Physics 100A – Summer 2016
Chapter 5

Solutions are provided only for problems from your textbook. The other problems already have so much guidance and notes that you should be able to understand where you have gone wrong.

Problems

4. Picture the Problem: You exert a horizontal force that accelerates both your little sister and the sled.

Strategy: Apply Newton's Second Law to the sled + sister combination, and solve for the mass of your sister.

Solution: 1. Use Newton's Second Law to find the total mass of the sled + sister combination:

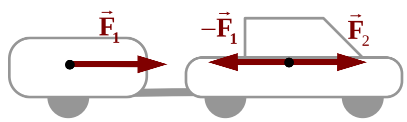
$$m_{\text{total}} = \frac{F}{a} = \frac{120\ \text{N}}{2.5\ \text{m/s}^2} = 48\ \text{kg}$$

2. Find the mass of your sister by subtracting:

$$m_{\text{sister}} = m_{\text{total}} - m_{\text{sled}} = 48\ \text{kg} - 7.4\ \text{kg} = \boxed{41\ \text{kg}}$$

Insight: A more massive sister would decrease the acceleration of the sled if the pulling force remained the same.

18. Picture the Problem: The free body diagrams for the car and the trailer is shown at right. The diagram assumes there is no friction.



Strategy: In order to determine the forces acting on an object, you must consider only the forces acting on that object and the motion of that object alone. For the trailer there is only one force $\vec{\mathbf{F}}_1$ exerted on it by the car, and it has the same acceleration (1.85 m/s^2) as the car. For the car there are two forces acting on it, the engine $\vec{\mathbf{F}}_2$ and the trailer $-\vec{\mathbf{F}}_1$. Apply Newton's Second and Third Laws as appropriate to find the requested forces.

Solution: 1. (a) Write Newton's Second Law for the trailer:

$$\sum \vec{\mathbf{F}} = \vec{\mathbf{F}}_1 = m\vec{\mathbf{a}} = (560\ \text{kg})(1.85\ \text{m/s}^2)\hat{\mathbf{x}} = \boxed{(1.0\ \text{k}}$$

2. (b) Newton's Third Law states that the force the trailer exerts on the car is equal and opposite to the

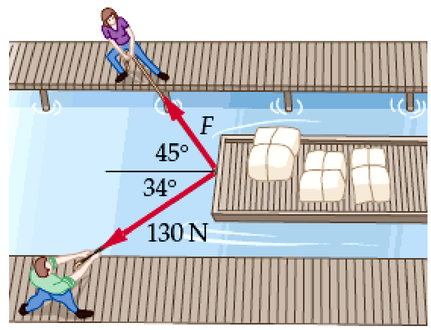
$$-\vec{\mathbf{F}}_1 = \boxed{(-1.0\ \text{kN})\hat{\mathbf{x}}}$$

force the car
exerts on the trailer:

3. (c) Write Newton's Second Law for the car: $\sum \vec{\mathbf{F}} = M\,\vec{\mathbf{a}} = (1400\text{ kg})(1.85\text{ m/s}^2)\hat{\mathbf{x}} = \boxed{(2.6\text{ kN}}$

Insight: The engine force $\vec{\mathbf{F}}_2$ must be $(3.6\text{ kN})\hat{\mathbf{x}}$ because it must both balance the 1.0-kN force from the trailer but also accelerate the car in the forward direction, requiring an additional 2.6 kN of force.

28. Picture the Problem: The two men pull on the barge in the directions indicated by the figure at right.



Strategy: Place the x-axis along the forward direction of the boat. Use the vector sum of the forces to find the force F such that the net force in the
y-direction is zero.

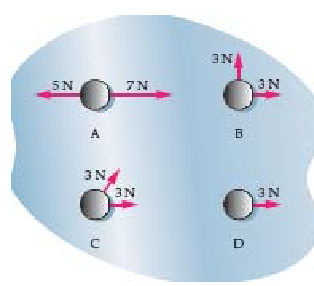
Solution: Set the sum of the forces in the y direction equal to zero:

$$\sum F_y = -(130\text{ N})\sin 34° + F\sin 45° =$$

$$F = (130\text{ N})\frac{\sin 34°}{\sin 45°} = 100\text{ N } = \boxed{0.10\text{ k}}$$

Insight: The second crewman doesn't have to pull as hard as the first because a larger component of his force is pulling in the y direction. However, his force in the forward direction (73 N) is not as large as the first crewman (110 N).

29. Picture the Problem: The displayed free body diagrams depict the forces exerted on identical hockey pucks.



Strategy: Add the forces as vectors to find the net force. The largest net force will produce the largest acceleration according to Newton's Second Law.

Solution: The net force for case A is $(7-5\text{ N}) = 2\text{ N}$. For case B its magnitude is $\sqrt{3^2+3^2\text{ N}^2} = 4.24\text{ N}$. For case C we must add the components:

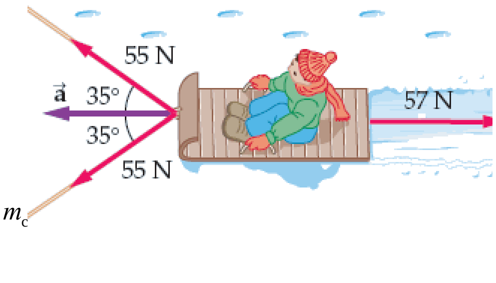
$C_x = 3\text{ N} + (3\text{ N})\cos 45° = 5.12\text{ N}$ $\quad C_y = (3\text{ N})\sin 45° = 2.12\text{ N}$

$C = \sqrt{5.12^2 + 2.12^2\text{ N}^2} = 5.54\text{ N}$

Finally, the net force in case D is 3 N. Therefore, the ranking of the accelerations, from smallest to greatest, is:
$\boxed{\text{A} < \text{D} < \text{B} < \text{C}}$.

