Halliday/Resnick/Walker 7e
Chapter 5

1. We are only concerned with horizontal forces in this problem (gravity plays no direct role). We take East as the $+x$ direction and North as $+y$. This calculation is efficiently implemented on a vector-capable calculator, using magnitude-angle notation (with SI units understood).

$$\vec{a} = \frac{\vec{F}}{m} = \frac{(9.0 \angle 0°) + (8.0 \angle 118°)}{3.0} = (2.9 \angle 53°)$$

Therefore, the acceleration has a magnitude of 2.9 m/s^2.

4. 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 $\vec{a} = (\vec{F}_1 + \vec{F}_2 + \vec{F}_3)/m$.

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

$$\begin{aligned} \vec{F}_1 &= 32(\cos 30°\hat{\text{i}} + \sin 30°\hat{\text{j}}) = 27.7\hat{\text{i}} + 16\hat{\text{j}} \\ \vec{F}_2 &= 55(\cos 0°\hat{\text{i}} + \sin 0°\hat{\text{j}}) = 55\hat{\text{i}} \\ \vec{F}_3 &= 41(\cos(-60°)\hat{\text{i}} + \sin(-60°)\hat{\text{j}}) = 20.5\hat{\text{i}} - 35.5\hat{\text{j}}. \end{aligned}$$

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

$$\vec{a} = \frac{(27.7\hat{\text{i}} + 16\hat{\text{j}}) + (55\hat{\text{i}}) + (20.5\hat{\text{i}} - 35.5\hat{\text{j}})}{120} = (0.86\text{m/s}^2)\hat{\text{i}} - (0.16\text{m/s}^2)\hat{\text{j}}.$$

(b) The magnitude of the acceleration vector is

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

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

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

5. We denote the two forces $\vec{F}_1$ and $\vec{F}_2$. According to Newton's second law, $\vec{F}_1 + \vec{F}_2 = m\vec{a}$, so $\vec{F}_2 = m\vec{a} - \vec{F}_1$.

(a) In unit vector notation $\vec{F}_1 = (20.0\text{ N})\hat{\text{i}}$ and

$$\vec{a} = -\left(12.0\sin 30.0°\,\text{m/s}^2\right)\hat{\text{i}} - \left(12.0\cos 30.0°\,\text{m/s}^2\right)\hat{\text{j}} = -\left(6.00\text{ m/s}^2\right)\hat{\text{i}} - \left(10.4\text{m/s}^2\right)\hat{\text{j}}.$$

Therefore,

$$\begin{aligned}\vec{F}_2 &= (2.00\,\text{kg})\left(-6.00\,\text{m/s}^2\right)\hat{\text{i}} + (2.00\text{ kg})\left(-10.4\text{ m/s}^2\right)\hat{\text{j}} - (20.0\text{ N})\hat{\text{i}} \\ &= (-32.0\text{ N})\hat{\text{i}} - (20.8\text{ N})\hat{\text{j}}.\end{aligned}$$

(b) The magnitude of $\vec{F}_2$ is

$$|\vec{F}_2| = \sqrt{F_{2x}^2 + F_{2y}^2} = \sqrt{(-32.0)^2 + (-20.8)^2} = 38.2\text{ N}.$$

(c) The angle that $\vec{F}_2$ makes with the positive x axis is found from

$$\tan\theta = (F_{2y}/F_{2x}) = [(-20.8)/(-32.0)] = 0.656.$$

Consequently, the angle is either 33.0° or 33.0° + 180° = 213°. Since both the x and y components are negative, the correct result is 213°. An alternative answer is $213° - 360° = -147°$.

9. (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.

11. (a) From the fact that T_3 = 9.8 N, we conclude the mass of disk D is 1.0 kg. Both this and that of disk C cause the tension T_2 = 49 N, which allows us to conclude that disk C has a mass of 4.0 kg. The weights of these two disks plus that of disk B determine the tension T_1 = 58.8 N, which leads to the conclusion that m_B = 1.0 kg. The weights of all the disks must add to the 98 N force described in the problem; therefore, disk A has mass 4.0 kg.

(b) m_B = 1.0 kg, as found in part (a).

(c) m_C = 4.0 kg, as found in part (a).

