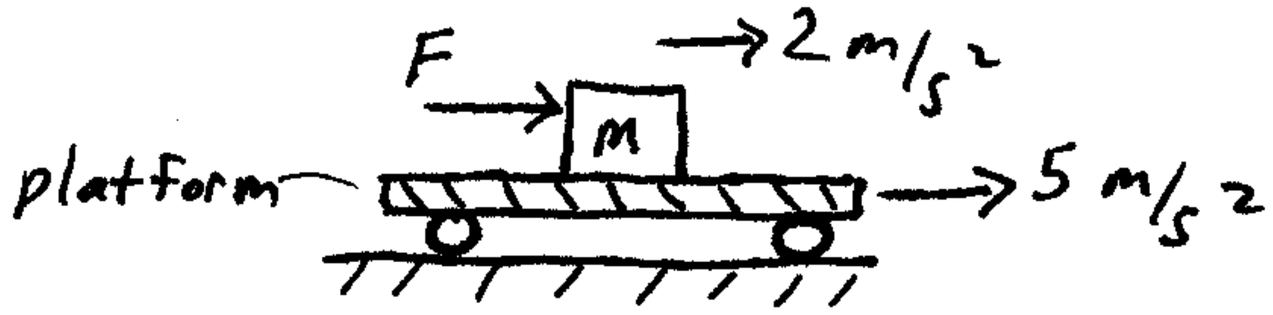
Sep. 27, 2020

This is a force and motion problem involving Friction.

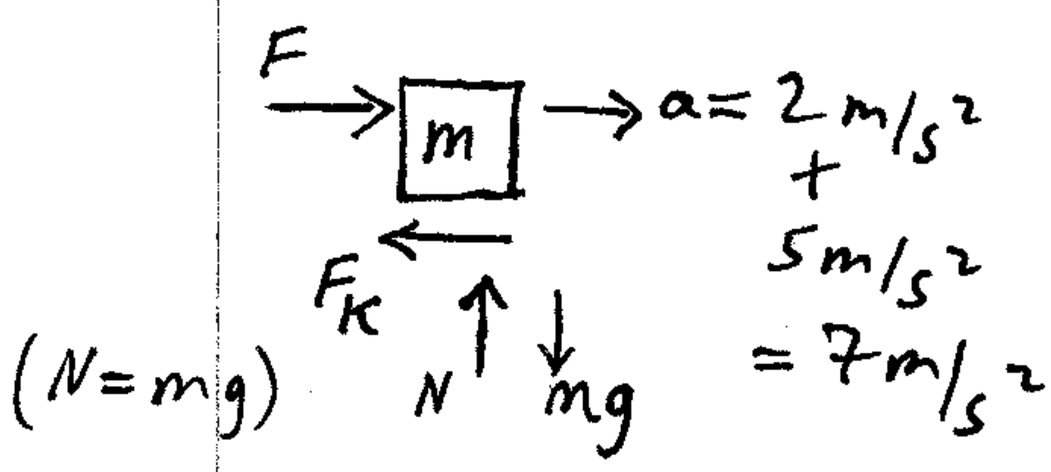


A platform is accelerating to the right at $5\ m/s^2$, and a mass m is on top of the platform and has an acceleration of $2\ m/s^2$ relative to the platform. If $m = 6\ kg$ and the coefficient of kinetic friction between the mass and platform is 0.25, what is the force F applied to the mass? If the relative acceleration of the mass is in the opposite direction, what is the force F?

Solution:

Case 1 -

Sign convention: → +

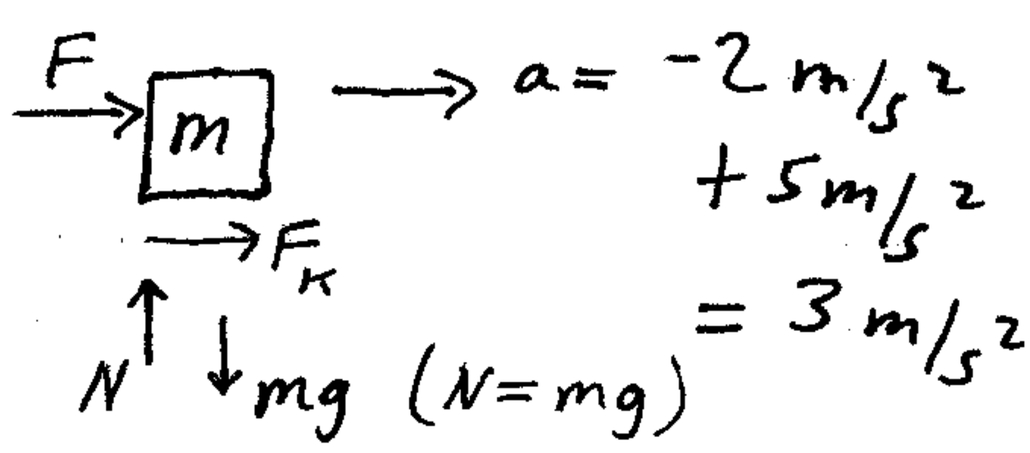


$F_K = N\mu_K = mg\mu_K$

Newton's second law:

$F - F_K = ma$

Case 2 -



$F_K = N\mu_K = mg\mu_K$

Newton's second law:

$F + F_K = ma$

Reminder: Acceleration must be with respect to an inertial reference frame (e.g. ground) to use Newton's second law. 2/2

For Case 1, $F - F_K = ma \Rightarrow F - mg\mu_K = ma$

$\Rightarrow F - (6)(9.8)(0.25) = (6)(7)$

$\Rightarrow F = 56.7\ N$ (answer)

For Case 2, $F + F_K = ma \Rightarrow F + mg\mu_K = ma$

$\Rightarrow F + (6)(9.8)(0.25) = 6(3)$

$\Rightarrow F = 3.3\ N$ (answer)

An interesting variation on this problem is to ask what the acceleration of the mass is relative to the platform if slipping occurs and the only horizontal force acting on the mass is kinetic friction (i.e. $F=0$).

So, $a = a_{rel} + 5\ m/s^2$, solve for a_{rel}.

$F_K = N\mu_K = mg\mu_K \rightarrow$ (acting to the right)

Apply Newton's second law:

$F_K = ma \Rightarrow F_K = m(a_{rel} + 5)$

$\Rightarrow mg\mu_K = m(a_{rel} + 5)$

$\Rightarrow a_{rel} = g\mu_K - 5$

$\Rightarrow a_{rel} = (9.8)(0.25) - 5$

$\Rightarrow a_{rel} = -2.55\ m/s^2$

So, a_{rel} is $2.55\ m/s^2$ to the left. (answer)