4.1 What Is Net Force?

1) **Net force with horizontal motion:** Your instructor will demonstrate two carts with attached fans moving on tracks. Both carts start from rest and accelerate due to the applied force from the fan.

   a) Does the first cart accelerate all the way along the track to the end of the track?

   b) The box in the diagram represents a fan cart.

   Draw an arrow on the diagram to indicate the direction of the force of friction opposing the force of the fan. The arrow length indicates the amount of force.

   Is the force of friction larger, smaller, or the same as the force of the fan?

   c) Is the acceleration of the second cart greater, less, or the same as acceleration of the first cart?  

   Why?

   d) Draw an arrow on the diagram to indicate the direction and amount of the force of friction opposing the force of the fan.

   e) Considering the motion of the cart along the entire length of the track, is the force \( F \) in \( F = M \cdot a \) equal to the force of the fan, the force of friction, or the combination of these forces (the net force)?  

   f) Group Discussion Question: A car travels on a level, straight road with its cruise control set at 65 miles per hour. What horizontal forces act on this car? What is the net force acting on it?
4.2 What Forces Act on a Falling Object?

2) Net force with vertical motion: Your instructor will demonstrate the net force on falling objects.

Crumple a sheet of paper into a tight ball. Slightly crumple just the edges of a second sheet of paper. Drop both sheets from the same height and observe the rates of their fall.

a) On the diagrams, arrows show the force of gravity acting down equally on each sheet of paper.

What other force acts on each sheet of paper as it falls? ________________________________

b) Draw arrows on each diagram to show the direction and relative size of this force.

c) On which sheet of paper is the net force larger? ________________________________

3) Net force on a parachute:

A parachute is designed so that once the chute opens, the force of air resistance is equal to the force of gravity.

a) If the parachute reaches a constant velocity, what is the net force on the parachutist? ____________

b) From \( F = M a \), what can you conclude about the acceleration of the parachutist?

c) Group Discussion Question: What is the advantage to a parachutist of falling toward the earth at a constant velocity?
4.3 Frictional Force - What Determines the Amount and Type of Friction?

4) Types of friction: static and sliding. Your instructor will demonstrate a toy truck pulling a wooden block with a spring scale attached.
   a) How much force does the scale measure just before the block starts to move? __________
   b) How much force does the scale measure while the block is moving? __________
   c) Which of the two types of friction is greater? __________________________

5) How does force affect friction?
   a) Attach the spring scale to the screw eye on the front of the wooden cart. Drag the cart upside down at a constant velocity across the smooth board. How much force is required to move the cart at a constant velocity? ______________
   b) Place a 1 kg mass on the cart and again drag the cart upside down at a constant velocity across the smooth board. How much force is required to move the cart with the 1 kg mass at a constant velocity? ______________
   c) Explain how the amount of force pressing the cart against the board affects the amount of friction between the cart and the board.

6) How does surface smoothness affect friction? Compare the amount of friction between a wooden cart and the surfaces it slides across by calculating the coefficient of friction between the cart and the surfaces.
   a) Find the weight in newtons of the wooden cart by suspending it from the blue spring scale. ______________
   b) How much force is required to move the cart at a constant velocity across the smooth board? ______________
   c) Calculate the coefficient of friction between the cart and the smooth board by forming the ratio of the force required to drag the cart divided by the weight of the cart.
d) Drag the cart upside down at a constant velocity across the rough board. How much force is required to move the cart at a constant velocity? ______

e) Calculate the coefficient of friction between the cart and the rough surface.

f) In which case is the coefficient of friction greater? Explain how the amount of friction is related to surface smoothness.

7) **What factors determine the friction between surfaces?**

a) Your instructor will demonstrate the force of friction when a wooden block is pulled across two equally smooth surfaces made of different materials. Is there greater friction with a rubber or a vinyl surface? ________________________

b) List three factors that determine the amount of friction between surfaces.
   1)
   2)
   3)

c) Is friction always undesirable? _________ Your instructor will demonstrate two toy cars moving up an incline. Explain the differences in the motion of the cars as they go up the incline.
Period 4 Exercises: Forces

Write answers to the questions below. Show your mathematical steps and the units of the quantities. This sheet with your answers should be turned in at the beginning of Period 5.

1. Understanding net force:
   Do the vehicles described below experience a net force?
   a) a bicyclist rides up a hill at a constant speed
   b) a race car goes around a circular track at a constant speed
   c) a roller coaster car rolls down a steep track

2. Calculating frictional force:
   A box is at rest on a rough surface. When you push the box with a constant force of 8 newtons, the velocity of the box increases by 2 meters/sec each second.
   a) Draw arrows on the box to show the horizontal forces acting on it. Label these forces.
   b) The mass of the box is 3 kilograms. How large is the net force on the box when the box is moving?
   c) What is the frictional force between the box and the rough surface?
   d) The weight of the box is 29 newtons. What is the coefficient of friction between the box and the surface?