(2 marks)*

4 A block is being pulled up a rough plane inclined at an angle of 22° to the horizontal by a rope parallel to the plane, as shown in the diagram.

The mass of the block is 0.7 kg, and the tension in the rope is T newtons.



(a) Draw a diagram to show the forces acting on the block. *(1 mark)*

(b) Show that the normal reaction force between the block and the plane has magnitude 6.36 newtons, correct to three significant figures. *(3 marks)*

(c) The coefficient of friction between the block and the plane is 0.25. Find the magnitude of the frictional force acting on the block during its motion. *(2 marks)*

(d) The tension in the rope is 5.6 newtons. Find the acceleration of the block. *(4 marks)*

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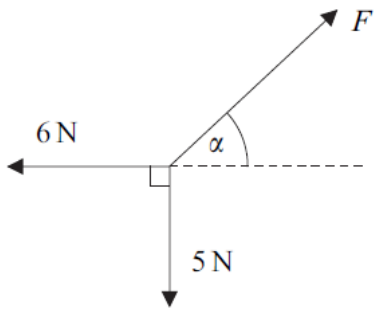
3 The diagram shows three forces which act in the same plane and are in equilibrium.



(a) Find F. *(3 marks)*

(b) Find α. *(3 marks)*

6 A trolley, of mass 100 kg, rolls at a constant speed along a straight line down a slope inclined at an angle of 4° to the horizontal.

Assume that a constant resistance force, of magnitude P newtons, acts on the trolley as it moves. Model the trolley as a particle.

(a) Draw a diagram to show the forces acting on the trolley. *(1 mark)*

(b) Show that $P = 68.4$ N, correct to three significant figures. *(3 marks)*

(c) (i) Find the acceleration of the trolley if it rolls down a slope inclined at 5° to the horizontal and experiences the same constant force of magnitude P that you found in part (b). *(4 marks)*

(ii) Make one criticism of the assumption that the resistance force on the trolley is constant. *(1 mark)*

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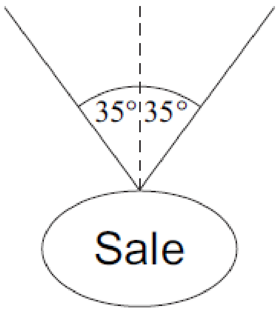
3 A sign, of mass 2 kg, is suspended from the ceiling of a supermarket by two light strings. It hangs in equilibrium with each string making an angle of 35° to the vertical, as shown in the diagram. Model the sign as a particle.



(a) By resolving forces horizontally, show that the tension is the same in each string. *(2 marks)*

(b) Find the tension in each string. *(5 marks)*

(c) If the tension in a string exceeds 40 N, the string will break. Find the mass of the heaviest sign that could be suspended as shown in the diagram. *(3 marks)*

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6 A box, of mass 3 kg, is placed on a slope inclined at an angle of $30°$ to the horizontal. The box slides down the slope. Assume that air resistance can be ignored.

(a) A simple model assumes that the slope is smooth.

(i) Draw a diagram to show the forces acting on the box. *(1 mark)*

(ii) Show that the acceleration of the box is $4.9\ \mathrm{m\,s^{-2}}$. *(2 marks)*

(b) A revised model assumes that the slope is rough. The box slides down the slope from rest, travelling 5 metres in 2 seconds.

(i) Show that the acceleration of the box is $2.5\ \mathrm{m\,s^{-2}}$. *(2 marks)*

(ii) Find the magnitude of the friction force acting on the box. *(3 marks)*

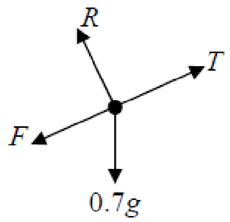
(iii) Find the coefficient of friction between the box and the slope. *(5 marks)*

(iv) In reality, air resistance affects the motion of the box. Explain how its acceleration would change if you took this into account. *(2 marks)*

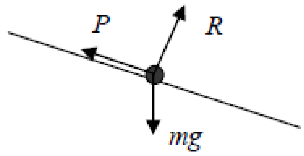
Resolving Forces Answers

8(a)(i)	$R = 80\cos 25^\circ$	M1		component attempted
		A1		correct component
	$R = 72.5\text{N}$	A1	3	cao
(ii)	$F = 0.32 \times 72.5$	M1		condone inequality
	$F = 23.2\text{N}$	A1	2	cao
(iii)	$T + F = 80\cos 65^\circ$	M2		3 forces direction correct, component attempted
		A1		component
	$T = 10.6\text{N}$	A1$\sqrt{}$	4	$\sqrt{}$ friction
(iv)	$T = F + 80\cos 65^\circ$	M1		3 forces, direction correct, component attempted
		A1		component
	$T = 57.0\text{N}\ (57\text{N})$	A1$\sqrt{}$	3	$\sqrt{}$ friction
(iv)	$\text{Mass} = \dfrac{80}{g} = (8.16\text{kg})$	B1	1	
(b)	$80\cos 65^\circ - F = \text{mass} \times \text{acceleration}$	M1		3 terms, component attempted
	$10.6 = \dfrac{80}{g} \times \text{acc}$	A1		all correct
	$\text{acc} = 1.30\,\text{m s}^{-2}$ $(1.3\,\text{ms}^{-2})$	A1	3	cao
	Total		**16**	

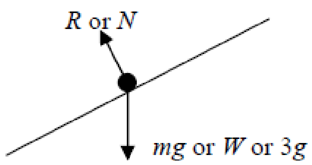
2(a)	$P = 5 + 8\cos 60^\circ$	M1		Both relevant forces, component of 8N attempted
		A1		All correct
	$P = 9$	A1	3	CAO
(b)	$Q = 8\cos 30^\circ$	M1		Component of 8N attempted
	$Q = 6.93$ or $4\sqrt{3}$	A1	2	AWRT 6.93
	Total		**5**	

