SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

915

Motion and Inertia

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Adapted by: Stephen Druger

Contents

This micro-unit was adapted by **Stephen Druger** (Northwestem University, Evanston, Ill.)

Student Sheet

Science as Inquiry

Pulling the Rug Out

How do changes in motion affect the speed of an object?

Overview:

Suppose we try to increase the speed of an object. How effective will our efforts be? How does this depend on how we try to change its speed? In this activity you'll use a piece of paper and a stack of blocks to examine these questions.

Procedure:

First place one block on a piece of paper at the end of the worktable. Place another block on top of it, and a third on top of that. Pull the paper very slowly and smoothly across the table and observe what happens.

Repeat, but this time yank the paper very abruptly across the table. Start from the paper at rest and then pull it along the table surface as suddenly and quickly as possible. Observe what happens.

Next, try pulling the paper in an intermediate way, between yanking abruptly on the paper and pulling slowly, and observe what happens.

Finally, with one hand on each end of the paper, smoothly start pulling the paper and blocks slowly across the table and bring it to an abrupt stop. What happens?

Questions:

1. What patterns of behavior did you observe when you pulled on the paper in different ways?

2. How can you explain what you observed in terms of resistance of the blocks to changes in their motion?

3. Suppose that the upper part of your body, above your hips, corresponds to the column of blocks, and suppose the piece of paper corresponds to the car seat you are in. Compare what you would experience when the car accelerates rapidly, accelerates slowly, and stops abruptly with what you observed in this activity.

4. How can you explain what you feel when a car accelerates rapidly or comes to an abrupt stop in terms of whether objects do or do not resist changes in motion?

5. When you suddenly changed the motion of the paper and blocks, how did your observations suggest a tendency for objects in motion to continue moving? How did they suggest a tendency for objects at rest to remain at rest?

Science as Inquiry

Using a Line Level to Measure Motion

What can a line level tell us about linear and circular motion?

Overview:

When you ride in a car, the speedometer tells you how fast the car is moving. Your eyes tell you its direction relative to the road. But is there more involved in motion? A simple device, designed for a completely different purpose, can tell us about some other aspects of motion.

The device is a line level, a glass tube filled with liquid except for a small bubble of air. Its intended use is to test whether a surface, such as the top of a desk, is horizontal or tilted slightly. Here, however, we will use the level for a different purpose. We will try moving the level to see how it reacts and examine what this reaction tells us about its motion.

Procedure:

The line level is essentially a small tube filled with liquid with a bubble of air deliberately left in it. Try examining and using the level for its intended purpose to familiarize yourself with how it works. In particular, use the level to test whether the tabletop you are using is horizontal. If it is slightly nonhorizontal, note just where the bubble in the level rests when it is pointed parallel to the long side of the table.

Now move the level in a straight line parallel to the length of the table. Try to keep the speed of motion almost constant. Note how the location of the bubble when the level moves at a constant rate compares with its location when the level is at rest on the table.

Repeat the motion, except this time start the motion with the level initially at rest and gradually increase the speed as you move it. What did you observe while its speed was increasing, before you had to stop moving it?

Finally, tie a string to the end of the level and hold the other end of the string to the table with your finger. Keep the level pointed radially outward along the direction of the string. Use the string to keep the level at a constant distance from your finger while moving it along a circular path at a constant rate. How does the level behave now?

Questions:

1. How does the line level work when used for its intended purpose of deciding whether a flat surface is tilted or horizontal?

2. What did you observe when the level was moved at a roughly constant speed along a straight-line path, and how would you explain this?

3. When the line level was increasing in speed, what did you observe and how would you explain it?

4. Now suppose you know that the tabletop is level and you are shown a photograph of someone's

hand moving the level as you did along a straight-line path. (a) If the bubble appears in to be forward of the center of the level, what does this tell you about the motion? (b) If the picture shows the bubble to be displaced backward from its rest position in the level, what does that tell you about the motion?

5. The line level registered changes in its motion when it was moved in a straight line. Was there anything related to changes in motion shown by the level when it was moved in a circle? If so, what aspect of the motion was changing?

6. How do the changes in motion for the circular motion compare with changes in motion when you increase the speed of an object that moves in a straight line?

Student Sheet

Science as Inquiry

A Bus Ride

What is a bus ride like from an accelerometer's perspective?

Overview:

To further study motion and changes in motion we experience every day, we can use the line level (or other device of the same sort) to directly observe what we experience in a car or bus that not only moves in traffic but also routinely speeds up and slows down.

Procedure:

Borrow one of the line levels or a similar device (i.e., an "accelerometer") for detecting changes in speed. Bring it with you while riding as a passenger in the school bus or other vehicle. When the vehicle is at rest, find an approximately horizontal surface to hold the level on or else hold it as close to horizontal as possible by hand. Observe what happens when the vehicle slows down, when it speeds up, and when it moves at a constant speed. Pay attention also to what forces you feel acting on you in each of these three cases.

Questions:

1. What response did you observe in the line level when the vehicle moved at a constant rate, when it speeded up, and when it slowed down?

2. How can you explain the above responses in terms of whether objects tend to resist changes in their speed?

3. How do those responses compare with what would happen if you were able to push the liquid one way or another inside the tube when everything else remained motionless?

4. What forces do you feel acting on you when the vehicle speeds up rapidly, slows down rapidly, or stays the same?

5. How can you explain your answer to question four in terms of whether objects resist changes in their motion?

6. How do the forces you experience when the vehicle accelerates relate to the behavior shown by the accelerometer (i.e., the line level or other device used)?

Science as Inquiry

Going Around in Circles

How do you keep an object on a circular path?

Overview:

The velocity of a moving object is its speed and direction of motion. How fast the velocity changes is its acceleration. Here we examine the acceleration involved in velocity changes when movement is in a circle and when movement is in a straight line.

Procedure:

Tie the string to the marker, hold the other end in place with one finger, and use it to guide the marker in a circular path to mark off a circle with a radius of 7–12 inches. Hold the pencil at one end and use the other end to tap a small rubber ball lightly, repeating as needed to keep it moving in a circular path. Repeat, this time to keep it in a straight-line path, noting the differences in what must be done.

Questions:

1. In each of the two cases, was the velocity (meaning the speed in a specific direction) changing? If so, in what way?

2. Was an acceleration involved in making the ball move in a straight line? If so, during what parts of the motion and in what way? And how was the acceleration produced?

3. Was acceleration involved in making the ball roll around in a circle? How do you know this?

4. Compare the effort needed to keep the ball moving in a circle with that needed to keep it moving in a straight line. In each case, did you have to keep tapping the ball? And when you did have to tap it, was it always in the same direction or in different directions?