(d) m_D = 1.0 kg, as found in part (a).

12. (a) There are six legs, and the vertical component of the tension force in each leg is $T\sin\theta$ where $\theta = 40°$. For vertical equilibrium (zero acceleration in the y direction) then Newton's second law leads to

$$6T\sin\theta = mg \Rightarrow T = \frac{mg}{6\sin\theta}$$

which (expressed as a multiple of the bug's weight mg) gives roughly $T/mg \approx 0.260$.

(b) The angle θ is measured from horizontal, so as the insect "straightens out the legs" θ will increase (getting closer to $90°$), which causes $\sin\theta$ to increase (getting closer to 1) and consequently (since $\sin\theta$ is in the denominator) causes T to decrease.

13. We note that the free-body diagram is shown in Fig. 5-18 of the text.

(a) Since the acceleration of the block is zero, the components of the Newton's second law equation yield

$$T - mg\sin\theta = 0$$
$$F_N - mg\cos\theta = 0.$$

Solving the first equation for the tension in the string, we find

$$T = mg\sin\theta = (8.5\text{ kg})(9.8\text{ m/s}^2)\sin 30° = 42\text{ N}.$$

(b) We solve the second equation in part (a) for the normal force F_N:

$$F_N = mg\cos\theta = (8.5\text{ kg})(9.8\text{ m/s}^2)\cos 30° = 72\text{ N}.$$

(c) When the string is cut, it no longer exerts a force on the block and the block accelerates. The x component of the second law becomes $-mg\sin\theta = ma$, so the acceleration becomes

$$a = -g\sin\theta = -9.8\sin 30° = -4.9\text{ m/s}^2.$$

The negative sign indicates the acceleration is down the plane. The magnitude of the acceleration is 4.9 m/s^2.

14. (a) The reaction force to $\vec{F}_{MW} = 180\text{ N}$ west is, by Newton's third law, $\vec{F}_{WM} = 180\text{ N}$.

(b) The direction of $\vec{F}_{WM}$ is east.

(c) Applying $\vec{F} = m\vec{a}$ to the woman gives an acceleration $a = 180/45 = 4.0$ m/s^2.

(d) The acceleration of the woman is directed west.

(e) Applying $\vec{F} = m\vec{a}$ to the man gives an acceleration $a = 180/90 = 2.0$ m/s^2.

(f) The acceleration of the man is directed east.

15. (a) The slope of each graph gives the corresponding component of acceleration. Thus, we find a_x = 3.00 m/s^2 and a_y = –5.00 m/s^2. The magnitude of the acceleration vector is therefore $a=\sqrt{(3.00)^2+(-5.00)^2}=5.83\text{ m/s}^2$, and the force is obtained from this by multiplying with the mass (m= 2.00 kg). The result is $F = ma$ =11.7 N.

(b) The direction of the force is the same as that of the acceleration:

$$\theta = \tan^{-1}(-5.00/3.00) = -59.0°.$$

17. In terms of magnitudes, Newton's second law is $F = ma$, where $F = \left|\vec{F}_{\text{net}}\right|$, $a = |\vec{a}|$, and m is the (always positive) mass. The magnitude of the acceleration can be found using constant acceleration kinematics (Table 2-1). Solving $v = v_0 + at$ for the case where it starts from rest, we have $a = v/t$ (which we interpret in terms of magnitudes, making specification of coordinate directions unnecessary). The velocity is v = (1600 km/h) (1000 m/km)/(3600 s/h) = 444 m/s, so

$$F = (500\text{ kg})\,\frac{444\text{ m/s}}{1.8\text{ s}} = 1.2\times10^5\text{ N}.$$

19. (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

$$s = \frac{1}{2}at^2 = \frac{1}{2}\left(0.0222\text{ m/s}^2\right)(86400\text{ s})^2 = 8.3\times10^7\text{ m} .$$

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

$$v = at = \left(0.0222\text{ m/s}^2\right)(86400\text{ s}) = 1.9\times10^3\text{ m/s} .$$

22. The stopping force $\vec{F}$ and the path of the car are horizontal. Thus, the weight of the car contributes only (via Eq. 5-12) to information about its mass ($m = W/g$ = 1327 kg). Our +x axis is in the direction of the car's velocity, so that its acceleration (''deceleration") is negative-valued and the stopping force is in the –x direction: $\vec{F} = -F\,\hat{\text{i}}$.

