Torque in Daily Life

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Title:
Torque in Daily Life
Grade Level:
5,6,7,8
Subject:
Science,Physical Science,Physics
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Lesson Plan Type:
Inquiry,Interactive Instruction
Keywords:
Torque, Center of Mass, Pivot Point, Axis of Rotation, Lever Arm, Simple Machine, Science of NFL Football, NBC Learn
Brief Description:
Introduces students to the concept of torque through a short NBC Learn video on the science of the NFL, demonstrations, and a lab activity. Students learn how to calculate torque. Students also learn how torque is used in simple machines, everyday life, and in sports.

[1]

California State Standards Addressed:
Science/6/Investigation and Experimentation)7.0

Related Links:
Link 1:
Goal(s):
Students will learn how to calculate torque. Students also learn how torque is used in simple machines, everyday life, and in sports.
Specific Objectives:

Students will be able to:

- Define torque
- Calculate the torque produced if given the force and lever arm

- List at least 2 examples in which torque is used in daily life
- Describe how offensive linemen use the concept of torque to their advantage

Required Materials:

NBC Learn video Torque & Center of Mass [1]

Per group of 2-3 students: One ruler, one pencil, 20 pennies

Optional Class Demonstrations Materials:
- Broom handle or equivalent stick, 3-6 lb weight, string
- Wrench and something with a bolt (preferably larger diameter)
- 4 foot or greater length of 2 x 4 (or larger cross section) wood, small block or object to be used as a fulcrum

Anticipatory Set (Lead-in):

Ask Students: “What do the following actions have in common: opening a door, playing on a teeter-totter, riding a Ferris wheel, and using a wrench or screwdriver; In all cases forces are applied to rotate an object. In physics we have a name for this “turning force.” We call it torque.

In addition to the above examples, we use torque dozens of time throughout the day, any time we want to revolve something around a pivot point (you can walk while you are saying this and point to your hip joint.) Even walking, as our thighs rotate about a ball joint in our hips, our muscles are applying torques to our legs.

Every sport involves torques, and the short video we are about to watch will describe how torque is used by NFL linemen battling on the front lines of a football game. Show the NBC Learn video on Torque [1].

Lesson Plan Procedure:

Note to teachers: Although the theory of torque is relatively simple (Torque= perpendicular force x lever arm), it is a rather complex task to use it to analyze the dynamics between two opposing football players. There are many variables at play in this interaction (friction, momentum, inertia, center of mass etc…) and the role of torque in any block or tackle depends upon these other variables. Thus, in this lesson, torque will be examined under very simplified conditions, and at the end of the lesson there will be a final reflection question relating to football.

Part I: Introduction and Term Definitions, Demonstrations (15 minutes)

i. After watching the NBC Learn video on torque [1]have students record on the activity worksheet a written description of the following concepts and discuss as necessary:
- Torque is the tendency of force to produce a rotation
- Torque= Perpendicular Force x Lever Arm
- Pivot Point or Axis of Rotation is the point or axis about which an object rotates.
- Lever Arm is the distance from the pivot point or axis of rotation to where the force is applied.

ii. Emphasize and demonstrate that the amount of torque a given force produces is more than just a question of force; it is essential to consider where that force is applied.

A few good demonstration of this are the following:
- Using the door to the classroom, demonstrate how difficult it is to open if you push right next to the hinges. Explain that in this case, the object you are trying to rotate is the door. The pivot point/axis of rotation is at the hinges, and thus, in order to maximize the lever arm, the doorknob where we normally push is located as far as possible from the axis of rotation. This is done to minimize the amount of force needed to “open a door” (aka rotate the body about an axis).
- Another demonstration involves asking a student to hold on to one end of a stick with one hand (The stick should be sturdy, like a broom handle or a few meter sticks taped together, and the student should be asked to grab it at the very end.) Have the student hold the stick horizontally and

right next to their hand, on the stick, hang a textbook or something that weighs 3-5 pounds. Gradually move the weight to distances further away and the class will see that it becomes nearly impossible for the student to keep the stick horizontal. CAUTION: warn the student that if the stick rotates downward, the object may tend to slide off so be careful to not let the stick fly upwards if this happens.

- Use a wrench on a bolt, and demonstrate how much more difficult it is if you apply a force on the wrench right next to the bolt versus at the end of the wrench opposite the bolt. You might mention, that a common practice used by mechanics for large bolts, particularly if they are stuck, is to put a metal pipe (aka “cheater bar”) on the end of a wrench in order to produce more torque for a given force.

Part II: Activity: Torque, Levers, and Simple Machines (30 Minutes)

Discuss with the students the role of torque in a teeter-totter. If two different sized people sit on it at equal distances from the fulcrum what will happen? Of course the larger person will go down (explain that each person is using their weight to apply a torque to the system and the device will rotate if one of the torques is greater. You can also introduce the idea of clockwise and counter-clockwise torque) Ask students if there is a way for 2 people to balance on a teeter-totter with seats that can be adjusted at different distances from the fulcrum? (Answer: If the smaller person is seated further away from the fulcrum, this could produce a torque of equal magnitude in the opposite rotational direction.)

Now introduce the activity:

Each group will be given a ruler, a pencil to act as a fulcrum, and 20 pennies. Have students place the middle of the ruler over the pencil and place a stack of 5 pennies (call this the “load”) on one side of the ruler about with the center of the stack 3 inches from the fulcrum (pencil). You may suggest that the load be taped to this position, as it will not change for this activity.

The goal will be to use the remaining pennies at different locations (with different lever arms) to create applied torques that overcome the torque of the “load” and lifts the load. Have them work in groups of 2-3 students and record their findings on the activity worksheet. Be sure to clarify to the students that the “lever arm” is NOT the reading on the ruler, but that the ruler markings can be used to determine the lever arm, which is the distance from the fulcrum to the CENTER of the stack of pennies.

When finished, students can start the post activity reflections, or you can assign them for homework and go over answers the following day.

Note: Depending upon the level of your students, you can leave torque calculations unit-less. That is, just multiply the length of the lever arm (the amount of inches or centimeters) by number of pennies. Similarly, you could have them include the units of the weight of the pennies in Newtons or pounds and thus come up with torque units such as inch-pounds or cm-Newtons. (A penny weighs about .006 lbs which is about .027 N)

Closure (Reflect Anticipatory Set):

Take a 4-foot or greater section of 2 x 4 wood (or larger cross section) and use a small block as the fulcrum. Discuss levers and show that by extending the lever arm on one side of the fulcrum, and shortening it on the other, you get “leverage”. Demonstrate by having a student try to hold down or stand on the shorter lever arm while you easily lift them by applying a much smaller force with a much greater lever arm. (An optional extension would be to discuss and demonstrate class 1, 2, and 3 simple machines.)

Plan for Independent Practice:

Post Activity Questions

Assessment Based on Objectives:

Informal assessment can be made as students whiteboard and/or present their answers to the Post Activity Questions.

Possible Connections to Other Subjects:

English or History: Students can research and write about the historical uses of simple machines.

Adaptations and Extensions:

This lesson can lead to a more in depth look at class 1, 2, and 3 simple machines. It can also be coordinated with a discussion of the center of mass and related topics such as stability and toppling.

Links:
[1] http://www.nbclearn.com/portal/site/learn/nfl/cuecard/51154/