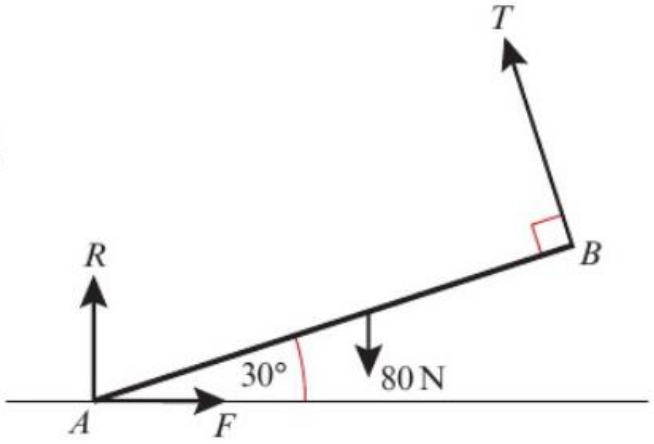
Exercise 7D

Whenever a numerical value of g is required, take $g = 9.8\,\text{m s}^{-2}$.

1 A uniform rod AB of weight 80 N rests with its lower end A on a rough horizontal floor. A string attached to end B keeps the rod in equilibrium. The string is held at 90° to the rod. The tension in the string is T. The coefficient of friction between the rod and the ground is μ. R is the normal reaction at A and F is the frictional force at A.

a Find the magnitudes of T, R and F, and the least possible value of μ.

b Find the magnitude and direction of the reaction of the floor on the rod.



Hint The reaction is not a normal reaction here because the floor is rough and therefore the reaction has a frictional component as well as a normal component. The reaction of the floor on the rod will be the resultant of the two components.

Exercise 7D

1 **a** 34.6 N, 50 N, 17.3 N, 0.35

b 53 N at 71° above the horizontal (2 s.f.)

2 **a** 22.8 N **b** 98 N, 22.8 N **c** 0.233

d The weight of a uniform ladder passes through its midpoint.

3 **a** 41.6° **b** 24.0°

c No friction at the wall.

2 A uniform ladder of mass 10 kg and length 5 m rests against a smooth vertical wall with its lower end on rough horizontal ground. The ladder rests in equilibrium at an angle of 65° to the horizontal. Find:

a the magnitude of the normal reaction S at the wall

b the magnitude of the normal reaction R at the ground and the frictional force at the ground

c the least possible value of the coefficient of friction between the ladder and the ground.

d State how you have used the assumption that the ladder is uniform in your calculations.

3 A uniform ladder AB of mass 20 kg rests with its top A against a smooth vertical wall and its base B on rough horizontal ground. The coefficient of friction between the ladder and the ground is $\frac{3}{4}$. A mass of 10 kg is attached to the ladder. Given that the ladder is about to slip, find the inclination of the ladder to the horizontal, if the 10 kg mass is attached

a at A **b** at B.

c State how you have used the assumption that the wall is smooth in your calculations.

4 A uniform ladder of mass 20 kg and length 8 m rests against a smooth vertical wall with its lower end on rough horizontal ground. The coefficient of friction between the ground and the ladder is 0.3. The ladder is inclined at an angle θ to the horizontal, where $\tan\theta = 2$. A boy of mass 30 kg climbs up the ladder. By modelling the ladder as a uniform rod, the boy as a particle and the wall as smooth and vertical,

a find how far up the ladder the boy can climb before the ladder slips. **(8 marks)**

b Suggest one limitation of this model with respect to:

i the ladder **ii** the wall. **(2 marks)**