

Name:

5.1

The First Law: Force and Inertia



Question: How does the first law apply to objects at rest and in motion?

1 Setting up the experiment

There are no questions to answer in Part 1.

2 Reflecting on Newton's first law

a. State Newton's first law in your own words.

b. Place the steel ball in the center of the track so it stays at rest. What do you know about the forces on the ball? Identify the forces acting on it.

c. If an object is moving and there are no unbalanced forces acting on it, does its speed increase, decrease, or remain the same? Explain.

d. Push the ball with your finger and let it roll along the track. Does it appear to speed up or slow down? If so, you may wish to adjust the level of the track so that the ball seems to roll with constant speed.

3 Creating constant speed motion

- a. Release the ball from the hill at the free end of the track. Allow it to roll through both of the photogates. If there are no unbalanced forces acting on the ball, how should the time it takes to pass through photogate A (t_A) compare with the time it takes to pass through photogate B (t_B)? Explain.

- b. Read t_A and t_B on your Timer. How do the two values compare? What does this tell you about the speed of the ball as it rolls along the track? Continue to adjust the track until t_A and t_B are 0.0005 seconds apart or less. This takes repeated trials, so do not get discouraged.

4 Collecting data on the first law

Table I: Time and speed data

Photogate A			Photogate B			Time	Accel.
Position (cm)	Time t_A (sec)	Speed (cm/sec)	Position (cm)	Time t_B (sec)	Speed (cm/sec)	t_{AB} (sec)	(cm/sec ²)

5 Analyzing the data

- a. Were any forces acting on the ball as it rolled along the level track? Identify the forces. Explain how Newton's first law is applied to describe the motion you observed.

- b. What changes occur in the forces acting on the ball when the track is tilted slightly up or down? Explain how the first law is applied to describe the observed motion in the case of uphill or downhill slope.

Name:

5.2 The Second Law: Force, Mass, and Acceleration



Question: What is the relationship between force, mass, and acceleration?

1 Setting up the experiment

There are no questions to answer in Part 1.

2 Analyzing the system to find the tension in the string

There are no questions to answer in Part 2.

3 Measure forces and masses

Table 1: Force and mass data

	No. of washers	Mass (kg)	Force (N)
Mass #1		$m_1 =$	$F_1 =$
Mass #2		$m_2 =$	$F_2 =$

4 Thinking about force

- a. Which way do the masses move? Does m_1 rise or fall? Does m_2 rise or fall?

- b. The three forces acting are T , F_1 , and F_2 . Based on your answers to (4a) above, arrange these forces in order from smallest to largest. Explain what physical reasoning you used to arrange the forces.

5**Measuring the acceleration****Table 2: Distance, time, and acceleration data**

Time (sec)	Distance (m)	Acceleration (m/sec ²)	String tension (N)

a. Does the strength of the tension force in the experiment agree with your prediction from Part 4?

b. If the pulley created a friction force, would the tension force in the string be larger, smaller, or stay about the same? (This is tricky because you need to consider the sides of the string separately.)

Name:

5.3

The Third Law: Action and Reaction



Question: Can you identify action-reaction forces?

1

Identifying action-reaction pairs

For each of the situations described below, sketch the situation and identify at least one pair of forces that make up an action-reaction pair.

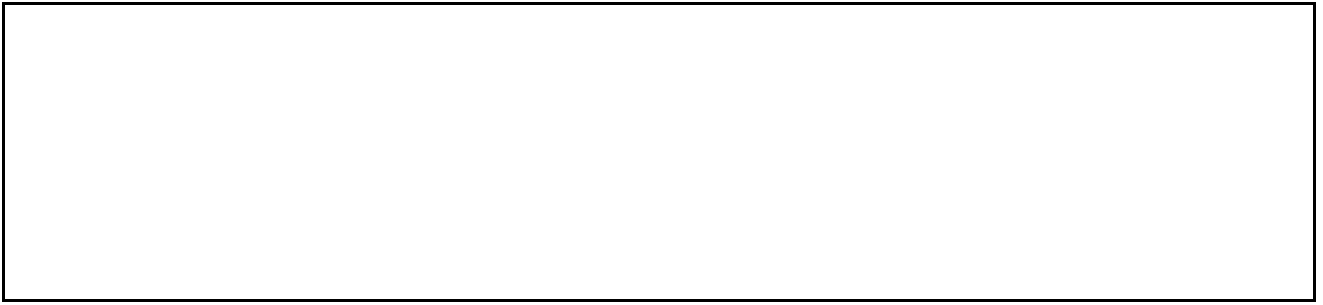
- a. A can of soda sitting on a table.

- b. A skateboarder pushing off the ground.

