10. In addition to the forces already shown in Fig. 6-22, a free-body diagram would include an upward normal force $\vec{N}$ exerted by the floor on the block, a downward $m\vec{g}$ representing the gravitational pull exerted by Earth, and an assumed-leftward $\vec{f}$ for the kinetic or static friction. We choose $+x$ rightwards and $+y$ upwards. We apply Newton's second law to these axes:

$$\begin{aligned}(6.0\,\text{N}) - f &= ma \\ P + N - mg &= 0\end{aligned}$$

where $m = 2.5$ kg is the mass of the block.

(a) In this case, $P = 8.0$ N leads to $N = (2.5)(9.8) - 8.0$ so that the normal force is $N = 16.5$ N. Using Eq. 6-1, this implies $f_{s,\text{max}} = \mu_s N = 6.6$ N, which is larger than the 6.0 N rightward force – so the block (which was initially at rest) does not move. Putting $a = 0$ into the first of our equations above yields a static friction force of $f = P = 6.0$ N. Since its value is positive, then our assumption for the direction of $\vec{f}$ (leftward) is correct.

(b) In this case, $P = 10$ N leads to $N = (2.5)(9.8) - 10$ so that the normal force is $N = 14.5$ N. Using Eq. 6-1, this implies $f_{s,\text{max}} = \mu_s N = 5.8$ N, which is less than the 6.0 N rightward force – so the block does move. Hence, we are dealing not with static but with kinetic friction, which Eq. 6-2 reveals to be $f_k = \mu_k N = 3.6$ N. Again, its value is positive, so our assumption for the direction of $\vec{f}$ (leftward) is correct.

(c) In this last case, $P = 12$ N leads to $N = 12.5$ N and thus to $f_{s,\text{max}} = \mu_s N = 5.0$ N, which (as expected) is less than the 6.0 N rightward force – so the block moves. The kinetic friction force, then, is $f_k = \mu_k N = 3.1$ N. Once again, its value is positive, so our assumption for the direction of $\vec{f}$ (leftward) is correct.