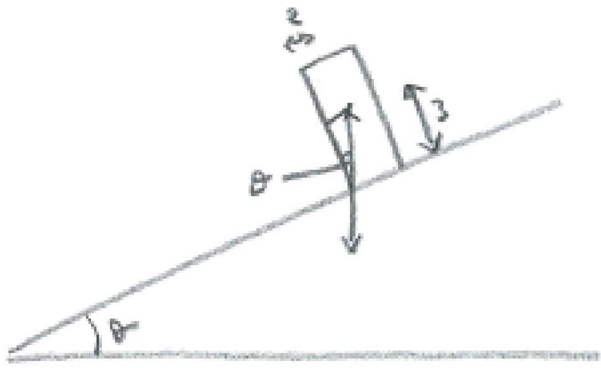
Toppling (2 pages; 13/11/20)

(1) Toppling on a slope

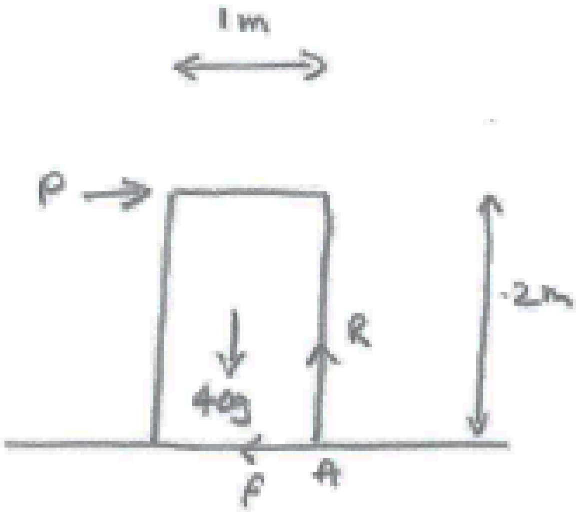
Whenever there are 3 forces on an object that is in rotational equilibrium, the lines of action of these forces must meet at a common point (otherwise the moment of one of the forces about the intersection of the lines of action of the other two forces would not be zero).

In the left-hand diagram (where F is the frictional force), the normal reaction R must be acting at the point shown, in order for the forces to meet at a common point. In the right-hand diagram, the extreme situation is reached where R acts at the left-hand corner (about which the object is liable to topple). Any increase in θ would cause toppling to occur, as it would not be possible for the line of action of R to be any further to the left.

Thus the angle of toppling is determined by the centre of mass of the block being directly above the left-hand corner. Thus, in the diagram below, $tan\theta = \frac{2}{3}$ (Note, as a check on the angle, that when the block is on a level surface, its left-hand edge makes an angle of 0° with the vertical.)



(2) Toppling by an applied force



When the block is about to topple, it will be pivoting about A, so that R must act at A (as this is the only point of contact between the block and the surface). As the block is not yet rotating, the total moment about A must be zero.

Thus $-2P + 40g(0.5) = 0$,

so that $P = \frac{1}{2}(40)(9.8)(0.5) = 98\ N$