## Unit 2: Force and Motion

8.P.2 The student will demonstrate and understanding of the effects of forces on the motion and stability of an object.

<table>
<thead>
<tr>
<th>Concept 1:</th>
<th>Concept 2:</th>
<th>Concept 3:</th>
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<tbody>
<tr>
<td><strong>Effects of Varying Force and Mass</strong></td>
<td><strong>Gravity and Friction</strong></td>
<td><strong>Newton’s First and Third Laws of Motion</strong></td>
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<tr>
<td><strong>Objectives:</strong> Explain how varying the amount of force or mass of an object affects the motion, shape or orientation of the object.</td>
<td><strong>Objectives:</strong> Describe and predict the effects of forces (gravity and friction) on the speed and direction of an object.</td>
<td><strong>Objectives:</strong> Explain the relationship between mass and inertia.</td>
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<tr>
<td><strong>Vocabulary:</strong> Speed, Force, Mass, Orientation</td>
<td><strong>Vocabulary:</strong> Gravity, Friction, Terminal Velocity</td>
<td><strong>Vocabulary:</strong> Inertia, Net Force, Action Force, Reaction Force</td>
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<td>Motion occurs when there is a change in position of an object with respect to a reference point. The final position of an object is determined by measuring the change in position and direction of the segments along a trip. While the speed of the object may vary during the total time it is moving, the average speed is the result of the total distance divided by the total time taken. Forces acting on an object can be balanced or unbalanced. Varying the amount of force or mass will affect the motion of an object. Inertia is the tendency of objects to resist any change in motion.</td>
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<tr>
<td>Concept 4: Newton’s Second Law of Motion</td>
<td>Concept 5: Average Speed and Time-Distance Graphs</td>
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<td><strong>Objectives:</strong></td>
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<tr>
<td>Compare and predict effects of balanced and unbalanced forces on an object’s motion.</td>
<td>Generate graphs that represent the motion of an object’s position and speed as a function of time.</td>
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<td>Use the formula ( F=ma ) to calculate force, mass or acceleration of an object.</td>
<td>Use the formula ( V=\frac{d}{t} ) to calculate speed, distance or time.</td>
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<tr>
<td><strong>Vocabulary:</strong></td>
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<tr>
<td>Balanced Force</td>
<td>Reference Point</td>
<td></td>
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<tr>
<td>Unbalanced Force</td>
<td>Position</td>
<td></td>
</tr>
<tr>
<td>Acceleration</td>
<td>Direction</td>
<td></td>
</tr>
<tr>
<td>Magnitude</td>
<td>Displacement</td>
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<tr>
<td>Newtons</td>
<td>Slope</td>
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<td><strong>Conceptual Understanding:</strong></td>
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Concept 1: Effects of Varying Force and Mass

Speed:

Force:
Mass:
Concept 2: Effects of Gravity and Friction

Gravity:

Friction:

Friction Force is affected by the smoothness of the surfaces
Concept 3: Newton’s 1\textsuperscript{st} and 3\textsuperscript{rd} Laws

Newton’s 1\textsuperscript{st} Law of Motion

Inertia:
Newton’s 3rd Law of Motion:

Practice:

A: Head bumps ball
R: ________________

A: Windshield hits bug
R: ________________

A: Hand pulls on flower
R: ________________

A: Athlete pushes bar upward
R: ________________

A: Bat hits ball
R: ________________

A: Hand touches nose
R: ________________
Newton’s Third Law Worksheet

1. State the reaction force for each of the following forces:
   a) the southward force of a field goal kicker’s toe on a football
   b) the backward force of a jogger’s shoe on the ground
   c) the downward force of a book on a desk
   d) the backward force of a jet’s engines on its exhaust gases
   e) the backward pull of a swimmer’s hands on the water in the butterfly stroke

2. A beginning physics student, confused by a seeming contradiction in Newton’s laws, asks her teacher the following question: “If, for every force there is an equal and opposite reaction force, than all forces in nature come in equal and opposite pairs, and are therefore balanced. Thus, since there can never be such a thing as an unbalanced force, how can any object ever accelerate?” Explain the fault in this common misconception.

3. A fireman at the scene of a fire is holding a heavy hose out of which water is gushing. To keep his balance, he often has to lean. Which way does he lean, forward or backward, and why?

4. A squirrel with an armful of nuts is sliding helplessly across a flat, icy roof, getting dangerously close to the edge. He understands Newton’s Third Law, and is able to save himself. Explain how he does it.

