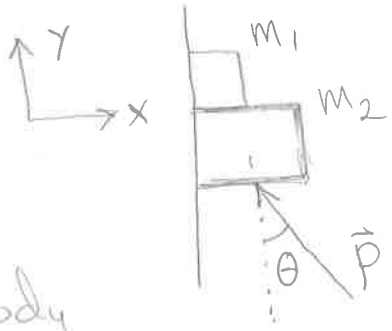
Example (2016, Q3)

The external force P is used to push two blocks up on a vertical wall. The coefficient of friction between the blocks and the wall is μ. Find the force exerted by the lower block on the upper block.



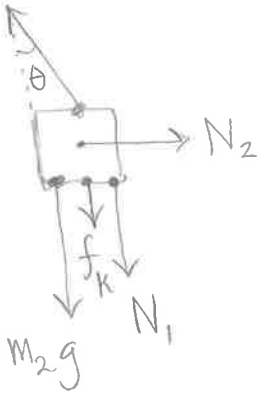
Solution

There are two objects, so draw a free-body for each one. Always start with the simpler object.

m1)

Doesn't wall push on m_1? No! Surfaces only push back in response to being pushed on. Note that m_2 pushes m_1 straight upward (normal direction)

m2)



Don't forget the Newton's 3rd Law reaction force N_1 that block 1 exerts on block 2. They must have same magnitude.

Newton's 2nd Law

m1) $N_1 - m_1 g = m_1 a$ ← don't forget to label the mass appropriately

m2) (y dir) $P\cos\theta - m_2 g - N_1 - f_K = m_2 a$ ← same acceleration as m_1

(x dir) $N_2 - P\sin\theta = 0$ (no acceleration in x dir)

This gives us 3 equations and 3 unknowns (a, N_1, N_2).

$$N_2 = P\sin\theta$$

Then we can find friction force $f_K = \mu N_2 = \mu P\sin\theta$.

Plug in: $P\cos\theta - m_2 g - N_1 - \mu P\sin\theta = m_2 a$

Solve m1 equation for $a \rightarrow a = \frac{N_1}{m_1} - g$

Plug into previous equation:

$$P\cos\theta - m_2 g - N_1 - \mu P\sin\theta = \frac{m_2}{m_1} N_1 - m_2 g$$

$$\Rightarrow P\cos\theta - \mu P\sin\theta = \left(\frac{m_2}{m_1} + 1\right) N_1$$

$$\Rightarrow \boxed{N_1 = \frac{P\cos\theta - \mu P\sin\theta}{1 + \frac{m_2}{m_1}}}$$