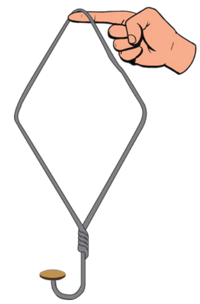
STUDENT ACTIVITY

Name: ____________________ Class: __________ Date: ____________

CRASH SCIENCE IN THE CLASSROOM

TWIRLING PENNY



MATERIALS NEEDED

Per pair of students

- 1-3 pennies
- 1 metal coat hanger

Per student

- 1 “Twirling Penny” Student Activity sheet
- 1 pair of safety glasses or goggles

Key Question(s)

- What forces keep a penny on a twirling hanger?
- How does Newton’s Second Law of Motion help to explain how seatbelts protect occupants during rollover crashes or accidents occurring when vehicles drive around sharp turns?
- How do banked curves on highways help vehicles safely negotiate these turns?

Purpose

- To calculate the magnitude and direction of the net force acting on an object
- To identify the forces acting on an object in circular motion
- To use Newton’s Second Law of Motion to explain circular motion
- To explain how the physics of circular motion affects occupants of vehicles driving around curves
- To describe how banked curves and seatbelt use make driving on curved roads safer

Figure 1

Did You Know?

Engineers design banked curves on some racetracks or highways to help vehicles maintain traction as they move through turns. On racetracks with high-speed turns, such as velodrome bicycle tracks (See Figure 1) or Indy raceways, the angle of the banked turns can be extreme. In this activity you will use pennies and a coat hanger to explore what forces affect a penny as it moves through a continuous high-speed turn.

Procedure

Part 1 - Calculating Net Force

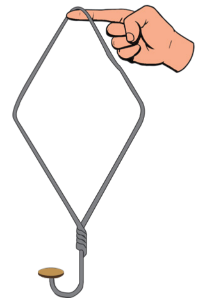
1. Assume that the trucks in Figure 2 are all of the same mass and are all pointed toward the right. Follow steps a, b, and c to calculate the net force acting on each truck.

a. If two or more forces are present on the left or right side of a truck, calculate the total of all of the forces on that side.

b. For each truck, subtract the larger total force (either on the left or the right side) from the smaller total force on the other side to determine both the magnitude of the net force acting on each truck as well as the direction of each net force (acting on the left or right).

c. In the “Net Force” column, use the marks on the lines next to each truck to draw arrows indicating both the direction of the net force (on the right or left side of each truck) and the magnitude of the net force in Newtons and write the total amount of the net force (such as “15N”) above each arrow.

