Chapter 5

2. We apply Newton's second law (Eq. 5-1 or, equivalently, Eq. 5-2). The net force applied on the chopping block is $\vec{F}_{\text{net}} = \vec{F}_1 + \vec{F}_2$, where the vector addition is done using unit-vector notation. The acceleration of the block is given by $\vec{a} = \left(\vec{F}_1 + \vec{F}_2\right) / m$.

(a) In the first case

$$\vec{F}_1 + \vec{F}_2 = \left[(3.0\text{N})\hat{\text{i}} + (4.0\text{N})\hat{\text{j}}\right] + \left[(-3.0\text{N})\hat{\text{i}} + (-4.0\text{N})\hat{\text{j}}\right] = 0$$

so $\vec{a} = 0$.

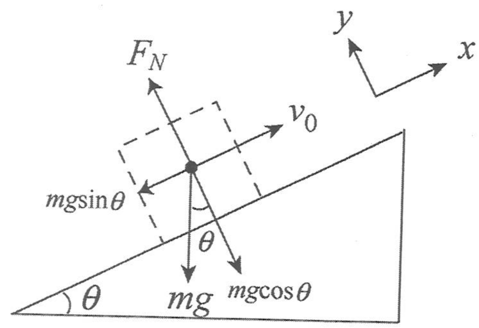
(b) In the second case, the acceleration $\vec{a}$ equals

$$\frac{\vec{F}_1 + \vec{F}_2}{m} = \frac{\left((3.0\text{N})\hat{\text{i}} + (4.0\text{N})\hat{\text{j}}\right) + \left((-3.0\text{N})\hat{\text{i}} + (4.0\text{N})\hat{\text{j}}\right)}{2.0\text{kg}} = (4.0\,\text{m/s}^2)\hat{\text{j}}.$$

(c) In this final situation, $\vec{a}$ is

$$\frac{\vec{F}_1 + \vec{F}_2}{m} = \frac{\left((3.0\text{N})\hat{\text{i}} + (4.0\text{N})\hat{\text{j}}\right) + \left((3.0\text{N})\hat{\text{i}} + (-4.0\text{N})\hat{\text{j}}\right)}{2.0\,\text{kg}} = (3.0\,\text{m/s}^2)\hat{\text{i}}.$$

31. The free-body diagram is shown below. $\vec{F}_N$ is the normal force of the plane on the block and $m\vec{g}$ is the force of gravity on the block. We take the $+x$ direction to be up the incline, and the $+y$ direction to be in the direction of the normal force exerted by the incline on the block. The x component of Newton's second law is then $mg \sin \theta = -ma$; thus, the acceleration is $a = -g \sin \theta$. Placing the origin at the bottom of the plane, the kinematic equations (Table 2-1) for motion along the x axis that we will use are $v^2 = v_0^2 + 2ax$ and $v = v_0 + at$. The block momentarily stops at its highest point, where $v = 0$; according to the second equation, this occurs at time $t = -v_0/a$.



(a) The position at which the block stops is

$$x = -\frac{1}{2}\frac{v_0^2}{a} = -\frac{1}{2}\left(\frac{(3.50 \text{ m/s})^2}{-\left(9.8 \text{ m/s}^2\right) \sin 32.0°}\right) = 1.18 \text{ m}.$$

(b) The time it takes for the block to get there is

$$t = \frac{v_0}{a} = -\frac{v_0}{-g \sin \theta} = -\frac{3.50 \text{ m/s}}{-(9.8 \text{ m/s}^2) \sin 32.0°} = 0.674 \text{ s}.$$

(c) That the return-speed is identical to the initial speed is to be expected since there are no dissipative forces in this problem. In order to prove this, one approach is to set $x = 0$ and solve $x = v_0 t + \frac{1}{2}at^2$ for the total time (up and back down) t. The result is

$$t = -\frac{2v_0}{a} = -\frac{2v_0}{-g \sin \theta} = -\frac{2(3.50 \text{ m/s})}{-(9.8 \text{ m/s}^2) \sin 32.0°} = 1.35 \text{ s}.$$

The velocity when it returns is therefore

$$v = v_0 + at = v_0 - gt \sin \theta = 3.50 \text{ m/s} - (9.8 \text{ m/s}^2)(1.35 \text{ s}) \sin 32° = -3.50 \text{ m/s}.$$

The negative sign indicates the direction is down the plane.