5. A clown on roller skates holds a bazooka. Explain what will happen to him (and why) when he fires the bazooka.

6. Two girls, one of mass 40 kg and the other of mass 60 kg, are standing side by side in the middle of a frozen pond. One pushes the other with a force of 360 N for 0.10 s. The ice is essentially frictionless. Which girl will move farther and why?

7. Think wayyyyyyyyy outside the box here. If all the people in the entire world started walking simultaneously in the same direction, what would theoretically happen (according to Newton’s 3rd law) to the earth’s rotation? Should we be concerned about such an organized march???? Why or why not.
Concept 4: Newton’s 2\textsuperscript{nd} Law of Motion

Magnitude:

Balanced Forces:
Unbalanced Forces:

Acceleration:

\[ F = MA \]
Practice:

Net Force = 

Net Force = \( a = \) \( a = \) 

\( 9 \text{ kg} \) \( a = 3 \text{ m/s}^2 \)

\( 5 \text{ kg} \) \( a = 40 \text{ m/s}^2 \)

\( F = \) \( F = \) 

\( ? \text{ Kg} \) \( a = 4 \text{ m/s}^2 \) \( 48 \text{ N} \)

\( ? \text{ Kg} \) \( a = 6 \text{ m/s}^2 \) \( 1200 \text{ N} \)

\( m = \) \( m = \)
1. What is force?

2. In what unit do we measure force?

3. Analyze each vector diagram and fill in the diagram below.

<table>
<thead>
<tr>
<th>Vector Diagram</th>
<th>Total Force</th>
<th>Resultant Force</th>
<th>Motion Direction</th>
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</thead>
<tbody>
<tr>
<td>5 N →</td>
<td>6 N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 N ←</td>
<td>5 N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 N →</td>
<td>7 N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 N →</td>
<td>3 N</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 N →</td>
<td>7 N</td>
<td></td>
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4. Describe the motion of an object that has balanced forces acting on it.

5. Describe the motion of an object that has unbalanced forces acting on it.

6. What are the unbalanced forces that cause a moving object to slow and stop?

7. Draw an arrow showing which direction will each box move?
Newton’s Second Law Worksheet

For each problem draw a well-labeled force diagram and show all general equations in your solution.

1. A 2.00 kg cart on a frictionless track is pulled by force of 3.00 N. What is the acceleration of the cart?

2. A 3.00 kg cart on a frictionless track is pulled by a string so that it accelerates at 2.00 m/s/s. What is the tension in the string?

3. A 20 N unbalanced force causes an object to accelerate at 1.5 m/s2. What is the mass of the object?

4. An unbalanced force of 500 N is applied to a 75 kg object. What is the acceleration of the object?

5. A 0.500 kg model rocket is initially pushed upwards by a thrust force of 15 N. If the force of air resistance is 1.00 N, what is the initial acceleration of the rocket?

6. A 70.0 kg skydiver falls towards the earth. If the force due to air resistance is 0 N, what is the acceleration of the skydiver?

7. The skydiver in problem 6 opens her chute. The force due to air resistance is now 1200 N. What is the acceleration of the skydiver?
Think About It:
In this activity, you will build a car and move it down a “track” of straws using an air pump. If you increase the mass of the car, how will it impact its acceleration? How will it affect the distance the car traveled?

Procedure
1. Practice safety. Wear your goggles, and stay alert.
2. Construct the car using the provided template.
3. Cut 15 straws in half to make 30 shorter straw pieces.
4. Place a meter stick on a smooth floor or tabletop. Put one straw next to the 0-centimeter mark of the meter stick. Place the second straw parallel to the first at the 2-centimeter mark. Continue placing all the other straws 2 centimeters apart. Be sure the straws are not touching the meter stick. The straws should be parallel to each other like the wooden ties of railroad tracks.
5. Set the car on the straws with the back of the car even with the 0-centimeter straw.
6. Carefully place an empty cup on top of the shaded circle inside the box of the car. Measure the mass of the car and empty cup. Record the mass on your Student Data Sheet.
7. Aim the nozzle of the balloon pump straight at the target on the back of the car. Shoot a blast of air at the car and observe what happens. Reset the straws and car and propel it again several times until the car always moves the same distance every time.
8. Begin the experiment by resetting the straws and car. Propel the car with the balloon pump and measure how far the car traveled. Record the distance on the data sheet. Record data for four trials and record the average distance the car traveled.
9. Reset the straws and car but place five pennies into the cup. Propel the car and measure how far it goes with the extra mass. Record your data.
10. Repeat experiment two more times with 10 and then 15 pennies.
11. Record and graph your data for each test on your Student Data Sheet.
**Group Members:**

**Analyze results**

1. Explain the effect mass has on distance traveled. Does your data support Newton’s Second Law of Motion?

2. Were your initial predictions in “Think About It” correct? Why or why not?

**Extension Questions**

1. What adaptations could be made to the car to improve upon its design?

   - Design and implement an adaptation using additional materials provided by your instructor.
   - Rerun your procedures using your new design. What differences did the new design have on your results?

