Homework 6

1) A box of mass 10kg sits on a smooth surface inclined at an angle of 15^o to the horizontal. A force of magnitude 40 newtons is applied horizontally to push the object up the slope until it reaches a speed of $3ms^{-1}$ and then the force ceases. The box then slows down until it momentarily stops.

From the instant the force is applied until the box momentarily stops how far will it travel altogether? **5**

2) A block is released from rest at the top of a smooth plane which is inclined at angle θ to the horizontal. Show that the time, in seconds, taken for the block to reach the bottom of the plane is given by

$$\sqrt{\frac{2h}{g\sin^2\theta}}$$

where h metres is the vertical distance between the top and the bottom of the plane. **4**

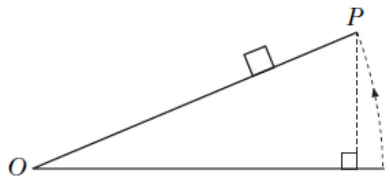
3) A sledge is released from rest at the top of a ski run which is to be modelled as a rough plane inclined at angle θ to the horizontal. The coefficient of friction between the sledge and ski run surface is μ.

Show that the distance, s metres, travelled down the plane by the sledge to achieve a speed of $V\,\mathrm{m\,s^{-1}}$ is given by

$$s = \frac{V^2}{2g(\sin\theta - \mu\cos\theta)}.$$ **4**

4) A rough ramp OP of length 6 m is hinged at O. A point P at the other end is able to move about O in a vertical plane as illustrated in the diagram.

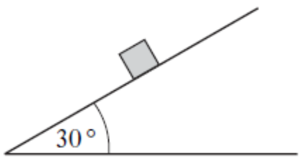
A small box of mass 2 kg is in equilibrium on the ramp.



(*a*) When P is 2 m above the horizontal plane through O, the box is on the point of sliding down the ramp. Calculate the coefficient of friction between the box and the ramp. **2**

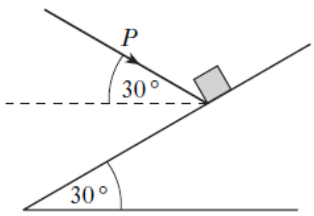
(*b*) P is now raised to a height of 4 m above the horizontal plane. A force of F newtons, applied to the box and acting parallel to the ramp, is just sufficient to prevent the box from sliding down the ramp. Calculate the magnitude of F. **3**

5) (*a*) A box of mass m kg is placed on a rough plane inclined at 30° to the horizontal. The coefficient of friction between the box and the plane is μ.



Given that the box remains in equilibrium, show that $\mu \geq \frac{1}{\sqrt{3}}$. **3**

(*b*) The same box is kept in equilibrium on another rough plane, which is also inclined at 30° to the horizontal, by the action of a force of magnitude P newtons as shown in the diagram below. This force is acting up the plane at an angle of 30° to the horizontal. The coefficient of friction between the box and this plane is 0·5 and the box is on the point of slipping down the plane.



(i) Show that the reaction force normal to the inclined plane has magnitude given by

$$R = \frac{\sqrt{3}}{2}(mg + P) \text{ newtons.}$$ **2**

(ii) Show further that

$$P = \frac{(2-\sqrt{3})mg}{2+\sqrt{3}} \text{ newtons.}$$ **5**