**Topic**

Dynamics

**Learning objectives**

1. To explain and understand phenomena when there is no net force acting on a stationary object, or on an object that is moving in a straight line using modelling technique [diagrammatic models, mathematical models (dynamics equations), or any set of predictive and explanatory rules/principles].
2. To predict changes in motion (if any) of an object based on the forces acting on it using modelling technique [diagrammatic models, mathematical models (dynamics equations), or any set of predictive and explanatory rules/principles].

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| *Note:*   * Ignore air resistance in all cases. |

### Activity 1

**HYPOTHESIZE**

1. Place a cardboard on top of a container. Put a coin on top of the cardboard. Flick the edge of the cardboard with your finger. What would happen to the coin? Explain your answer.
2. Place a strip of tape on the floor. Have your friend to back up about 30 meters behind the tape. Instruct him or her to run toward the tape as fast as possible and to stop exactly on the tape. Position yourself beside the tape and observe your friend. What would happen to your friend when he or she tries to stop? Explain your answer.

### Activity 2

**MODEL**

1. Tom has just been promoted and is pushing a file cabinet down the hall to his new office. He begins by looking at the file cabinet and considers how to best go about his task (Figure 1). He then begins pushing on the file cabinet, which, at first, does not move at all (Figure 2). He pushes it slightly harder, and it is on the verge of sliding (Figure 3). Eventually the file cabinet begins to slide across the floor, slowly moving towards his new office with some acceleration (Figure 4).
   1. Draw and label all the horizontal forces (if any) you think are **acting on the file cabinet** in each figure.

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| **Figure 1.** Tom is not pushing the file cabinet. |

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| **Figure 2.** Tom is pushing the file cabinet, but it is not moving. |

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| **Figure 3.** Tom is pushing the file cabinet, and it is on the verge of sliding. |

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| **Figure 4.** Tom is pushing the file cabinet, and it is moving to the right with some acceleration. |

**ANALYSE**

* 1. Why do you think the file cabinet moves in Figure 4 but not in Figure 1, 2, or 3?

### Activity 3

**INVESTIGATE**

Go to the PhET website <http://phet.colorado.edu/en/simulation/legacy/forces-and-motion>

Explore the simulation.

1. In the upper right hand box is what we call a **free body diagram**. Play with the page until you create a situation where there are four different coloured arrows in the diagram.
2. Now select “Ice (no friction)” on the page and apply some forces to the various objects. Make observations.
3. Apply a momentary force to an object. Make observations and record them below. Select the various graphs to aid you in a complete description of the object’s motion.
4. Describe what you have to do to stop the object.
5. If an object is given a push, and then the force is removed, describe the motion of the object. Be sure to discuss the object’s velocity and acceleration.
6. Create the following set up:
   * File cabinet
   * Graphs of Applied Force and Acceleration
   * Ice (no friction)
   * Applied Forces

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| **Force Applied (kg m/s2)** | **Measured Acceleration (m/s2)** | **Ratio of Force to Acceleration** |
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1. Is the ratio of the force to the acceleration constant? If so, what does this tell you about the relationship between force and acceleration?
2. Based on your observations and your data, create an equation that relates mass, force and motion. Test your equation with the simulation to verify your solution and show evidence of your tests.

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| **NOTE**  When objects slide past each other in contact, ***friction*** usually plays a part. There are two types of friction; ***Static***, which exists between objects BEFORE the objects start moving and ***kinetic*** which exists between objects that ARE MOVING. |

1. Now turn Friction on (select Wood) and play around some more.
2. Apply various size forces to the refrigerator with friction on. Explain why it does not move when the applied forces are small. Connect this to real life situations.

**HYPOTHESIZE**

1. Predict what will happen to the object’s motion when the net force iszero.
2. If you apply the same force to objects of different masses, predict what will happen to the objects’ motion?

**MODEL**

1. What do you have to do to get the file cabinet and the textbook to accelerate at the same rate? Draw a free-body diagram to support your explanation.
2. Create the following set up:

* Select file cabinet
* Set friction - Wood

Use the simulation to create Tom’s 4 scenarios from Activity 2 and answer the following questions.

1. Withoutmovement, the applied force and frictional force are \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Record your observation on the motion of the file cabinet when it starts to move with a constant applied force. Explain your answer in drawing and words.
3. What is the relationship between the applied force and frictional force when the file cabinet moves at a constant speed?

1. Compare your force drawings in 1 (a) (p. 3) to the free body diagram window for each figure and adjust your sketches with a new colour if necessary.

1. Look at your reasoning in 1 (b) (p. 4). Have your thoughts changed after you run the simulation? Explain your answer in drawing and words.

**Activity 4**

**EVALUATE**

1. A box is sliding on the floor. If there is a net force acting on the box in the same direction as it is sliding, the box would
2. speed up
3. slow down
4. remain at the same speed
5. remain at the same speed, but change direction
6. slow down, change direction, and then speed up going to the other way

Explain your answer in drawing and words.

1. A book is moving to the left. If there is net force acting to the right, the book would
2. speed up
3. slow down
4. remain at the same speed
5. remain at the same speed, but change direction
6. slow down, change direction, and then speed up going to the other way

Explain your answer in drawing and words.

1. A crate is moving to the right. If there is no net force acting on it, the crate would
2. speed up
3. slow down
4. remain at the same speed
5. remain at the same speed, but change direction
6. slow down, change direction, and then speed up going to the other way

Explain your answer in drawing and words.

1. Write a final summary of how you can predict, with the help of free body diagrams, what effects an external force will have on the speed and direction of an object’s motion.

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