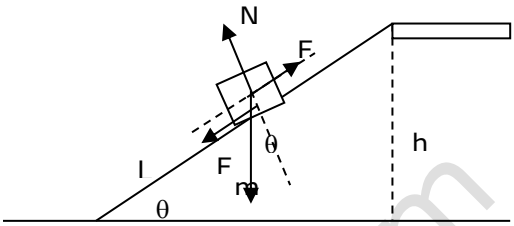
Q- Q- Gopal finds that a force *F* is required to push a crate of mass *m* up a plank of length *L* into a truck whose platforms is a vertical distance *h* above the road.

The forces acting on the crate are

1. The weight of the crate mg vertically downwards
2. The applied force F tangentially to the plank up the incline
3. The friction force F_f down the incline
4. The normal reaction N normal to the plank



Resolving the weight of the crate normal and along the incline we get the component normal to the plank mg cos θ is balanced by the normal reaction and thus

$N = mg \cos \theta$ ---------- (1)

The component of the weight along the incline will be mg sin θ
Now as the crate slides up the incline the firction will be down the incline and its limiting value will be

$F_f = \mu N = \mu mg \cos \theta$ ---------- (2)

(a) How much work does Gopal do in pushing the crate up the plank?

The work done is measured by the product of the force and the displacement in the direction of force and hence is given by

$W = F*L$

(b) Calculate Gopal's work input if the crate has a mass of 100kg, the length of the plank is 5.0m, the applied force is 490N, and the platform is 1.2m above the road.

The work done by Gopal will be

$W = F*L = 490*5.0 = 2450$ J

(c) What is the increase of potential energy of the crate once on the platform?

The increase in potential energy of mass m moved up by vertical distance h is given by

$\Delta U = mg\ h = 100*9.8*1.2 = 1176$ J

(d) How much work did Gopal do in overcoming friction?

The work done against the friction is the difference in the work done and increase in potential energy and given by

$W_f = 2450 - 1176 = 1274$ J

(e) What is the efficiency of the plank?

The inclined plane is a simple machine and the efficiency of a simple machine is given by the ratio of the useful work done to the total work done. Thus, the efficiency of the plank is

$e = 1176/2450 = 0.48$ or 48 %