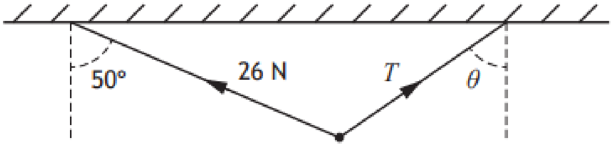
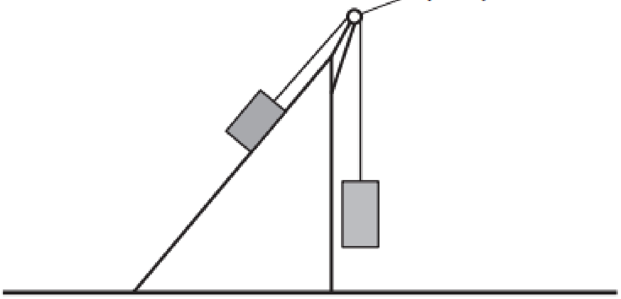
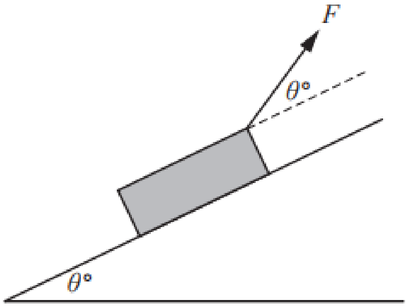
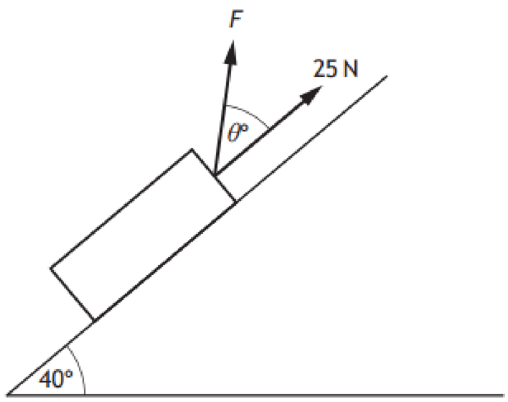
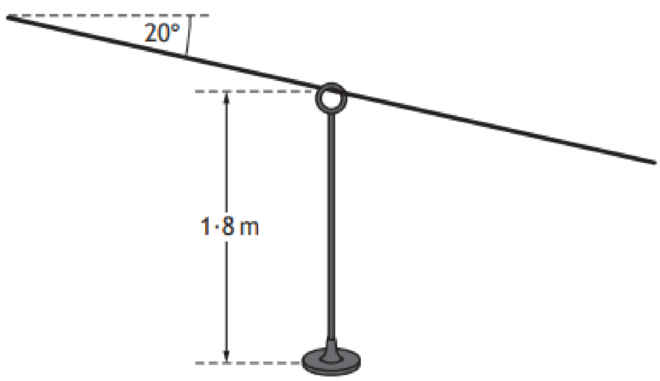
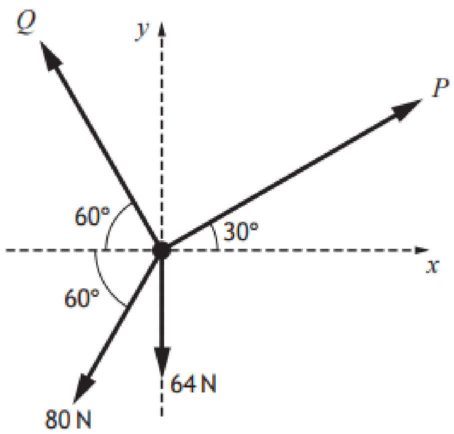
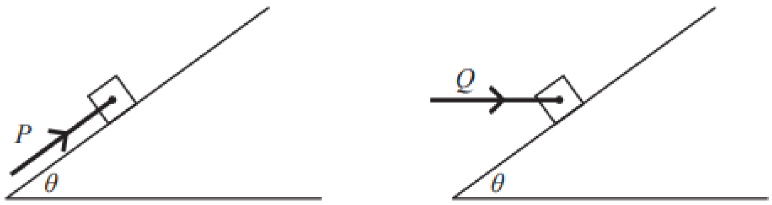
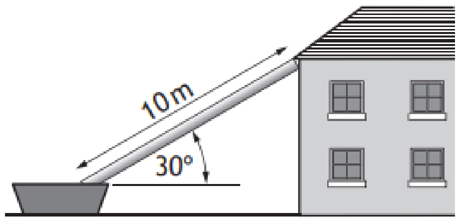
Y	Q	Forces
24	1	A body of mass 8 kg is held in equilibrium by two light inextensible strings attached to a horizontal ceiling. The tensions in the strings are 26 newtons and T newtons, and the angles the strings make with the downward vertical are 50° and θ respectively, as shown in the diagram.  Calculate the values of T and θ. **4**
24	18	A box is placed on a rough plane inclined at 10° to the horizontal. The total mass of the box and its contents when full is 60 kg. The box can be moved up the plane with constant velocity by a force of magnitude P newtons parallel to the slope. When the box is empty, it has a mass of 40 kg and can be moved down the plane with constant velocity by a force of magnitude Q newtons. Q acts in the opposite direction to P and $P = 5Q$. (a) Show that the value of the coefficient of friction between the box and the plane is 0.327 to three significant figures. **5** The full box is now attached to a light inextensible cable. Starting from rest, the box is pulled up the plane by the cable. The tension in the cable is of magnitude 300 newtons and acts parallel to the slope. After 10 seconds the cable snaps and the box continues to move until it comes to rest. (b) Calculate the total distance the box travels up the plane. **6**