(a) We use Eq. 2-16 and SI units (noting that v = 0 and v_0 = 40(1000/3600) = 11.1 m/s).

$$v^2 = v_0^2 + 2a\Delta x \;\;\Rightarrow\;\; a = -\frac{v_0^2}{2\Delta x} = -\frac{11.1^2}{2(15)}$$

which yields a = – 4.12 m/s^2. Assuming there are no significant horizontal forces other than the stopping force, Eq. 5-1 leads to

$$\vec{F} = m\vec{a} \;\;\Rightarrow\;\; -F = (1327\text{ kg})\left(-4.12\text{ m/s}^2\right)$$

which results in $F = 5.5 \times 10^3$ N.

(b) Eq. 2-11 readily yields $t = -v_0/a = 2.7$ s.

(c) Keeping F the same means keeping a the same, in which case (since $v = 0$) Eq. 2-16 expresses a direct proportionality between Δx and v_0^2. Therefore, doubling v_0 means quadrupling Δx. That is, the new over the old stopping distances is a factor of 4.0.

(d) Eq. 2-11 illustrates a direct proportionality between t and v_0 so that doubling one means doubling the other. That is, the new time of stopping is a factor of 2.0 greater than the one found in part (b).

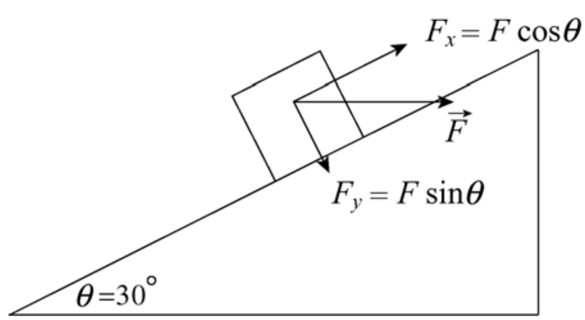
23. The acceleration of the electron is vertical and for all practical purposes the only force acting on it is the electric force. The force of gravity is negligible. We take the $+x$ axis to be in the direction of the initial velocity and the $+y$ axis to be in the direction of the electrical force, and place the origin at the initial position of the electron. Since the force and acceleration are constant, we use the equations from Table 2-1: $x = v_0 t$ and

$$y = \frac{1}{2}at^2 = \frac{1}{2}\left(\frac{F}{m}\right)t^2 .$$

The time taken by the electron to travel a distance x (= 30 mm) horizontally is $t = x/v_0$ and its deflection in the direction of the force is

$$y = \frac{1}{2}\frac{F}{m}\left(\frac{x}{v_0}\right)^2 = \frac{1}{2}\left(\frac{4.5\times10^{-16}}{9.11\times10^{-31}}\right)\left(\frac{30\times10^{-3}}{1.2\times10^{7}}\right)^2 = 1.5\times10^{-3}\ \text{m} .$$

24. We resolve this horizontal force into appropriate components.



(a) Newton's second law applied to the x axis produces

$$F\cos\theta - mg\sin\theta = ma.$$

For $a = 0$, this yields $F = 566$ N.

(b) Applying Newton's second law to the y axis (where there is no acceleration), we have

$$F_N - F\sin\theta - mg\cos\theta = 0$$

which yields the normal force $F_N = 1.13 \times 10^3$ N

27. (a) Since friction is negligible the force of the girl is the only horizontal force on the sled. The vertical forces (the force of gravity and the normal force of the ice) sum to zero. The acceleration of the sled is

$$a_s = \frac{F}{m_s} = \frac{5.2\ \text{N}}{8.4\ \text{kg}} = 0.62\ \text{m/s}^2\ .$$

(b) According to Newton's third law, the force of the sled on the girl is also 5.2 N. Her acceleration is

$$a_g = \frac{F}{m_g} = \frac{5.2\ \text{N}}{40\ \text{kg}} = 0.13\ \text{m/s}^2\ .$$

