20. If the block is sliding then we compute the kinetic friction from Eq. 6-2; if it is not sliding, then we determine the extent of static friction from applying Newton's law, with zero acceleration, to the x axis (which is parallel to the incline surface). The question of whether or not it is sliding is therefore crucial, and depends on the maximum static friction force, as calculated from Eq. 6-1. The forces are resolved in the incline plane coordinate system in Figure 6-5 in the textbook. The acceleration, if there is any, is along the x axis, and we are taking uphill as $+x$. The net force along the y axis, then, is certainly zero, which provides the following relationship:

$$\sum \vec{F}_y = 0 \quad \Longrightarrow \quad N = W \cos\theta$$

where $W = 45$ N is the weight of the block, and $\theta = 15°$ is the incline angle. Thus, $N = 43.5$ N, which implies that the maximum static friction force should be $f_{s,\,\max} = (0.50)(43.5) = 21.7$ N.

(a) For $\vec{P} = 5.0$ N downhill, Newton's second law, applied to the x axis becomes

$$f - P - W\sin\theta = ma \quad \text{where} \;\; m = \frac{W}{g} \;.$$

Here we are assuming $\vec{f}$ is pointing uphill, as shown in Figure 6-5, and if it turns out that it points downhill (which *is* a possibility), then the result for f_s will be negative. If $f = f_s$ then $a = 0$, we obtain $f_s = 17$ N, which is clearly allowed since it is less than $f_{s,\,\max}$.

(b) For $\vec{P} = 8.0$ N downhill, we obtain (from the same equation) $f_s = 20$ N, which is still allowed since it is less than $f_{s,\,\max}$.

(c) But for $\vec{P} = 15$ N downhill, we obtain (from the same equation) $f_s = 27$ N, which is not allowed since it is larger than $f_{s,\,\max}$. Thus, we conclude that it is the kinetic friction, not the static friction, that is relevant in this case. We compute the result $f_k = (0.34)(43.5) = 15$ N. Here, as in the other parts of this problem, the friction is directed uphill.