23	16	A box of mass 3 kg sits on a rough slope inclined at an angle of 50° to the horizontal. The box is attached to a light inextensible string which passes up the slope and over a smooth fixed pulley to a free hanging mass of 3.4 kg.  The box is on the point of moving up the slope. (a) Calculate the coefficient of friction between the box and the slope. The 3.4 kg mass is removed, and the box slides down the slope. (b) Calculate the time it will take for the box to travel 8 metres down the slope, given that it does not reach the bottom of the slope during this time.	 3 3
22	12	A box of mass m kg is at rest on a rough slope inclined at an angle $\theta°$ to the horizontal. It is held in place by an external force of magnitude F newtons, which is at the same angle $\theta°$ to the slope, as shown in the diagram.  (a) The box is on the point of sliding down the slope when F is equal to $\frac{1}{2}mg$. Show that $\mu = \dfrac{2\tan\theta° - 1}{2 - \tan\theta°}$. When $\theta° = 30°$, the external force is increased so that the box is on the point of moving up the slope. (b) Determine the magnitude of the new force. Express your answer in the form kmg, where k is a constant.	MARKS 5 5

19	9	A box of mass 5 kg rests on a smooth surface that is inclined at an angle of 40° to the horizontal. Two external forces are applied to hold the box in equilibrium. These are a force of magnitude 25 newtons that is parallel to the slope, and a force of magnitude *F* newtons at an angle $\theta°$ to the slope as shown in the diagram.  The normal reaction force between the box and the slope is of magnitude 30 newtons. Calculate the angle $\theta°$, and the magnitude of the force *F*.	5
18	12	A zip wire can be modelled by a taut inextensible cable with a seat attached to it by a light metal rod of length 1·8 metres. The cable is at an angle of 20° to the horizontal, as shown in the diagram.  A child sits on a seat at the higher end of the zip wire and is given an initial speed of $2\,\text{m}\,\text{s}^{-1}$, parallel to the cable. The combined mass of the child and seat is m kg. The coefficient of friction between the rod and the cable is 0·3 and the cable is 20 m long. You may assume that the rod remains vertical as it travels along the cable. (a) Calculate the speed of the child at the lower end of the zip wire.	4
17	1	A skier starts from rest and skis straight down a slope inclined at an angle θ to the horizontal, where $\sin\theta = \frac{1}{4}$. The coefficient of friction between the skis and the snow is 0·125. Find the speed of the skier after she has travelled 75 metres.	4

17	17	A body of mass 12 kg is moving down a rough plane inclined at an angle θ to the horizontal, where $\sin\theta = \frac{3}{4}$. As it passes through a point A it has a speed of 5 m s^{-1}. (a) At a point B further down the slope its speed is 10 m s^{-1}. Show that the distance AB is $\frac{150}{\left(3-\sqrt{7}\mu\right)g}$ metres, where μ is the coefficient of friction between the body and the plane. **5** On reaching a speed of 10 m s^{-1} a horizontal force of 260 N is applied to the body. This brings the body to rest in a distance half that of distance AB. (b) Calculate the value of the coefficient of friction. Give your answer to **two significant figures.** **6**
16	2	In a children's playground game, four light inextensible ropes are attached at one end to a small toy ring. Four children each take the other end of a rope and pull it taut. The ring is in equilibrium and the whole system is in a horizontal plane with appropriate axes as shown in the diagram.  The tensions in the four ropes are P, Q, 80 and 64 newtons respectively, and their directions relative to the axes are shown. Calculate the magnitude of the tensions P and Q. **4**

16	14	A block of weight W is placed on a rough inclined plane at an angle θ to the plane. It can be held on the point of slipping down the plane by a force P acting parallel to the plane or a horizontal force Q as shown by the diagrams.  Prove that $P = \dfrac{QW}{Q\sin\theta + W\cos\theta}$.	**7**
16 (Sp)	9	A house is being re-roofed. The old tiles slide down a rough plastic chute into a skip at the side of the house. The chute is 10 metres long and inclined at an angle of 30° to the horizontal as shown.  A tile of mass m kg is given an initial speed of $2\,\text{m s}^{-1}$ at the top of the chute. The coefficient of friction between the tile and the chute is $\frac{1}{2\sqrt{3}}$. Show that the speed of the tile at the bottom of the chute is $\sqrt{53}\,\text{m s}^{-1}$.	**5**