THE MAGNITUDE OF A TORQUE

Imagine a cat trying to leave a house by pushing perpendicularly on a cat-flap door. **Figure 15** shows a cat-flap door hinged at the top. In this configuration, the door is free to rotate around a line that passes through the hinge. This is the door's *axis of rotation*. When the cat pushes at the bottom edge of the door with a force that is perpendicular to the door, the door opens. The ability of a force to rotate an object around some axis is measured by a quantity called **torque.**

torque

a quantity that measures the ability of a force to rotate an object around some axis

Torque depends on the force and the lever arm

If a cat pushed on the door with the same force but at a point closer to the hinge, the door would be more difficult to rotate. How easily an object rotates depends not only on how much force is applied but also on where the force is applied. The farther the force is from the axis of rotation, the easier it is to rotate the object and the more torque is produced. The perpendicular distance from the axis of rotation to a line drawn along the direction of the force is called the **lever arm.**

lever arm

the perpendicular distance from the axis of rotation to a line drawn along the direction of the force

Figure 16 shows a diagram of the force **F** applied by the pet perpendicular to the cat-flap door. If you examine the definition of *lever arm,* you will see that in this case the lever arm is the distance *d* shown in the figure, the distance from the pet's nose to the hinge. That is, *d* is the perpendicular distance from the axis of rotation to the line along which the applied force acts. If the pet pressed on the door at a higher point, the lever arm would be shorter. As a result, the cat would need to exert a greater force to apply the same torque.

Figure 15
The cat-flap door rotates on a hinge, allowing pets to enter and leave a house at will.

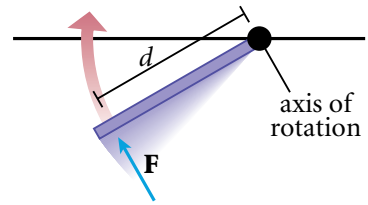

Figure 16
A force applied to an extended object can produce a torque. This torque, in turn, causes the object to rotate.

Quick Lab

Changing the Lever Arm

MATERIALS LIST

- door
- masking tape

In this activity, you will explore how the amount of force required to open a door changes when the lever arm changes. Using only perpendicular forces, open a door several times by applying a force at different distances from the hinge. You may have to tape the latch so that the door will open when you push without turning the knob. Because the angle of the applied force is kept constant, decreasing the distance to the hinge decreases the lever arm. Compare the relative effort required to open the door when pushing near the edge to that required when pushing near the hinged side of the door. Summarize your findings in terms of torque and the lever arm.