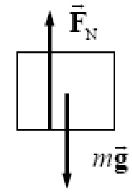
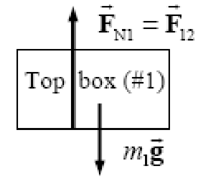
10. (*a*) The 20.0 kg box resting on the table has the free-body diagram shown. Its weight is $mg = (20.0\text{ kg})(9.80\,\text{m/s}^2) = \boxed{196\,\text{N}}$. Since the box is at rest, the net force on the box must be 0, and so the normal force must also be $\boxed{196\,\text{N}}$.



(*b*) Free-body diagrams are shown for both boxes. $\vec{\mathbf{F}}_{12}$ is the force on box 1 (the top box) due to box 2 (the bottom box), and is the normal force on box 1. $\vec{\mathbf{F}}_{21}$ is the force on box 2 due to box 1, and has the same magnitude as $\vec{\mathbf{F}}_{12}$ by Newton's third law. $\vec{\mathbf{F}}_{N2}$ is the force of the table on box 2. That is the normal force on box 2. Since both boxes are at rest, the net force on each box must be 0. Write Newton's second law in the vertical direction for each box, taking the upward direction to be positive.

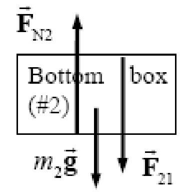


$$\sum F_1 = F_{N1} - m_1 g = 0$$

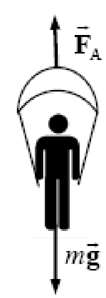
$$F_{N1} = m_1 g = (10.0\,\text{kg})(9.80\,\text{m/s}^2) = \boxed{98.0\text{ N}} = F_{12} = F_{21}$$

$$\sum F_2 = F_{N2} - F_{21} - m_2 g = 0$$

$$F_{N2} = F_{21} + m_2 g = 98.0\text{ N} + (20.0\,\text{kg})(9.80\,\text{m/s}^2) = \boxed{294\text{ N}}$$



22. (*a*) There will be two forces on the skydivers – their combined weight, and the upward force of air resistance, $\vec{\mathbf{F}}_A$. Choose up to be the positive direction. Write Newton's second law for the skydivers.



$$\sum F = F_A - mg = ma \quad\rightarrow\quad 0.25mg - mg = ma \quad\rightarrow$$

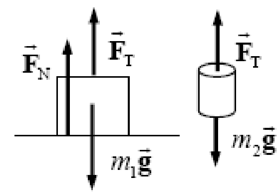
$$a = -0.75g = -0.75(9.80\,\text{m/s}^2) = \boxed{-7.35\,\text{m/s}^2}$$

Due to the sign of the result, the direction of the acceleration is down.

(*b*) If they are descending at constant speed, then the net force on them must be zero, and so the force of air resistance must be equal to their weight.

$$F_A = mg = (132\text{ kg})(9.80\,\text{m/s}^2) = \boxed{1.29\times10^3\,\text{N}}$$

27. Free-body diagrams for the box and the weight are shown below. The tension exerts the same magnitude of force on both objects.



(*a*) If the weight of the hanging weight is less than the weight of the box, the objects will not move, and the tension will be the same as the weight of the hanging weight. The acceleration of the box will also be zero, and so the sum of the forces on it will be zero. For the box,

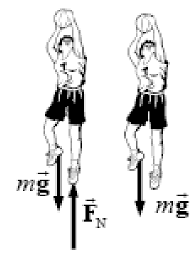
$$F_N + F_T - m_1 g = 0 \quad \rightarrow \quad F_N = m_1 g - F_T = m_1 g - m_2 g = 77.0\text{N} - 30.0\text{ N} = \boxed{47.0\text{ N}}$$

(*b*) The same analysis as for part (*a*) applies here.

