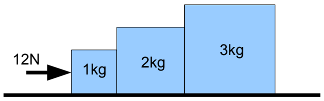
Chapter 4 Problem 47 [†]



Solution

Find the force exerted on the right block by the middle block.

Since all of the blocks are touching, they will accelerate at the same rate. Treating the collection of three blocks as a single object and applying Newton's 2nd law we get

$$\Sigma F = ma$$

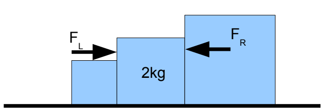
where $m = 1\ kg + 2\ kg + 3\ kg = 6\ kg$. Focusing only on the horizontal force and not on the vertical forces of gravity and the table's normal force, we get an acceleration of

$$a = \frac{F}{m} = \frac{12\ N}{6\ kg} = 2\ m/s^2$$

Now focus on the block to the right. The only horizontal force acting on this block is that from the middle block. If the right block accelerates at $2\ m/s^2$, then the force must be

$$F = ma = (3\ kg)(2\ m/s^2) = 6\ N$$

A more interesting question is "What is the force the left block exerts on the middle block?" In this case we can use the following free body diagram.



By Newton's 3rd law the force exerted by the right block on the middle block is equal and opposite of the force calculated previously. Therefore, $F_R = 6\ N$ to the left. Using Newton's 2nd law gives

$$\Sigma\vec{F} = m\vec{a}$$

$$\vec{F}_L + \vec{F}_R = m\vec{a}$$

$$F_L\hat{\imath} - F_R\hat{\imath} = ma\hat{\imath}$$

Since all of the terms in this equation are in the horizonal direction, drop the $\hat{\imath}$ and solve for F_L.

$$F_L = ma + F_R$$

Substituting in the appropriate values gives

$$F_L = (2\ kg)(2\ m/s^2) + 6\ N = 10\ N$$

Notice that the difference between F_R and F_L is $4\ N$, which is sufficient to provide an acceleration of $2\ m/s^2$ for a $2\ kg$ block.

[†]Problem from Essential University Physics, Wolfson