**UNIT 5**
**APPLICATIONS OF NEWTON'S LAWS**

## Objectives

- To understand the concept of kinetic friction
- To be able to apply Newton's Laws to work problems

Watch the following video clip from the American Red Cross.

Equipment:

1 piece of cloth
Motion Detector
LoggerPro software
LabPro computer interface
1 spring
1 meterstick
1 bathroom scale

**5.1** A person sitting on a piece of cloth is being pulled across the floor with a constant force. The force is not parallel to the floor; it is at some angle θ above the horizontal.

**a.** Consider the person and cloth to be one object. Draw a force diagram for the person-cloth.

Apply Newton's Second Law to the horizontal and vertical components of forces.

**b.** Use a very stiff spring (obtain a spring from an instructor) to pull a person on a piece of cloth with constant force, as described above. A force of 58.8N stretches the spring 2cm. Use a motion detector to measure the acceleration horizontal to the floor (in the x-direction). Measure the angle at which the force is applied and the distance the spring is stretched while you are pulling the person. You will also have to measure the mass of the person. Apply Newton's Second Law in the x-direction to determine the magnitude of the frictional force.

**c.** What is the acceleration in the y-direction? Apply Newton's Second Law in the y-direction to determine the magnitude of the normal force.

**d.** When an object is moving, the frictional force is called the force of *kinetic* friction. This is different from the frictional force when the object is at rest. The magnitude of the force of kinetic friction is found to be proportional to the magnitude of the normal force. The constant of proportionality is called the *coefficient of kinetic friction*. This can be written as

$$F_{kinetic} = \mu_k F_N$$

Find the coefficient of kinetic friction for the person sitting on the cloth.

**5.2** The bathroom scale in the lab measures the force of the object on the scale.

**a.** Take the bathroom scale into the elevator and stand on it. Ride the elevator up to the third floor and back down. Watch the scale.

**b.** Draw a force diagram for the person on the scale.

**c.** Consider three cases:

(i) the acceleration of the person is upwards and the person is moving upwards
(ii) the acceleration of the person is downwards, but the person is moving upwards
(iii) the acceleration is zero

Is the net force on the person zero in any of the three cases? Explain.

**d.** In the case where the net force on the person is zero, use Newton's second law to compare the force of the scale upward on the person to the person's weight.

What is the Newton's third law pair force for the force of the scale upward on the person?

Remember, the scale reads the force of the person on the scale.

**e.** In cases (i) and (ii) in part **c**, is the net force on the person zero? Which force, of the two forces acting on the person, changes depending on the acceleration? The scale reads the changing force. Explain.

**f.** Use Newton's second law to determine the acceleration of the elevator in each of the three cases in part **c**? Show your work.

Discuss your answers with an instructor.

**5.3** Consider a person walking across the floor.

**a.** Draw a force diagram for the person, while they are walking. What force is pushing horizontally on the person? Draw a force diagram for the floor.

**5.4** Work the following problem:

Two students of different masses sit on kinesthetic carts. They push off from one another. Shortly after the push, both of their velocities are measured at the same time. One cart plus student has a mass of 60kg and a velocity after the push of 1.2m/s. The other cart has a velocity of 0.8m/s. Determine the mass of the other student-cart.

**a.** Work the problem in symbols. Do not use any numbers.

**b.** Put the numbers in.

## SUMMARY

You should understand the concept of kinetic friction. You should understand and be able to apply Newton's Laws to work problems.