$$F_N = m_1 g - m_2 g = 77.0\text{ N} - 60.0\text{ N} = \boxed{17.0\text{ N}}$$

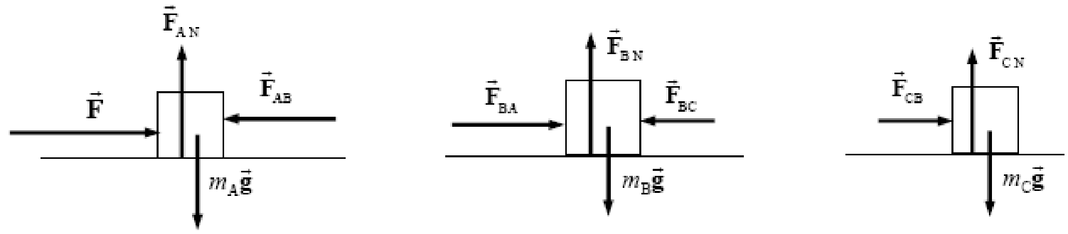
(*c*) Since the hanging weight has more weight than the box on the table, the box on the table will be lifted up off the table, and normal force of the table on the box will be $\boxed{0\text{ N}}$.

28. (*a*) Just before the player leaves the ground, the forces on the player are his weight and the floor pushing up on the player. If the player jumps straight up, then the force of the floor will be straight up – a normal force. See the first diagram. In this case, while touching the floor, $F_N > mg$.



(*b*) While the player is in the air, the only force on the player is their weight. See the second diagram.

46. (*a*) In the free-body diagrams below, $\vec{\mathbf{F}}_{AB}$ = force on block A exerted by block B, $\vec{\mathbf{F}}_{BA}$ = force on block B exerted by block A, $\vec{\mathbf{F}}_{BC}$ = force on block B exerted by block C, and $\vec{\mathbf{F}}_{CB}$ = force on block C exerted by block B. The magnitudes of $\vec{\mathbf{F}}_{BA}$ and $\vec{\mathbf{F}}_{AB}$ are equal, and the magnitudes of $\vec{\mathbf{F}}_{BC}$ and $\vec{\mathbf{F}}_{CB}$ are equal, by Newton's third law.



(*b*) All of the vertical forces on each block add up to zero, since there is no acceleration in the vertical direction. Thus for each block, $F_N = mg$. For the horizontal direction, we have the following.

$$\sum F = F - F_{AB} + F_{BA} - F_{BC} + F_{CB} = F = \left(m_A + m_B + m_C\right) a \quad \rightarrow \quad \boxed{a = \frac{F}{m_A + m_B + m_C}}$$

(*c*) For each block, the net force must be *ma* by Newton's second law. Each block has the same acceleration since they are in contact with each other.

$$\boxed{F_{A\,net} = F\frac{m_A}{m_A + m_B + m_C}} \qquad \boxed{F_{B\,net} = F\frac{m_B}{m_A + m_B + m_C}} \qquad \boxed{F_{3\,net} = F\frac{m_C}{m_A + m_B + m_C}}$$

(*d*) From the free-body diagram, we see that for m_C, $F_{CB} = F_{C\,net} = \boxed{F\frac{m_C}{m_A + m_B + m_C}}$. And by Newton's third law, $F_{BC} = F_{CB} = \boxed{F\frac{m_C}{m_A + m_B + m_C}}$. Of course, $\vec{\mathbf{F}}_{23}$ and $\vec{\mathbf{F}}_{32}$ are in opposite directions. Also from the free-body diagram, we use the net force on m_A.

$$F - F_{AB} = F_{A\,net} = F\frac{m_A}{m_A + m_B + m_C} \quad \rightarrow \quad F_{AB} = F - F\frac{m_A}{m_A + m_B + m_C} \quad \rightarrow$$

$$\boxed{F_{AB} = F\frac{m_B + m_C}{m_A + m_B + m_C}}$$

By Newton's third law, $F_{BC} = F_{AB} = \boxed{F\frac{m_2 + m_3}{m_1 + m_2 + m_3}}$.

