RMIT UNIVERSITY

WORKED SOLUTIONS

ENST2.5: STATIC FRICTION

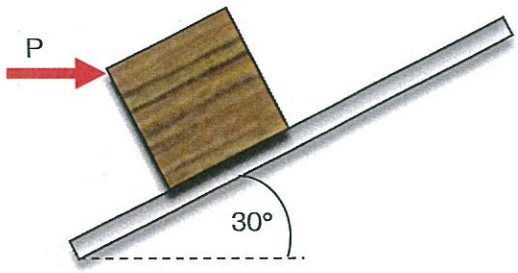
Question

The crate shown below has a mass of 50kg and the coefficient of static friction between the crate and the plane is $\mu_s = 0.25$. $g = 9.81 ms^{-2}$

(a) Calculate the minimum force P required to stop the crate from sliding down the plane.

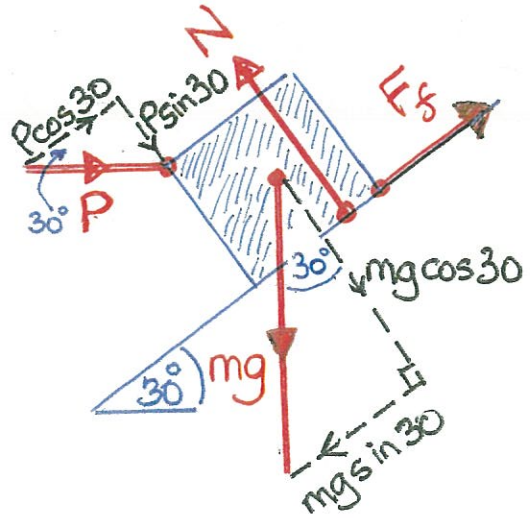
(b) Calculate the minimum force P required to push the crate up the plane.

(Hibbeler, R.C, 2010, *Engineering Mechanics: Statics* , Pearson)



Worked Solution (a)

Free Body Diagram



NOTE:

- Normal force N must act a distance from the crate's centre to counteract the tipping effect caused by P
- Friction force F_f must act up the plane to prevent crate from slipping down.
- $F_f = \mu_s N$

Resolving forces parallel to plane $\nearrow^{+} \Sigma F_{\parallel} = 0$

$$P\cos 30 + F_f - mg\sin 30 = 0$$
$$P\cos 30 + \mu_s N - 50(9.81)\sin 30 = 0$$
$$0.87P + 0.25N - 245.25 = 0 \Rightarrow N = \frac{245.25 - 0.87P}{0.25}$$

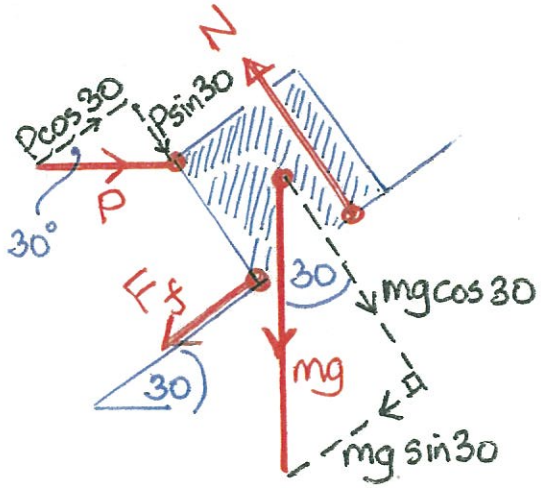
Resolving forces perpendicular to plane $\nwarrow^{+} \Sigma F_{\perp} = 0$

$N - P\sin 30 - mg\cos 30 = 0$, and substituting for N above

$$\frac{245.25 - 0.87P}{0.25} - 0.5P - 424.78 = 0 \Rightarrow P = 140\,N$$

Worked Solution (b)

Free Body Diagram



NOTE:
Friction force F_f must act down the plane to resist crate being pushed up the plane.

Resolving forces parallel to plane $\nearrow^{+} \Sigma F_{\parallel} = 0$

$$P\cos 30 - F_f - mg\sin 30 = 0$$
$$P\cos 30 - \mu_s N - 50(9.81)\sin 30 = 0$$
$$0.87P - 0.25N - 245.25 = 0 \Rightarrow N = \frac{0.87P - 245.25}{0.25}$$

Resolving forces perpendicular to plane $\nwarrow^{+} \Sigma F_{\perp} = 0$

$N - P\sin 30 - mg\cos 30 = 0$, and substituting for N above

$$\frac{0.87P - 245.25}{0.25} - 0.5P - 424.78 = 0 \Rightarrow P = 474\,N$$