4(a)		B1	1	Accept W or mg (or 6.86) for weight Arrows and labels needed (can replace W with 2 correct components)
(b)	$R = 0.7g\cos 22^\circ$ $R = 6.36$ N	M1 A1 A1	3	component of weight attempted all correct, including signs CAO
(c)	$F = 0.25 \times 6.36$ $F = 1.59\text{N}$	M1 A1	2	CAO
(d)	$5.6 - 0.7g\sin 22^\circ - 1.59 = 0.7a$ $a = 2.06\text{ms}^{-2}$	M1 A2 A1F	4	4 terms with weight component attempted A marks -1 each error, accept $\pm 0.7a$ FT one error, accept $\pm$
	Total		**10**	

3(a)	$F = \sqrt{6^2 + 5^2}$ $= \sqrt{61} = 7.81$ **Alt** $\alpha = \tan^{-1}\left(\frac{5}{6}\right) = 39.8^\circ$ $F = \frac{6}{\cos 39.8} = 7.81$ or $F = \frac{5}{\sin 39.8} = 7.81$	M1A1 A1 (M1A1) (A1)	3	Obtaining an equation for F with square or root. Correct equation Correct force Equation for F with a value for α . Correct equation Correct force
(b)	$\alpha = \tan^{-1}\left(\frac{5}{6}\right)$ or $\cos^{-1}\left(\frac{6}{7.81}\right)$ or $\sin^{-1}\left(\frac{6}{7.81}\right)$ $= 39.8^\circ$ **Alt** $\frac{\sin\alpha}{5} = \frac{\sin 90^\circ}{\sqrt{61}}$ $\alpha = 39.8^\circ$	M1 A1 A1	3	Obtaining an equation for α using trigonometry. Correct equation (using their F) Correct angle Accept values between 39.7 and 39.9
	Total		**6**	

6(a)		B1	1	Correct diagram with arrows and labels Must not use F instead of P Condone resistance instead of P
(b)	$P = 100 \times 9.8 \sin 4°$	M1 M1		Resolving weight (must see 100) Using $\sin 4°$ or $\cos 86°$
	$= 68.4$	A1	3	**AG** Correct P from correct working
(c)	$100a = 100 \times 9.8 \sin 5° - 100 \times 9.8 \sin 4°$	M1 A1 A1		Three term equation of motion Weight resolved correctly Correct equation
	$a = \dfrac{100 \times 9.8 \sin 5° - 100 \times 9.8 \sin 4°}{100}$ $= 0.171$	A1	4	Correct a. (Accept 0.170 or 0.17)
(d)	You would expect P to vary with the speed of the car.	B1	1	Correct explanation
			9	

3(a)	$T_1 \sin 35° = T_2 \sin 35°$	M1		Resolving two forces and forming an equation, with different tensions for each string
	$T_1 = T_2$ **OR** $T_1 \cos 55° = T_2 \cos 55°$ $T_1 = T_2$	A1	2	Correct result from correct working
(b)	$T_1 \cos 35° + T_2 \cos 35° = 2 \times 9.8$ $T_1 \cos 35° + T_1 \cos 35° = 2 \times 9.8$	M1 A1 A1		Resolving forces to form a three term vertical equation Correct equation T_1 or T_2 eliminated correctly
	$T_1 = \dfrac{2 \times 9.8}{2 \cos 35°} = 12.0$ N (to 3sf)	dM1 A1	5	Solving for T_1 or T_2 Correct tension Accept 12 N or 11.9 N
(c)	$2 \times 40 \cos 35° = 9.8m$	M1 A1		Forming an equation with two tensions to find m Correct equation
	$m = \dfrac{80 \cos 35°}{9.8} = 6.69$ kg	A1	3	Correct mass Accept 6.68
	OR $m = \dfrac{40}{11.96} \times 2$ $= 6.69$ kg	(M1) (A1) (A1)		
	Total		**10**	

6(a)(i)		B1	1	Correct diagram with arrows and labels
(ii)	$3a = 3g\sin 30°$	M1		Two term equation of motion
	$a = g\sin 30° = 4.9$ ms^{-2}	A1	2	AG Correct acceleration from correct working (Allow $a = g\sin 30°$)
(b)(i)	$5 = \frac{1}{2}a\times 2^2$	M1		Constant acceleration equation with $u = 0$
	$a = 2.5$ ms^{-2}	A1	2	AG Correct answer from correct working. (Use of $v = 5$ must be justified)
(ii)	$3\times 2.5 = 3g\sin 30° - F$	M1 A1		Three term equation of motion Correct equation
	$F = 3g\sin 30° - 7.5$ $= 7.20$ N (to 3 sf)	A1	3	Correct F Accept 7.2 N
(iii)	$R = 3g\cos 30°\ \ (= 25.46)$	M1 A1		Resolving perpendicular to the slope to find R Correct R
	$7.2 = \mu\times 3g\cos 30°$	M1 A1F		Use of $F = \mu R$ Correct expression
	$\mu = \frac{7.2}{3g\cos 30°} = 0.283$	A1F	5	Correct μ Accept 0.282 (Follow through from incorrect F from above, but not an incorrect R)
(iv)	Reduce a, as the air resistance would reduce the magnitude of the resultant force or because the air resistance increases as the velocity increases towards its terminal value	B1 B1	2	Reduces Explanation Second B1 dependent on the first B1 mark
	Total		**15**	