(*e*) Using the given values, $a=\frac{F}{m_1+m_2+m_3}=\frac{96.0\text{ N}}{30.0\text{ kg}}=\boxed{3.20\,\text{m/s}^2}$. Since all three masses are the same value, the net force on each mass is $F_{\text{net}}=ma=(10.0\text{ kg})(3.20\,\text{m/s}^2)=32.0\text{ N}$. This is also the value of F_{CB} and F_{BC}. The value of F_{AB} and F_{BA} is found as follows.

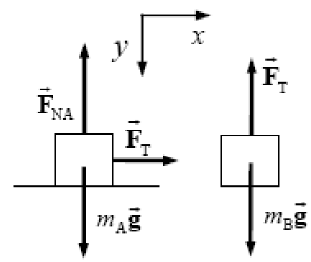
$$F_{\text{AB}}=F_{\text{BA}}=(m_2+m_3)a=(20.0\text{ kg})(3.20\,\text{m/s}^2)=64.0\text{ N}$$

To summarize:

$$F_{\text{A net}}=F_{\text{B net}}=F_{\text{C net}}=\boxed{32.0\text{ N}}\qquad F_{\text{AB}}=F_{\text{BA}}=\boxed{64.0\text{ N}}\qquad F_{\text{BC}}=F_{\text{CB}}=\boxed{32.0\text{ N}}$$

The values make sense in that in order of magnitude, we should have $F>F_{\text{BA}}>F_{\text{CB}}$, since F is the net force pushing the entire set of blocks, F_{AB} is the net force pushing the right two blocks, and F_{BC} is the net force pushing the right block only.

51. (*a*) See the free-body diagrams included.



(*b*) For block A, since there is no motion in the vertical direction, we have $F_{\text{NA}}=m_{\text{A}}g$. We write Newton's second law for the x direction: $\sum F_{\text{A}x}=F_{\text{T}}=m_{\text{A}}a_{\text{A}x}$. For block B, we only need to consider vertical forces: $\sum F_{\text{B}y}=m_{\text{B}}g-F_{\text{T}}=m_{\text{B}}a_{\text{B}y}$. Since the two blocks are connected, the magnitudes of their accelerations will be the same, and so let $a_{\text{A}x}=a_{\text{B}y}=a$. Combine the two force equations from above, and solve for a by substitution.

$$F_{\text{T}}=m_{\text{A}}a \quad m_{\text{B}}g-F_{\text{T}}=m_{\text{B}}a \quad\rightarrow\quad m_{\text{B}}g-m_{\text{A}}a=m_{\text{B}}a \quad\rightarrow$$

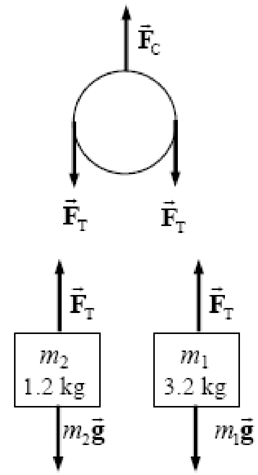
$$m_{\text{A}}a+m_{\text{B}}a=m_{\text{B}}g \quad\rightarrow\quad \boxed{a=g\frac{m_{\text{B}}}{m_{\text{A}}+m_{\text{B}}} \qquad F_{\text{T}}=m_{\text{A}}a=g\frac{m_{\text{A}}m_{\text{B}}}{m_{\text{A}}+m_{\text{B}}}}$$

54. We draw a free-body diagram for each mass. We choose UP to be the positive direction. The tension force in the cord is found from analyzing the two hanging masses. Notice that the same tension force is applied to each mass. Write Newton's second law for each of the masses.

$$F_T - m_1 g = m_1 a_1 \qquad F_T - m_2 g = m_2 a_2$$

Since the masses are joined together by the cord, their accelerations will have the same magnitude but opposite directions. Thus $a_1 = -a_2$.