2. How does Newton’s Second Law of Motion affect astronauts aboard the International Space Station?
Concept 5: Average Speed and Distance Time Graphs

Reference Point:

Position:

Displacement:

Direction:

Practice:

Example:
A man moves from point A to point B then to point C and finally to point D as shown in the opposite diagram. Find the distance and displacement travelled by the man.
Distance Time Graphs:

Slope:
Practice:

Match each scenario to the graph:

Tom went out for a walk with some friends. He suddenly realized he had left his wallet behind. He ran home to get it and then had to run to catch up with the others.

Opposite Tom’s home is a hill. Tom climbed slowly up the hill, walked across the top, and then ran quickly down the other side.

Tom ran from his home to the bus stop and waited. He realized that he had missed the bus so he walked home.

Average Speed:
Practice:

1. Calculate the speed for a car that went a distance of 125 kilometers in 2 hours time.

2. If Steve throws the football 50 meters in 3 seconds, what is the average speed (velocity) of the football?

3. Sarah backstrokes at an average speed of 8 meters per second, how long will it take her to complete the race of 200 meters length?

4. Mike rides his motorcycle at an average speed (velocity) of 20 meters/second for 500 seconds, how far did he ride?
DISTANCE AND DISPLACEMENT PROBLEMS

Find the distance and displacement for the following problems:

1. Jamison rides on a stationary bike for 1 hour then gets off.

2. Cassidee walks 3 mile north then turns west and walks 1 miles.

3. Taja walks two miles north from her door to the park, then returns home to her door.

4. Sandy ran 8 blocks north, and then 2 blocks south back toward her starting point.

5. Neva swam 3 complete laps in a 50 meter pool. (1 lap is one length of the pool)

6. John flies directly east for 20 km, then turns to the north and flies for another 10 km before dodging a flock of geese.

7. Cameron flies directly west for 13 km, then turns to the south and flies for another 30 km. He then flies east for 13 km before landing at the airport.

8. Marissa runs north for 37 meters, then turns east and runs for another 10 meters, then stops.

9. Alex walks east for 3 km, stops for a break, and then runs the same direction for 4 km before he stops.

10. Taylor rides her bicycle 20 km north, turns around, and then rides the bicycle 15 km back toward her starting point.
YOU MUST SHOW YOUR WORK. You can use a calculator but you must show all of the steps involved in doing the problem.

1. If a car travels 400m in 20 seconds how fast is it going?

2. If you move 50 meters in 10 seconds, what is your speed?

3. You arrive in my class 45 seconds after leaving math which is 90 meters away. How fast did you travel?

4. A plane travels 395,000 meters in 9000 seconds. What was its speed?

5. It takes Serina 0.25 hours to drive to school. Her route is 16 km long. What is Serina’s average speed on her drive to school?

6. How much time will it take for a bug to travel 5 meters across the floor if it is traveling at 1 m/s?

7. You need to get to class, 200 meters away, and you can only walk in the hallways at about 1.5 m/s. (if you run any faster, you’ll be caught for running). How much time will it take to get to your class?

8. In a competition, an athlete threw a flying disk 139 meters through the air. While in flight, the disk traveled at an average speed of 13.0 m/s. How long did the disk remain in the air?

9. How far can you get away from your little brother with the squirt gun filled with paint if you can travel at 3 m/s and you have 15s before he sees you?

10. How far can your little brother get if he can travel at 2.5 m/s and in 5 seconds you will discover that his squirt gun has run out of paint?

11. If you shout into the Grand Canyon, your voice travels at the speed of sound (340 m/s) to the bottom of the canyon and back, and you hear an echo. How deep is the Grand Canyon at a spot where you can hear your echo 5.2 seconds after you shout?

CHALLENGE PROBLEM

Bill and Amy want to ride their bikes from their neighborhood to school which is 14.4 kilometers away. It takes Amy 40 minutes to arrive at school. Bill arrives 20 minutes after Amy. How much faster (in meters/second) is Amy’s average speed for the entire trip?

***Be sure to show all necessary metric conversions!!!