(c) The accelerations of the sled and girl are in opposite directions. Assuming the girl starts at the origin and moves in the +*x* direction, her coordinate is given by $x_g = \frac{1}{2} a_g t^2$. The sled starts at x_0 = 1.5 m and moves in the –*x* direction. Its coordinate is given by $x_s = x_0 - \frac{1}{2} a_s t^2$. They meet when $x_g = x_s$, or

$$\frac{1}{2} a_g t^2 = x_0 - \frac{1}{2} a_s t^2.$$

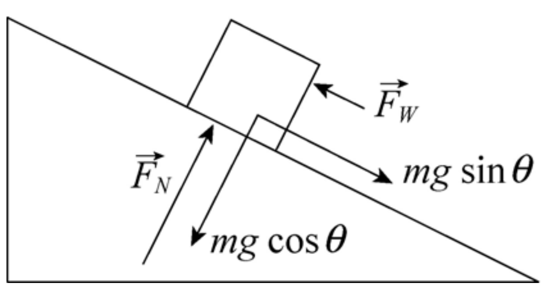
This occurs at time

$$t = \sqrt{\frac{2x_0}{a_g + a_s}}.$$

By then, the girl has gone the distance

$$x_g = \frac{1}{2} a_g t^2 = \frac{x_0 a_g}{a_g + a_s} = \frac{(15)(0.13)}{0.13 + 0.62} = 2.6\ \text{m}.$$

28. We label the 40 kg skier "*m*" which is represented as a block in the figure shown. The force of the wind is denoted $\vec{F}_w$ and might be either "uphill" or "downhill" (it is shown uphill in our sketch). The incline angle θ is 10°. The –*x* direction is downhill.



(a) Constant velocity implies zero acceleration; thus, application of Newton's second law along the x axis leads to

$$mg\sin\theta - F_w = 0\ .$$

This yields F_w = 68 N (uphill).

(b) Given our coordinate choice, we have $a = |a| = 1.0$ m/s^2. Newton's second law

$$mg\sin\theta - F_w = ma$$

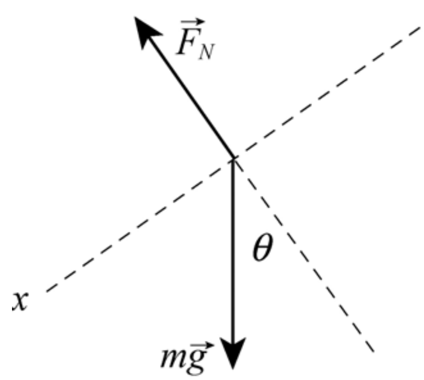
now leads to F_w = 28 N (uphill).

(c) Continuing with the forces as shown in our figure, the equation

$$mg\sin\theta - F_w = ma$$

will lead to F_w = – 12 N when $|a|$ = 2.0 m/s^2. This simply tells us that the wind is opposite to the direction shown in our sketch; in other words, $\vec{F}_w = 12\text{ N}$ *downhill*.

29. The free-body diagram is shown next. $\vec{F}_N$ 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 down the incline, in the direction of the acceleration, 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 $a = g\sin\theta$.



(a) Placing the origin at the bottom of the plane, the kinematic equations (Table 2-1) for motion along the x axis which 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 $t = -v_0/a$. The position where it stops is

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

or $|x| = 1.18$ m.

(b) The time 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

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

31. The solutions to parts (a) and (b) have been combined here. The free-body diagram is shown below, with the tension of the string $\vec{T}$, the force of gravity $m\vec{g}$, and the force of the air $\vec{F}$. Our coordinate system is shown. Since the sphere is motionless the net force on it is zero, and the x and the y components of the equations are:

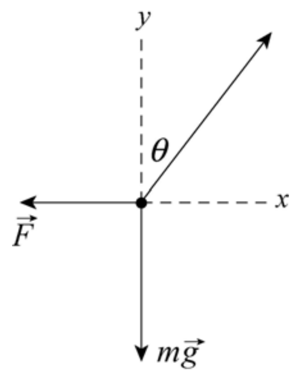
$$T\sin\theta - F = 0$$
$$T\cos\theta - mg = 0,$$

where $\theta = 37°$. We answer the questions in the reverse order. Solving $T\cos\theta - mg = 0$ for the tension, we obtain

$$T = mg/\cos\theta = (3.0\times10^{-4})(9.8)/\cos 37° = 3.7\times10^{-3}\text{ N}.$$

Solving $T\sin\theta - F = 0$ for the force of the air:

$$F = T\sin\theta = (3.7\times10^{-3})\sin 37° = 2.2\times10^{-3}\text{ N}.$$



33. The free-body diagram is shown below. Let $\vec{T}$ be the tension of the cable and $m\vec{g}$ be the force of gravity. If the upward direction is positive, then Newton's second law is $T - mg = ma$, where a is the acceleration.