- c. A swimmer moving through the water.

- d. A runner pushing off from a starting block.

- e. A boater paddling through the water.

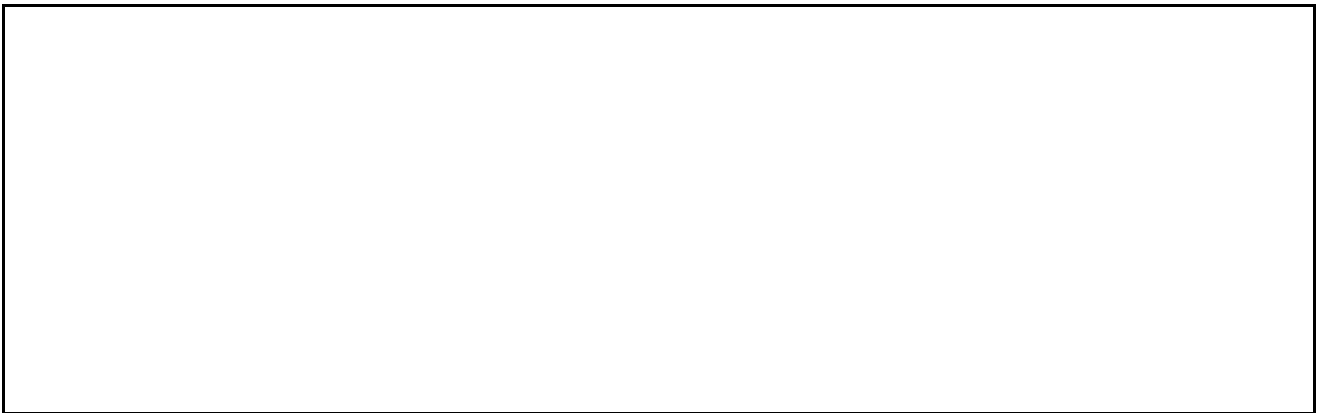


2

Identifying action-reaction pairs in your life

- a. List five specific activities you do on a weekly basis. For example, if you are on the tennis team, you might list “hitting a tennis ball” as one activity.

- b. Make a free body diagram of each activity.



- c. For each activity, identify at least one pair of forces that are an action-reaction pair.

3

Why don't equal and opposite forces cancel each other out?

- a. Create a sketch showing your calculator sitting on top of your textbook which is sitting on top of your desk which is standing on the tile floor.



- b. Identify the forces that serve as the action-reaction forces and draw them in your sketch.

- c. Now draw a free body diagram that shows each object by itself (the calculator, the textbook, the table, the tile floor, and Earth) and uses arrows to represent the forces acting on each particular object.



- d. Look at the forces on any one object. That object *does not* have both forces from any single action-reaction pair acting on it. Is this true for all of the objects? (This is the key to Newton's third law: The action-reaction forces are equal in size and opposite in direction but since they act on different objects, they do not cancel each other out.)

6.1

Mass, Weight and Gravity



Question: What is the relationship between mass and weight?

1 Setting up the experiment

There are no questions to answer in Part 1.

2 Analyzing the system to find the acceleration

There are no questions to answer in Part 2.

3 A hypothesis that can be tested

- Rearrange the last equation to get a formula for the acceleration, a_1 .
-
- Use the equations for uniformly accelerated motion to derive a formula that gives the time (t) it takes to fall a height (h) after the masses start moving. You may assume zero initial speed.
-

The formula you get in (b) is actually a hypothesis that the experiment can test to see if the theory is correct. Note that we made some assumptions to arrive at this hypothesis. The assumptions are that there is no friction and that the pulley has no mass.

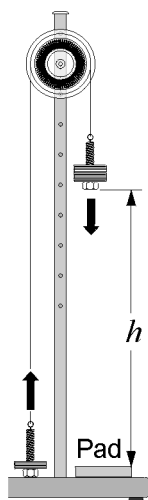


Table 1: Mass and Speed

m_1	Washers	
	mass (kg)	
m_2	Washers	
	mass (kg)	
Calculated acceleration (a)		
Measured height (h)		
Predicted Time (t)		

- Measure the mass of each hanger (m_1 and m_2) and record the results in Table 1.
- Calculate the predicted speed three seconds after release.

4 Measuring the speed

There are no questions to answer in Part 4.

5**Testing the hypothesis**

- a. Discuss the accuracy and precision of the experiment. How much variability was there in the times you measured? What does that tell you about how well your experiment is able to test your hypothesis?

- b. Compare the predicted time with the measured time. Does your experiment confirm your hypothesis? How does your answer to question (a) above affect the conclusion of the experiment (whether the hypothesis is confirmed)?

