1. Suppose you are shown some data for a puck sliding down an incline, as follows:

<table>
<thead>
<tr>
<th>Time, s</th>
<th>Velocity, cm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>-5.5</td>
</tr>
<tr>
<td>0.2</td>
<td>-4.1</td>
</tr>
<tr>
<td>0.4</td>
<td>-3</td>
</tr>
<tr>
<td>0.6</td>
<td>-1.6</td>
</tr>
<tr>
<td>0.8</td>
<td>-0.2</td>
</tr>
<tr>
<td>1</td>
<td>1.1</td>
</tr>
<tr>
<td>1.2</td>
<td>2.3</td>
</tr>
<tr>
<td>1.4</td>
<td>3.7</td>
</tr>
<tr>
<td>1.6</td>
<td>4.8</td>
</tr>
</tbody>
</table>

- Plot the data on graph paper, carefully and accurately. (Or you can use a spreadsheet. But if so, include grid lines.)
- Draw a “best” straight line through the points. Note that the points do not fall on a perfectly straight line, so you will have to use some judgement here. Calculate the slope of the line, making it clear how you did it. (Note that you cannot use any of the data in the table for calculating the slope of the line, because that does not make sense: if you use two points from the table, why did you plot all those other points?) **Be sure to indicate the units of the slope.**
- What does the slope represent?
- If the puck has a mass of 0.12 kg, what was the net force on the puck? (Careful: you have to use SI units.)

**Answers:**

- You should find that the slope is pretty close to 6.5 cm/s².
- The slope represents the acceleration of the puck.
- In SI units, \( a = 0.065 \text{ m/s}^2 \). We use Newton’s second law:

\[
F_{\text{NET}} = ma = (0.12 \text{ kg})(0.065 \text{ m/s}^2) = 0.0078 \text{ N}
\]
2. Suppose an airplane has an air speed of 120 mph. It makes a round trip to a point 150 miles distant from the airport. One the way there, it had a tailwind of 30 mph, so the airplane’s speed with respect to the ground was 150 mph. On the return trip, the wind was against it, so the airplane’s ground speed was 90 mph. (Note: mph = “miles per hour”).

Question: what was the airplane’s average speed for the round trip? What was the airplane’s average velocity for the round-trip? (Remember: velocity = (change in position)/(change in time). This will seem like a “trick” question.)

We must figure out the total time and divide that into total distance, without regard to direction. (We pretend that the airplane has an odometer like a car.) The time for the first “leg” of the trip is

\[ t = \frac{x}{v} = \frac{150 \text{ mi}}{150 \text{ mi/h}} = 1.0 \text{ h} \]

The second leg takes

\[ t = \frac{150 \text{ mi}}{90 \text{ mi/h}} = 1.67 \text{ h} \]

The total time is 2.67 hours. The total distance is 300 miles, so the average speed is

\[ t = \frac{300 \text{ mi}}{2.67 \text{ h}} = \left[ 113 \text{ mi/h} \right] \]

Now, what is the displacement, or change in position, for the entire trip? Since the airplane returned to its original position, the displacement is zero. Therefore the average velocity is zero.
3. Suppose a 80-kg bike rider is traveling at 8.0 m/s, and then he stops pedalling. After a time of 3.0 seconds, his speed is 3.0 m/s. (A) Draw a free-body diagram of the cyclist while he is not pedalling. (B) Find the acceleration during the time described. (C) Find the force of friction on the bicyclist. (Hint: in this case, friction is the only horizontal force, so it is the “net force.”)

(A) We usually do not try to be “artistic”: just draw the object of interest as an oval or square:

(B) By definition of acceleration:

\[
a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{t_f - t_i}
\]

\[
= \frac{3.0 \text{ m/s} - 8.0 \text{ m/s}}{3.0 \text{ s}}
\]

\[
= -1.67 \text{ m/s}^2 \text{ or } -1.7 \text{ m/s}^2
\]

(C) We use Newton’s second law:

\[
F_{NET} = ma = (80 \text{ kg})(-1.67 \text{ m/s}^2) = 130 \text{ N}
\]
4. Suppose you are on a bicycle coasting down a hill. What are the two forces on you which are directed parallel to the hill? (One force is directed up the hill, and the other is down the hill.) Explain using a force diagram. What will determine whether you are speeding up or slowing down?

The two forces are (1) friction, directed opposite to the velocity, and (2) the component of weight \((mg)\) which is pointing along the incline (and always down the incline.) If you are coasting down the hill the frictional force is pointing up the hill.

The heavy arrows shown are the actual forces. We may break up the weight into two components: one along the hill, and the other opposite the normal force. These are shown by dashed lines. They are NOT separate from the weight, hence the dashed lines. But we could erase the arrow representing the weight and replace it by the two components.

The sum of forces perpendicular to the hill is zero: the bike is not accelerating off the hill. The net force will be the vector sum of friction and the downhill weight component. If the downhill weight component is larger than friction, the bike will accelerate down the hill. If the friction is greater than the downhill part of the weight, then the net force is uphill, and the bike will accelerate up the hill. But that does not mean the bike moves up the hill! The bike’s velocity it down the hill, so “accelerating up the hill” just means slowing down: this is adding velocity in the uphill direction.
5. What was Galileo’s view on the nature of comets?
   He believed them to be some kind of upper-atmosphere phenomenon. Since he could not bring them into sharp focus with his telescope, he did not believe them to be a real celestial body.

6. Marie Celeste was housed in a convent founded by St. Clare. Describe two of the rules for living in the convent which St. Clare established.

   (There are several you could mention.)

7. What in Galileo’s *Dialogue* made Pope Urban so angry that he never spoke to Galileo again?

   Someone suggested that Galileo had used the Pope’s own words in one of the speeches of Simplicio, the simpleton. Urban did not actually read the book to see for himself, but he took umbrage that Galileo would insult him in this way.

8. What catastrophe in about 1630 slowed the approval process for Galileo’s *Dialogue Concerning the Two Chief Systems*?

   The bubonic plague slowed communication greatly, since everything had to pass through quarantine-type delays.