Thus, the tension is $T = m(g + a)$. We use constant acceleration kinematics (Table 2-1) to find the acceleration (where $v = 0$ is the final velocity, $v_0 = -12$ m/s is the initial velocity, and $y = -42$ m is the coordinate at the stopping point). Consequently, $v^2 = v_0^2 + 2ay$ leads to

$$a = -\frac{v_0^2}{2y} = -\frac{(-12)^2}{2(-42)} = 1.71\,\mathrm{m/s^2}.$$

We now return to calculate the tension:

$$\begin{aligned} T &= m(g + a) \\ &= (1600\ \mathrm{kg})\,(9.8\ \mathrm{m/s^2} + 1.71\ \mathrm{m/s^2}) \\ &= 1.8 \times 10^4\ \mathrm{N}. \end{aligned}$$

34. (a) The term "deceleration" means the acceleration vector is in the direction opposite to the velocity vector (which the problem tells us is downward). Thus (with $+y$ upward) the acceleration is $a = +2.4$ m/s^2. Newton's second law leads to

$$T - mg = ma \ \Rightarrow\ m = \frac{T}{g + a}$$

which yields $m = 7.3$ kg for the mass.

(b) Repeating the above computation (now to solve for the tension) with $a = +2.4$ m/s^2 will, of course, lead us right back to $T = 89$ N. Since the direction of the velocity did not enter our computation, this is to be expected.

37. The mass of the bundle is m = (449/9.80) = 45.8 kg and we choose +y upward.

(a) Newton's second law, applied to the bundle, leads to

$$T - mg = ma \;\Rightarrow\; a = \frac{387 - 449}{45.8}$$

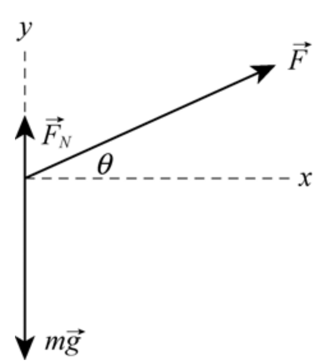
which yields a = –1.4 m/s^2 (or |a| = 1.4 m/s^2) for the acceleration. The minus sign in the result indicates the acceleration vector points down. Any downward acceleration of magnitude greater than this is also acceptable (since that would lead to even smaller values of tension).

(b) We use Eq. 2-16 (with Δx replaced by Δy = –6.1 m). We assume $v_0 = 0$.

$$|v| = \sqrt{2a\Delta y} = \sqrt{2(-1.35)(-6.1)} = 4.1 \text{ m/s}.$$

For downward accelerations greater than 1.4 m/s^2, the speeds at impact will be larger than 4.1 m/s.

41. The force diagram (not to scale) for the block is shown below. $\vec{F}_N$ is the normal force exerted by the floor and $m\vec{g}$ is the force of gravity.



(a) The x component of Newton's second law is $F\cos\theta = ma$, where m is the mass of the block and a is the x component of its acceleration. We obtain

$$a = \frac{F\cos\theta}{m} = \frac{(12.0\text{ N})\cos 25.0°}{5.00\text{ kg}} = 2.18 \text{ m/s}^2.$$

This is its acceleration provided it remains in contact with the floor. Assuming it does, we find the value of F_N (and if F_N is positive, then the assumption is true but if F_N is negative then the block leaves the floor). The y component of Newton's second law becomes

$$F_N + F\sin\theta - mg = 0,$$

so

$$F_N = mg - F\sin\theta = (5.00)(9.80) - (12.0)\sin 25.0° = 43.9 \text{ N}.$$

Hence the block remains on the floor and its acceleration is $a = 2.18 \text{ m/s}^2$.

