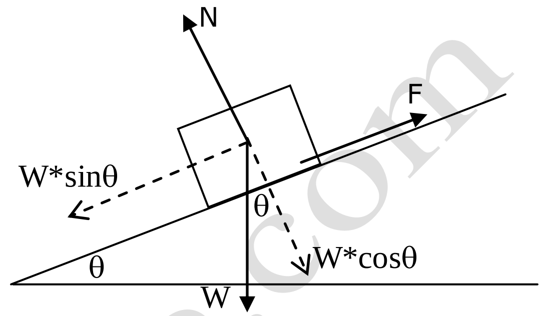
Q- An 80 N crate of apples sits at rest on a ramp that runs from the ground to the bed of a truck. The ramp is inclined at 30° to the ground.
(a) What is the normal force exerted on the crate by the ramp?
(b) What is the static frictional force exerted on the crate by the ramp?
(c) What is the minimum possible value of the coefficient of static friction?
(d) Find the magnitude and direction of the contact force on the crate by the ramp.

Resolving the weight W in the direction along the ramp and perpendicular to the ramp we get the component along the ramp W sin θ and the component normal to ramp will be W cos θ.



(a) Balancing the forces in normal direction we have the normal force of the ramp on the crate will be given by

$N - W \cos\theta = 0$

Or $N = W \cos\theta = 80*\cos 30^0 = 69.3$ N

(b) What is the static frictional force exerted on the crate by the ramp?

The crate is at rest hence the forces along the ramp will also in equilibrium and the friction will be just enough to keep it rest against the component of weight hence

$F - W \sin\theta = 0$

Or $F = W \sin\theta = 80*\sin 30 = 80*0.5 = 40$ N.

(c) What is the minimum possible value of the coefficient of static friction?

If the friction is just sufficient to hold it this value of friction will be equal to the limiting friction and hence

$F_{lim} = F = \mu_s*N$

Gives $\mu_s = F/N = 40/69.3 = 0.577$

This is the minimum coefficient of friction required to hold the crate on this ramp.

(d) The normal and frictional forces are perpendicular components of the contact force exerted on the crate by the ramp. Find the magnitude and direction of the contact force.

As the two force applied by the ramp are perpendicular to each other their resultant (total) or the magnitude of the total reaction of the ramp is given by

$$R = \sqrt{N^2 + F^2} = \sqrt{(69.3)^2 + (40)^2} = 80.0\ N$$

(Same as the weight of the crate)

And the direction will make angle with the ramp will be

$$\tan\theta = \frac{N}{F} = \frac{69.3}{40} = 1.732$$

Gives $\theta = 60$ deg.

This makes the angle with horizontal equal to 60 + 30 = 90 deg.
Hence the total reaction is vertically up opposite to the weight of the crate.