- c. What factors might account for any difference between measurement and prediction?

- d. Can you think of a way to make the experiment a more sensitive test of your hypothesis by accounting for any of the factors you identified in part (c)?

6.2

Friction



Question: How can we describe and model friction?

1

Static friction

Table I: Static friction data

Mass (kg)	Weight (N)	Friction force (N)	Ratio

2

Examining the data

- a. What happened to the friction force as the weight of the pulled objects increased?
- _____
- _____
- _____
- _____
- b. Discuss a possible explanation for the relationship.
- _____
- _____
- _____
- _____
- c. The ratio of the friction force to the weight of the pulled objects is called the *coefficient of static friction*. Was there a trend among these values or were they all roughly equal?
- _____
- _____
- _____
- _____
- d. What effect would placing the block on a rougher surface (such as sandpaper) have on the coefficient of static friction?
- _____
- _____
- _____
- _____

3**Sliding friction****Table 2: Sliding Friction Data**

Mass (kg)	Weight (N)	Friction force (N)	Ratio

4**Comparing static and sliding friction**

a. What happened to the friction force as the weight of the pulled objects increased in Table 2?

b. Is the relationship between the friction force and the total weight in Table 2 similar to the relationship in Table 1?

c. The ratio of the sliding friction force to the total weight is called the *coefficient of sliding friction*. Compare the coefficient of sliding friction to that of static friction. Are they different? Is one significantly different than the other, or are the two coefficients about equal?

d. Explain a possible reason the forces of static and sliding friction might not be equal.

5**Friction between other surfaces**

During the Investigation, you found the coefficients of static and sliding friction for felt on the tabletop. If time allows, determine the coefficients of friction for other combinations of surfaces. Some combinations you might try are the wood side of the block on a sheet of paper, felt on sandpaper, or wood on wood.

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6.3

Equilibrium of Forces and Hooke's Law



Question: How do you predict the force on a spring?

1 Setting up the experiment

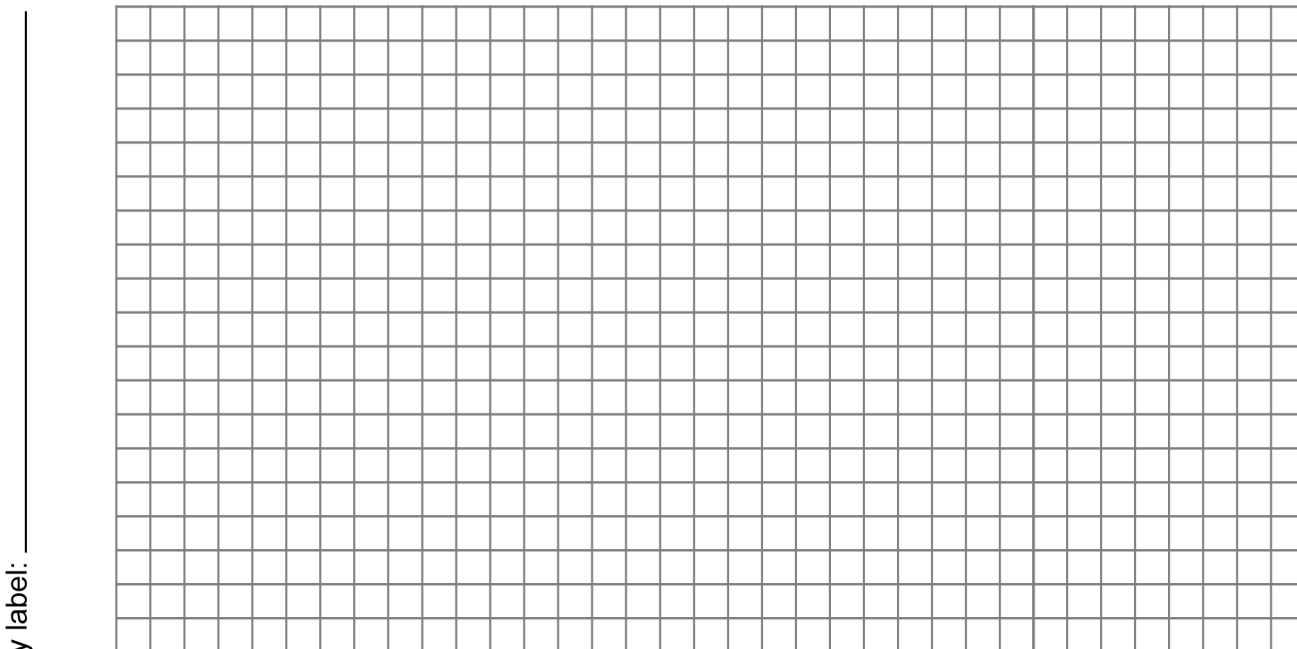
Table 1: Force and extension of a spring

Number of washers	Attached mass (kg)	Spring's position (cm)	Calculated extension (cm)	Calculated force (N)

2 Analyzing the data

- a. Make a graph of force versus extension for the spring.