Substitute this into the force expressions and solve for the tension force.



$$F_T - m_1 g = -m_1 a_2 \quad \rightarrow \quad F_T = m_1 g - m_1 a_2 \quad \rightarrow \quad a_2 = \frac{m_1 g - F_T}{m_1}$$

$$F_T - m_2 g = m_2 a_2 = m_2 \left(\frac{m_1 g - F_T}{m_1} \right) \quad \rightarrow \quad F_T = \frac{2 m_1 m_2 g}{m_1 + m_2}$$

Apply Newton's second law to the stationary pulley.

$$F_C - 2F_T = 0 \quad \rightarrow \quad F_C = 2F_T = \frac{4 m_1 m_2 g}{m_1 + m_2} = \frac{4(3.2\,\text{kg})(1.2\,\text{kg})(9.80\,\text{m/s}^2)}{4.4\,\text{kg}} = \boxed{34\,\text{N}}$$

57. Please refer to the free-body diagrams given in the textbook for this problem. Initially, treat the two boxes and the rope as a single system. Then the only accelerating force on the system is $\vec{\mathbf{F}}_P$. The mass of the system is 23.0 kg, and so using Newton's second law, the acceleration of the system is $a = \frac{F_P}{m} = \frac{35.0\text{ N}}{23.0\text{ kg}} = 1.522\,\text{m/s}^2 \approx \boxed{1.52\,\text{m/s}^2}$. This is the acceleration of each part of the system.

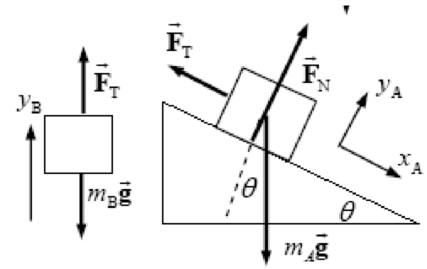
Now consider m_B alone. The only force on it is $\vec{\mathbf{F}}_{BT}$, and it has the acceleration found above. Thus F_{BT} can be found from Newton's second law.

$$F_{BT} = m_B a = (12.0\text{ kg})(1.522\,\text{m/s}^2) = 18.26\,\text{N} \approx \boxed{18.3\,\text{N}}$$

Now consider the rope alone. The net force on it is $\vec{\mathbf{F}}_{TA} - \vec{\mathbf{F}}_{TB}$, and it also has the acceleration found above. Thus F_{TA} can be found from Newton's second law.

$$F_{TA} - F_{TB} = m_C a \quad \rightarrow \quad F_{TA} = F_{TB} + m_C a = 18.26\text{ N} + (1.0\text{ kg})(1.522\,\text{m/s}^2) = \boxed{19.8\,\text{N}}$$

67. (*a*) Draw a free-body diagram for each block. Write Newton's second law for each block. Notice that the acceleration of block A in the y_A direction will be zero, since it has no motion in the y_A direction.



$$\sum F_{yA} = F_N - m_A g\cos\theta = 0 \quad \rightarrow \quad F_N = m_A g\cos\theta$$

$$\sum F_{xA} = m_A g\sin\theta - F_T = m_A a_{xA}$$

$$\sum F_{yB} = F_T - m_B g = m_B a_{yB} \quad \rightarrow \quad F_T = m_B\left(g + a_{yB}\right)$$

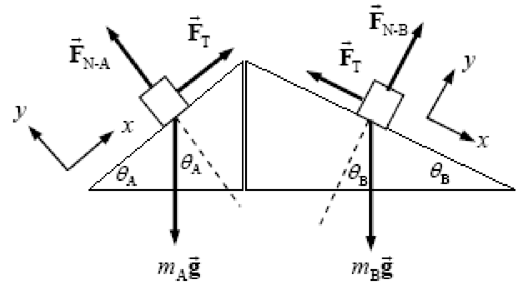
Since the blocks are connected by the cord, $a_{yB} = a_{xA} = a$. Substitute the expression for the tension force from the last equation into the x direction equation for block 1, and solve for the acceleration.