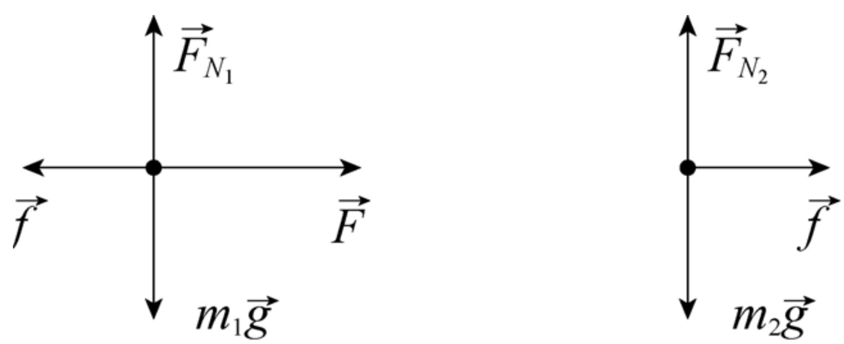
(b) If F is the minimum force for which the block leaves the floor, then $F_N = 0$ and the y component of the acceleration vanishes. The y component of the second law becomes

$$F\sin\theta - mg = 0 \quad\Rightarrow\quad F = \frac{mg}{\sin\theta} = \frac{(5.00)(9.80)}{\sin 25.0°} = 116 \text{ N}.$$

(c) The acceleration is still in the x direction and is still given by the equation developed in part (a):

$$a = \frac{F\cos\theta}{m} = \frac{116\cos 25.0°}{5.00} = 21.0 \text{ m/s}^2.$$

43. The free-body diagrams for part (a) are shown below. $\vec{F}$ is the applied force and $\vec{f}$ is the force exerted by block 1 on block 2. We note that $\vec{F}$ is applied directly to block 1 and that block 2 exerts the force $-\vec{f}$ on block 1 (taking Newton's third law into account).



(a) Newton's second law for block 1 is $F - f = m_1 a$, where a is the acceleration. The second law for block 2 is $f = m_2 a$. Since the blocks move together they have the same acceleration and the same symbol is used in both equations. From the second equation we obtain the expression $a = f/m_2$, which we substitute into the first equation to get $F - f = m_1 f/m_2$. Therefore,

$$f = \frac{Fm_2}{m_1 + m_2} = \frac{(3.2 \text{ N})(1.2 \text{ kg})}{2.3 \text{ kg} + 1.2 \text{ kg}} = 1.1 \text{ N}.$$

(b) If $\vec{F}$ is applied to block 2 instead of block 1 (and in the opposite direction), the force of contact between the blocks is

$$f = \frac{Fm_1}{m_1 + m_2} = \frac{(3.2\ \text{N})\,(2.3\ \text{kg})}{2.3\ \text{kg} + 1.2\ \text{kg}} = 2.1\ \text{N}\ .$$

(c) We note that the acceleration of the blocks is the same in the two cases. In part (a), the force f is the only horizontal force on the block of mass m_2 and in part (b) f is the only horizontal force on the block with $m_1 > m_2$. Since $f = m_2a$ in part (a) and $f = m_1a$ in part (b), then for the accelerations to be the same, f must be larger in part (b).

46. (a) The net force on the *system* (of total mass $M = 80.0$ kg) is the force of gravity acting on the total overhanging mass ($m_{BC} = 50.0$ kg). The magnitude of the acceleration is therefore $a = (m_{BC}\ g)/M = 6.125\ \text{m/s}^2$. Next we apply Newton's second law to block C itself (choosing *down* as the $+y$ direction) and obtain

$$m_C g - T_{BC} = m_C a.$$

This leads to $T_{BC} = 36.8$ N.

(b) We use Eq. 2-15 (choosing *rightward* as the $+x$ direction): $\Delta x = 0 + \frac{1}{2}at^2 = 0.191$ m.

50. The motion of the man-and-chair is positive if upward.

(a) When the man is grasping the rope, pulling with a force equal to the tension T in the rope, the total upward force on the man-and-chair due its two contact points with the rope is $2T$. Thus, Newton's second law leads to

$$2T - mg = ma$$

so that when $a = 0$, the tension is $T = 466$ N.

