1. e (the total momentum is conserved, not the velocity; the best way to approach this is to recognize that we don't even know the *direction* the blocks will move. They will move toward the left after the collision if block B's momentum to the left is greater than block A's momentum toward the right; otherwise the blocks will move toward the right after the collision.)

2. a (since the masses are the same, we can at least recognize that the blocks will move toward the left after the collision; if they move at 5 m/s, then block A changes from 10 m/s right to 5 m/s left; that is the same, but opposite, change as block B's 20 m/s left to 5 m/s left)

3. d (the only way for the kinetic energy to be zero is if they are both stationary; momentum can be zero if they are both zero or if each momentum is equal in magnitude but opposite in direction)

4. a (The air rotates with the earth and, as it is pulled toward the center of the hurricane, it spins faster in the same direction to conserve angular momentum; this direction appears counter-clockwise in the northern hemisphere)

5. (a) Yes. The forces are equal and opposite due to Newton's third law and the times are the same, so $\vec{F}\Delta t$ exerted on one object must be equal and opposite to $\vec{F}\Delta t$ exerted on the other object. From Newton's second law, $\vec{F}\Delta t = \Delta\vec{p}$, this means that $\vec{p}$ of one object must be equal and opposite to $\vec{p}$ of the other (where $\vec{p}$ is the momentum $m\vec{v}$).

   (b) Kinetic energy may or may not be conserved. It is only conserved if the collision is elastic. If it is not elastic, energy goes into deforming the object but we never get that energy back into kinetic energy. Instead the energy goes into heat or some other kind of energy.

   (c) Yes, since the total amount of energy is always conserved. We just have to make sure we keep track of all the different types.

6. (a) Apply conservation of energy, since direction of motion is not needed and path is curved (which makes determining the normal force difficult). As the first block slides down the ramp, it gains kinetic energy (i.e., it speeds up). Since there is no loss of

energy from friction, the gain in kinetic energy must equal the loss in gravitational energy. The change in gravitational energy is $mg\Delta s_y$, which equals (0.040 kg)(9.8 N/kg)(−1.00 m) or −0.392 J. The negative means that gravitational energy was lost. In the process, kinetic energy increases by the amount that gravitational energy decreased. This means that the block gained 0.392 J of kinetic energy. Since it started at rest, the block's kinetic energy at the bottom must be 0.392 J (if it didn't start at rest, we'd have to add the initial kinetic energy to this).

Since $E_k = \frac{1}{2}mv^2$, one can solve for the block's speed to get 4.427 m/s.

(b) Momentum is conserved. In this case, the momentum before the collision is known. The first block is moving at 4.427 m/s. Multiply by its mass (0.040 kg) to get a momentum of 0.177 kg·m/s toward the right. The initial momentum of the second block is zero (since it is at rest prior to the collision). Thus, the total momentum prior to the collision is 0.177 kg·m/s toward the right. Since momentum is conserved, that must also be the total momentum just after the collision.

$$\begin{aligned} 0.177\ \text{kg}\cdot\text{m/s} &= m_1 v_{1,f} + m_2 v_{2,f} \\ &= (0.040\ \text{kg}) v_{1,f} + (0.070\ \text{kg}) v_{2,f} \end{aligned}$$

Without more information, we cannot tell how much momentum is associated with one block vs. the other. To get that, we use the knowledge that the collision is elastic. That means that after the collision block 2 must be moving 4.427 m/s faster than block 1 (since the difference in speed must equal the same as what it was before the collision)[i].

$$4.427\ \text{m/s} = v_{2,f} - v_{1,f}.$$

Rearranging the momentum equation to solve for $v_{1,f}$ (the variable we don't really need and thus want to get rid of), we get

$$v_{1,f} = \frac{0.177\ \text{kg}\cdot\text{m/s} - (0.070\ \text{kg}) v_{2,f}}{(0.040\ \text{kg})}$$

[i] This also means that the kinetic energy is conserved but using the definition of kinetic energy just makes for messy math.

and plugging that into the second equation, we get

$$\begin{aligned}
4.427 \text{ m/s} &= v_{2,f} - \frac{0.177 \text{ kg} \cdot \text{m/s} - (0.070 \text{ kg})v_{2,f}}{(0.040 \text{ kg})} \\
&= v_{2,f}\left[1 + \frac{0.070 \text{ kg}}{0.040 \text{ kg}}\right] - \left[\frac{0.177 \text{ kg} \cdot \text{m/s}}{0.040 \text{ kg}}\right] \\
&= 2.75v_{2,f} - 4.427 \text{ m/s}
\end{aligned}$$

which gives us a final speed of block 2 of 3.220 m/s.

Note: Since we know the relative velocity is 4.427 m/s, that means that block 1 (after the collision) must be moving back toward the left at (4.427 m/s − 3.220 m/s) or 1.207 m/s. However, we aren't asked for that.

(c) Since block 2 has a speed of 3.220 m/s, its kinetic energy is

$$\begin{aligned}
E_k &= \tfrac{1}{2}mv^2 \\
&= \tfrac{1}{2}(0.070 \text{ kg})(3.220 \text{ m/s})^2 \\
&= 0.363 \text{ J}
\end{aligned}$$

Note: If you calculate the kinetic energy of the first block after the collision, you'll find that the rest of the kinetic energy is associated with that block (since the collision is elastic).

(d) To get over the second ramp, the second block must have a kinetic energy greater than or equal to the change in gravitational energy as it rises over the second hill. The change in gravitational energy is $mg\Delta y$, which equals (0.070 kg)(9.8 N/kg)(−0.50 m) or −0.343 J. Consequently, block 2 needs to have a kinetic energy greater than or equal to 0.343 J immediately after the collision in order to make it over the second hill.

From part (c), we know that the second block initially has a kinetic energy equal to 0.363 J. Since this is greater than 0.343 J, it will make it over the hill.

7. (a) The student should throw the shoe away from shore. That requires that the student exerts a force directed away from shore on the shoe. Due to Newton's third law, the shoe would exert an opposite force on the student, pushing the student toward shore.

(b) From the definition of momentum, the shoe obtains a momentum of mv equal to (1 kg)(20 m/s), which is 20 kg m/s away from shore. Due to conservation of momentum, the student must gain an equal amount but in the opposite direction. That means the student's mv must equal 20 kg m/s toward shore. Divide by the mass of the student (60 kg) to get the velocity of the student (0.33 m/s toward shore).