$$m_A g\sin\theta - m_B\left(g + a\right) = m_A a \quad \rightarrow \quad m_A g\sin\theta - m_B g = m_A a + m_B a$$

$$a = \boxed{g\frac{\left(m_A\sin\theta - m_B\right)}{\left(m_A + m_B\right)}}$$

(*b*) If the acceleration is to be down the plane, it must be positive. That will happen if $\boxed{m_A\sin\theta > m_B \ \text{(down the plane)}}$. The acceleration will be up the plane (negative) if $\boxed{m_A\sin\theta < m_B \ \text{(up the plane)}}$. If $m_A\sin\theta = m_B$, then the system will not accelerate. It will move with a constant speed if set in motion by a push.

69. (*a*) A free-body diagram is shown for each block. We define the positive *x*-direction for m_A to be up its incline, and the positive *x*-direction for m_B to be down its incline. With that definition the masses will both have the same acceleration. Write Newton's second law for each body in the *x* direction, and combine those equations to find the acceleration.



$m_A: \quad \sum F_x = F_T - m_A g \sin\theta_A = m_A a$

$m_B: \quad \sum F_x = m_B g \sin\theta_B - F_T = m_B a$ add these two equations

$$\left(F_T - m_A g \sin\theta_A\right) + \left(m_B g \sin\theta_B - F_T\right) = m_A a + m_B a \;\rightarrow\; a = \boxed{\frac{m_B \sin\theta_B - m_A \sin\theta_A}{m_A + m_B} g}$$

(*b*) For the system to be at rest, the acceleration must be 0.

$$a = \frac{m_B \sin\theta_B - m_A \sin\theta_A}{m_A + m_B} g = 0 \;\rightarrow\; m_B \sin\theta_B - m_A \sin\theta_A \;\rightarrow$$

$$m_B = m_A \frac{\sin\theta_A}{\sin\theta_B} = (5.0\,\text{kg}) \frac{\sin 32^\circ}{\sin 23^\circ} = \boxed{6.8\,\text{kg}}$$

The tension can be found from one of the Newton's second law expression from part (*a*).

$$m_A: \quad F_T - m_A g \sin\theta_A = 0 \;\rightarrow\; F_T = m_A g \sin\theta_A = (5.0\,\text{kg})\left(9.80\,\text{m/s}^2\right)\sin 32^\circ = \boxed{26\,\text{N}}$$

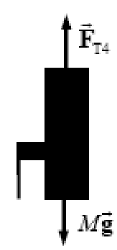
(*c*) As in part (*b*), the acceleration will be 0 for constant velocity in either direction.

$$a = \frac{m_B \sin\theta_B - m_A \sin\theta_A}{m_A + m_B} g = 0 \;\rightarrow\; m_B \sin\theta_B - m_A \sin\theta_A \;\rightarrow$$

$$\frac{m_A}{m_B} = \frac{\sin\theta_B}{\sin\theta_A} = \frac{\sin 23^\circ}{\sin 32^\circ} = \boxed{0.74}$$

75. (*a*) To find the minimum force, assume that the piano is moving with a constant velocity. Since the piano is not accelerating, $F_{T4} = Mg$. For the lower pulley, since the tension in a rope is the same throughout, and since the pulley is not accelerating, it is seen that $F_{T1} + F_{T2} = 2F_{T1} = Mg \;\rightarrow\; F_{T1} = F_{T2} = Mg/2$.

It also can be seen that since $F = F_{T2}$, that $\boxed{F = Mg/2}$.



(*b*) Draw a free-body diagram for the upper pulley. From that diagram, we see that $F_{T3} = F_{T1} + F_{T2} + F = \frac{3Mg}{2}$.

To summarize:

$$\boxed{F_{T1} = F_{T2} = Mg/2 \quad F_{T3} = 3Mg/2 \quad F_{T4} = Mg}$$