Lesson 9 Worksheet

1. A sky diver falls at a constant speed in the spread-eagle position. After he opens his parachute, is the sky diver accelerating? If so, in which direction? Explain your answer using Newton's 1st and 3rd laws.

- Initially the sky diver is travelling at a constant velocity (no acceleration).
- When he opens his parachute, his velocity will no longer be constant, and he will begin to slow down. Thus, he will be accelerating upwards. Note however, that his velocity will still be downwards, it's just that now he's falling at a much slower velocity (otherwise he'd get splattered when he hits the ground!).

We can explain this problem using Newton's laws:
- The first law tells us that without a net force, he will travel at a constant velocity. However, once he opens the parachute, a net force is applied, and his velocity changes.
- The third law tells us that for every action there is an equal and opposite reaction. By opening the parachute, the parachute pushes downwards against the air, and the air pushes upwards against the parachute. Because the parachute is attached to the sky diver, the sky diver is pushed upwards as well.

2. Meredith is walking to school when she checks her cell phone for the time. She's late! Panicked because she has a physics test in her first block, she starts to run. Realizing that Newton's Second Law will be on the test, she decides to practice for the test by calculating in her head how much horizontal force her feet are exerting against the ground as she starts to run. She knows that her mass is 55kg and she guesses that she accelerates at $0.30 m/s^2$. How much horizontal force are her feet exerting against the ground as she starts to run?

$$F = ma = (55kg)(0.30m/s^2) = 16.5N$$

3. William, with a mass of 65.0 kg, is standing by the boards at the side of an ice skating rink. He pushes off the boards with a force of 9.0 N. What is his resulting acceleration?

$$F = ma$$

$$\frac{F}{m} = a$$

$$a = \frac{F}{m} = \frac{9.0N}{65kg} = 0.14m/s^2$$

4. William, being the sly dog that he is, decides to ask his girl friend Kate to do the same experiment so he can determine her mass. He notes that Kate pushes off the boards with a force of 8.0N and accelerates at a rate of $0.15m/s^2$. What is Kate's mass?

$$F = ma$$

$$\frac{F}{a} = m$$

$$m = \frac{F}{a} = \frac{8.0N}{0.15m/s^2} = 53kg$$

5. A basket ball is dropped exactly vertically (no horizontal motion) from a height of 1.00m and bounces back up to 0.80m above the ground. Using Newton's 3rd Law, explain what happens when the ball hits the ground.

Also, any ideas as to why the ball doesn't bounce back up to the same height as it was dropped? Note that we haven't studied this yet in the course, so don't worry if you're not sure. It won't be on the test.

- The third law tells us that for every action there is an equal and opposite reaction. When the basket ball hits the ground, it applies a force into the ground. Of course, this means that the ground applies an equal but opposite force on the basket ball, sending it back into the air.

- Why doesn't the ball bounce back to its initial height? There are a number of reasons, and this question actually requires a pretty complicated explanation. To keep it simple though, energy is lost due the sound the ball makes when it hits the ground, a small amount of heat is generated due to friction when the ball and the ground collide, and some energy is used during the bending/deformation of the ball as it hits the ground and bounces back up. Note that if the basketball was under-inflated, it wouldn't bounce very high. Similarly, if it was bounced against a carpeted floor, it wouldn't bounce very high either. The air pressure inside the ball and the material the ball is bouncing against play a big role.