81. The mass of the pilot is $m = 735/9.8 = 75$ kg. Denoting the upward force exerted by the spaceship (his seat, presumably) on the pilot as $\vec{F}$ and choosing upward as the $+y$ direction, then Newton's second law leads to

$$F - mg_{\text{moon}} = ma \quad \Rightarrow \quad F = (75 \text{ kg})\left(1.6 \text{ m/s}^2 + 1.0 \text{ m/s}^2\right) = 195 \text{ N}.$$

5. The net force applied on the chopping block is $\vec{F}_{net} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3$, where the vector addition is done using unit-vector notation. The acceleration of the block is given by $\vec{a} = \left(\vec{F}_1 + \vec{F}_2 + \vec{F}_3\right) / m$.

(a) The forces exerted by the three astronauts can be expressed in unit-vector notation as follows:

$$\vec{F}_1 = (32\text{ N})\left(\cos 30°\hat{\imath} + \sin 30°\hat{\jmath}\right) = (27.7\text{ N})\hat{\imath} + (16\text{ N})\hat{\jmath}$$
$$\vec{F}_2 = (55\text{ N})\left(\cos 0°\hat{\imath} + \sin 0°\hat{\jmath}\right) = (55\text{ N})\hat{\imath}$$
$$\vec{F}_3 = (41\text{ N})\left(\cos(-60°)\hat{\imath} + \sin(-60°)\hat{\jmath}\right) = (20.5\text{ N})\hat{\imath} - (35.5\text{ N})\hat{\jmath}.$$

The resultant acceleration of the asteroid of mass $m = 120$ kg is therefore

$$\vec{a} = \frac{\left(27.7\hat{\imath} + 16\hat{\jmath}\right)\text{N} + \left(55\hat{\imath}\right)\text{N} + \left(20.5\hat{\imath} - 35.5\hat{\jmath}\right)\text{N}}{120\text{ kg}} = (0.86\text{m/s}^2)\hat{\imath} - (0.16\text{m/s}^2)\hat{\jmath}.$$

(b) The magnitude of the acceleration vector is

$$|\vec{a}| = \sqrt{a_x^2 + a_y^2} = \sqrt{(0.86\text{ m/s}^2)^2 + \left(-0.16\text{ m/s}^2\right)^2} = 0.88\text{ m/s}^2.$$

(c) The vector $\vec{a}$ makes an angle θ with the $+x$ axis, where

$$\theta = \tan^{-1}\left(\frac{a_y}{a_x}\right) = \tan^{-1}\left(\frac{-0.16\text{ m/s}^2}{0.86\text{ m/s}^2}\right) = -11°.$$

15. (a) – (c) In all three cases the scale is not accelerating, which means that the two cords exert forces of equal magnitude on it. The scale reads the magnitude of either of these forces. In each case the tension force of the cord attached to the salami must be the same in magnitude as the weight of the salami because the salami is not accelerating. Thus the scale reading is mg, where m is the mass of the salami. Its value is (11.0 kg) (9.8 m/s^2) = 108 N.

25. (a) The acceleration is

$$a = \frac{F}{m} = \frac{20\text{ N}}{900\text{ kg}} = 0.022\text{ m/s}^2.$$

(b) The distance traveled in 1 day (= 86400 s) is

$$s = \frac{1}{2}at^2 = \frac{1}{2}\left(0.0222\text{ m/s}^2\right)(86400\text{ s})^2 = 8.3 \times 10^7\text{ m}.$$

(c) The speed it will be traveling is given by

$$v = at = \left(0.0222\text{ m/s}^2\right)\left(86400\text{ s}\right) = 1.9 \times 10^3\text{ m/s}.$$