TWIRLING PENNY



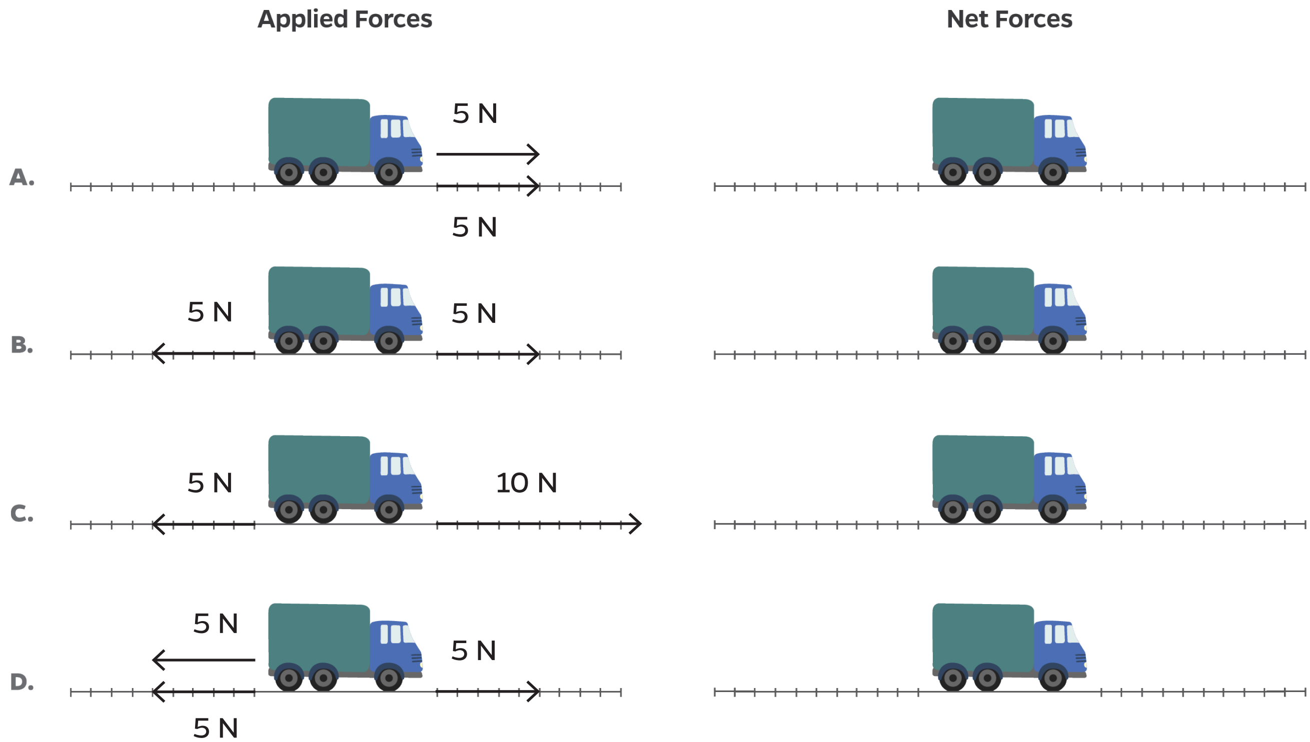


Figure 2

Analysis Questions

2. After your class discussion of Newton's Second Law and review of the equation a = F/m (where F = net force and a = acceleration), work with your partner to answer the following analysis questions regarding the trucks in Figure 2. HINT: Assume that the trucks all have the same mass.

a. Which trucks are going to have the same acceleration?

Circle all that apply: A. B. C. D.

b. Which truck is going to have the greatest acceleration?

Circle one: A. B. C. D.

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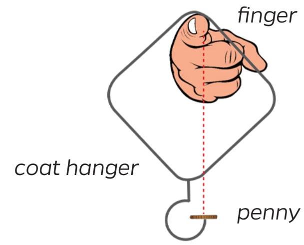

Figure 3

Part 2 – Investigating Circular Motion with a Twirling Penny

3. Follow your teacher's tips and the directions below to successfully twirl a penny on the tip of a coat hanger. To see Griff Jones twirl a penny, watch the activity's Introduction video at classroom.iihs.org/twirling-penny

***Safety Note:* Everyone must wear safety glasses until all groups have stopped twirling their hangers and groups must stay far enough apart to make sure no one is in the path of a twirling hanger.**

- ***a.*** Put on a pair of safety glasses.
- ***b.*** Hang the coat hanger on your index finger so that the tip of the hanger's hook is pointing upward towards your finger. If needed, adjust the bend of the hanger's hook so the tip is pointing straight upward towards your finger (See Figure 3).
- ***c.*** Carefully balance a penny on the tip of the hanger's hook.
- ***d.*** Practice gently swinging the hanger back and forth with successively larger swing heights without the penny dropping off the tip.
- ***e.*** Then, begin swinging the hanger back and forth with successively larger swing heights. Gradually increase the swing heights until you can twirl the hanger a full circle multiple times without the penny coming off of the hanger. Be patient! It takes practice to twirl the hanger in a smooth circular motion so the penny stays on the hanger.
- ***f.*** To stop the circular motion of the hanger and penny, take a giant step to the left or right (in the same direction as the penny is twirling) and stop the hanger on the upswing.
- ***g.*** After at least one group member has succeeded in keeping the penny on the twirling hanger several swings in a row, try completing these additional "Twirling Penny Challenges:"
  - ***i.*** Bring the twirling hanger to a stop without the penny falling off.
  - ***ii.*** Twirl the hanger as slowly as possible without the penny falling off.
  - ***iii.*** Twirl more than one penny on the tip of the hanger. (Griff's record is three pennies.)

Analysis Questions

4. If an object is at rest, is a net force required to accelerate an object in order to produce circular motion?

Circle one: YES NO

5. If an object is already in circular motion, will that object stay in circular motion at a constant speed if no net force is continuously applied to it?

Circle one: YES NO

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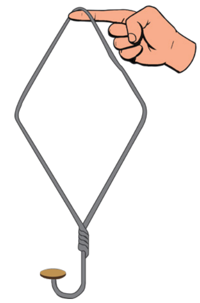

Watch the activity's Conclusion video at classroom.iihs.org/twirling-penny After your class discussion of the concepts of "centrifugal" force, centripetal force, support force, and the force of gravity, work with your partner to answer the following questions:

6. What two forces are acting on the penny when it is <u>motionless</u> on the tip of the hanger?

______________________ and ______________________

7. Using Newton's Second Law of Motion (a = F/m), explain how the penny stays on the tip of the twirling hanger when it is <u>in motion</u>.

Part 3 – Applying the Physics of Circular Motion to Driver Safety and Road Design

After your class discussion of how the physics of circular motion applies to vehicles driving on curved roads, answer the following questions:

Analysis Questions

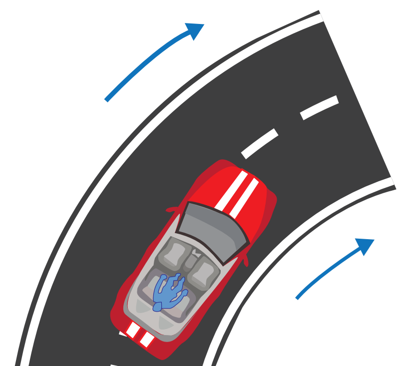

Figure 4

8. Use the following 3 terms to explain what happens to an unbelted back-seat passenger (see Figure 4) when a car turns swiftly to the right on a flat road:

» centripetal force
» friction
» inertia

9. Explain in your own words how banked turns on roads reduce vehicle accidents.