Title: _____



- b. Use your graph of force versus extension to determine the spring constant for the spring in the experiment. Express your result in N/cm.

3**Testing the model**

- a. Use your graph to predict how much the spring should extend for a hanger with 20 washers. You need to determine the weight of 20 washers (and the hanger) to make your prediction.

- b. Set up the experiment and test whether the model (Hooke's law) gives the correct prediction.

- c. How close did your prediction come to the actual extension of the spring? Calculate the difference between the measurement and the prediction as a percentage of the actual measurement.

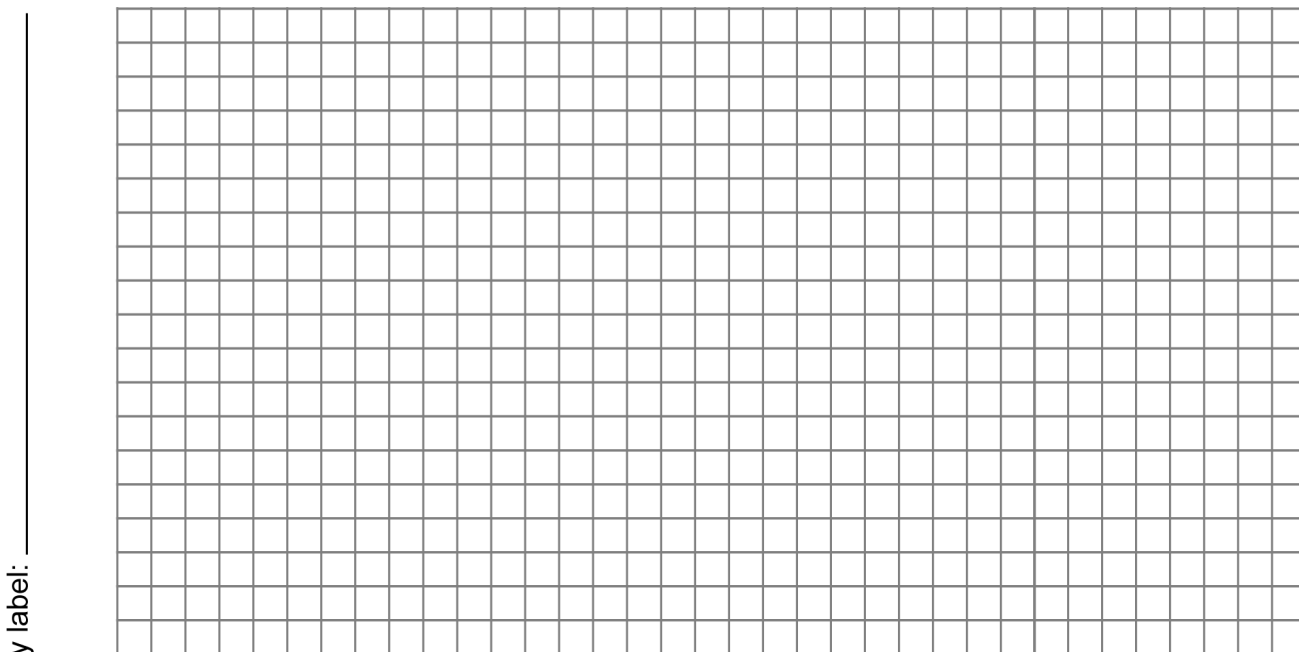
4**Compression springs****Table 2: Force and compression of a spring**

Number of washers	Added mass (kg)	Spring's position (cm)	Calculated compression (cm)	Calculated force (N)
0	0			
5				
10				
15				

5 Analyzing the data

- a. Make a graph of force versus compression for the spring.

Title: _____



- b. Use your graph of force versus compression to determine the spring constant for the spring in the experiment. Express your result in N/cm.

6 Testing the model

- a. Use your graph to predict how much the spring should compress when 20 washers are added. You need to determine the weight of 20 washers to make your prediction.

b. Set up the experiment and test whether the model (Hooke's law) gives the correct prediction.

c. How close did your prediction come to the actual compression of the spring? Calculate the difference between the measurement and the prediction as a percentage of the actual measurement.

d. Could this spring be used to measure the mass of one washer? If so, explain a procedure for how to make the measurement. If not, explain why not.

e. How much force would it take to cause a compression of 1 millimeter?