Insight: The question could be answered without any calculation. First we note that the net force in case A is 2 N, which is less than the 3-N net force in case D. Second, both cases B and C have net forces larger than 3 N. Third, we note that the two 3-N forces in case C are more nearly in the same direction, as compared with the two 3-N forces in case B. It follows that the puck in case C has the larger acceleration.

30. Picture the Problem: The two teenagers pull on the sled in the directions indicated by the figure at right.



Strategy: Write Newton's Second Law in the x direction (parallel to $\vec{\mathbf{a}}$) in order to find the acceleration of the sled.

Solution: Write Newton's Second Law in the x direction:

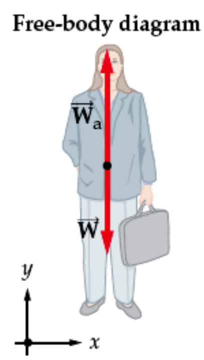
$$\sum F_x = 2F\cos 35° - 57\text{ N} = \left(m_{\text{sled}} + m_{\text{c}}\right.$$

$$a_x = \frac{2F\cos 35° - 57\text{ N}}{m_{\text{sled}} + m_{\text{child}}}$$

$$a_x = \frac{2(55\text{ N})\cos 35° - 57\text{ N}}{19 + 3.7\text{ kg}} = \boxed{1.5}$$

Insight: Some of the force exerted by the teenagers is exerted in the y direction and cancels out; only the x components of the forces move the sled.

41. Picture the Problem: The elevator accelerates up and down, changing your apparent weight W_a. A free body diagram of the situation is depicted at right.



Strategy: There are two forces acting on you: the applied force $\vec{\mathbf{F}} = \vec{\mathbf{W}}_a$ of the scale acting upward and the force of gravity $\vec{\mathbf{W}}$ acting downward. The force W_a represents your apparent weight because it is both the force the scale exerts on you and the force you exert on the scale. Use Newton's Second Law together with the known force W_a acceleration to determine the acceleration a.

Solution: 1. The direction of acceleration is $\boxed{\text{downward}}$. A downward acceleration results in an apparent weight less than the actual weight.

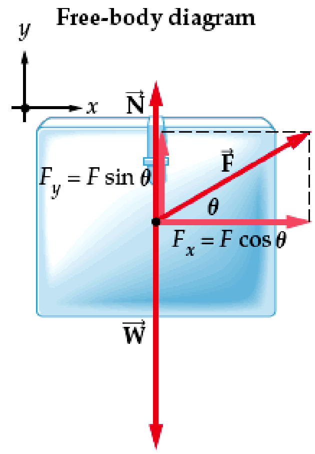
2. Use Newton's Second Law together with the known forces to determine the magnitude of the acceleration a.

$$\sum F_y = W_a - W = ma$$

$$|a| = \left|\frac{W_a - W}{m}\right| = \left|\frac{W_a - W}{W/g}\right| = \left|\frac{121 - 142\text{ lb}}{142\text{ lb}}\left(9.81\text{ m/s}^2\right)\right| = \boxed{1.5}$$

Insight: You feel the effects of apparent weight twice for each ride in an elevator, once as it accelerates from rest and again when it slows down and comes to rest.

44. Picture the Problem: The free body diagram of the suitcase is shown at right:



Strategy: Write Newton's Second Law in the vertical direction to determine the magnitude of the applied force *F*.

Solution: Use Newton's Second Law in the vertical direction to find *F*:

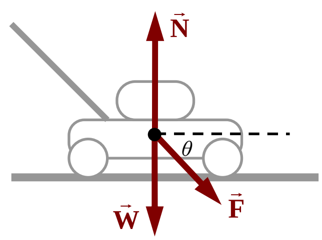
$$\sum F_y = N - W + F\sin\theta = 0$$

$$F = \frac{W - N}{\sin\theta} = \frac{(23\text{ kg})(9.81\text{ m/s}^2) - 18}{\sin 25°}$$

$$F = 110\text{ N} = \boxed{0.11\text{ kN}}$$

Insight: If the upward force applied by the handle were zero, the normal force *N* would equal the weight *W* of 230 N.

50. **Picture the Problem**: The free body diagram of the lawn mower is shown at right.



Strategy: Write Newton's Second Law in the vertical direction to determine the normal force.

Solution: 1. (a) Use Newton's Second Law to find *N*:

$$\sum F_y = N - F\sin\theta - mg = ma_y = 0$$

$$N = F\sin\theta + mg$$

$$= (219\text{ N})\sin 35° + (19\text{ kg})(9.81\text{ r}$$

$$N = 310\text{ N} = \boxed{0.31\text{ kN}}$$

2. (b) If the angle between the handle and the horizontal is increased, the normal force exerted by the lawn will increase because it must still balance the weight plus a larger downward force than before.

Insight: The vertical acceleration of the lawn mower will always remain zero because the ground prevents any vertical motion.