(b) When $a = +1.30\ \text{m/s}^2$ the equation in part (a) predicts that the tension will be $T = 527\ \text{N}$.

(c) When the man is not holding the rope (instead, the co-worker attached to the ground is pulling on the rope with a force equal to the tension T in it), there is only one contact point between the rope and the man-and-chair, and Newton's second law now leads to

$$T - mg = ma$$

so that when $a = 0$, the tension is $T = 931$ N.

(d) When $a = +1.30\ \text{m/s}^2$, the equation in (c) yields $T = 1.05 \times 10^3$ N.

(e) The rope comes into contact (pulling down in each case) at the left edge and the right edge of the pulley, producing a total downward force of magnitude $2T$ on the ceiling. Thus, in part (a) this gives $2T = 931$ N.

(f) In part (b) the downward force on the ceiling has magnitude $2T = 1.05 \times 10^3$ N.

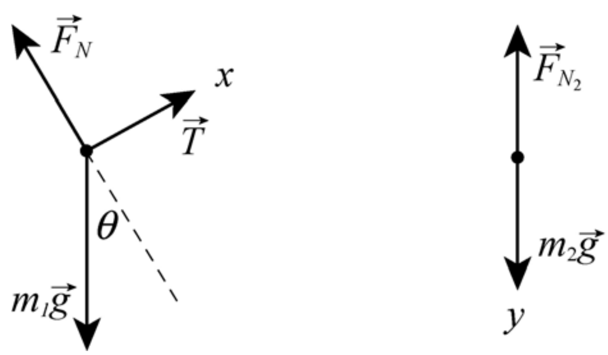
(g) In part (c) the downward force on the ceiling has magnitude $2T = 1.86 \times 10^3$ N.

(h) In part (d) the downward force on the ceiling has magnitude $2T = 2.11 \times 10^3$ N.

51. The free-body diagram for each block is shown below. T is the tension in the cord and $\theta = 30°$ is the angle of the incline. For block 1, we take the $+x$ direction to be up the incline and the $+y$ direction to be in the direction of the normal force $\vec{F}_N$ that the plane exerts on the block. For block 2, we take the $+y$ direction to be down. In this way, the accelerations of the two blocks can be represented by the same symbol a, without ambiguity. Applying Newton's second law to the x and y axes for block 1 and to the y axis of block 2, we obtain

$$\begin{aligned} T - m_1 g \sin\theta &= m_1 a \\ F_N - m_1 g \cos\theta &= 0 \\ m_2 g - T &= m_2 a \end{aligned}$$

respectively. The first and third of these equations provide a simultaneous set for obtaining values of a and T. The second equation is not needed in this problem, since the normal force is neither asked for nor is it needed as part of some further computation (such as can occur in formulas for friction).



(a) We add the first and third equations above:

$$m_2 g - m_1 g \sin\theta = m_1 a + m_2 a.$$

Consequently, we find

$$a = \frac{(m_2 - m_1 \sin\theta) g}{m_1 + m_2} = \frac{(2.30 - 3.70 \sin 30.0°)(9.80)}{3.70 + 2.30} = 0.735 \text{ m/s}^2.$$

(b) The result for a is positive, indicating that the acceleration of block 1 is indeed up the incline and that the acceleration of block 2 is vertically down.

(c) The tension in the cord is

$$T = m_1 a + m_1 g \sin\,\theta = (3.70)\,(0.735) + (3.70)\,(9.80)\,\sin 30.0° = 20.8\text{N}.$$

53. The forces on the balloon are the force of gravity $m\vec{g}$ (down) and the force of the air $\vec{F}_a$ (up). We take the $+y$ to be up, and use a to mean the *magnitude* of the acceleration (which is not its usual use in this chapter). When the mass is M (before the ballast is thrown out) the acceleration is downward and Newton's second law is

$$F_a - Mg = -Ma.$$

After the ballast is thrown out, the mass is $M - m$ (where m is the mass of the ballast) and the acceleration is upward. Newton's second law leads to

$$F_a - (M - m)g = (M - m)a.$$

The previous equation gives $F_a = M(g - a)$, and this plugs into the new equation to give

$$M(g - a) - (M - m)g = (M - m)a \;\Rightarrow\; m = \frac{2Ma}{g + a}.$$