CONCEPTS

- Gravity pulls down on all objects on Earth, including the bodies of organisms.
- Muscles work against gravity.
- Center of gravity is the point around which all the weight of an object is equally distributed.

OVERVIEW

Students will learn about center of gravity and how the body adjusts to the force of gravity to remain balanced.

SCIENCE, HEALTH & MATH SKILLS

- Predicting
- Observing
- Gathering and recording data
- Drawing conclusions

7. Gravity and Muscles

Background

Gravity places a heavy load on the human body. Only through coordinated muscle movement is the body able to counteract the downward pull of gravity and remain upright. Muscles in the back, legs, ankles and feet are used most. The nervous system tells these muscles which changes to make to help the body maintain posture and balance during movement.

To balance itself, the body makes tiny adjustments to maintain its center of gravity over the feet. The center of gravity is an imaginary point within the body at which there is balance and from where the weight on all sides is equal. Fortunately, the minor muscle adjustments necessary to maintain balance and posture are made automatically.

Time

10 minutes for set-up; 60 minutes to conduct activity

Materials

Part 1

Each team of 2 students will need:

- copy of "Balancing Act" student sheet
- meter stick
- standard weight items such as heavy coins, washers, etc.
- masking tape

Part 2

Each group will need:

- light-weight chair
- copies of "Balancing You!" sheet

Set-up and Management

Place meter sticks, weights and masking tape in a central location. Have students work in pairs.

Procedure

Part 1. Balance, Weight and Stability

1. Ask students, *Do you usually fall over when you are walking, riding a bicycle or standing on a bus? Why?* Encourage students to think about how the body coordinates balance. Ask, *Do you need muscles to keep your balance? Would your skeletal system alone be able to keep you upright in a moving vehicle?* Explain to students that they will be investigating balance and stability using different amounts of weight and meter sticks (Part One) and that they will be learning how living things use muscles and body position to maintain balance (Part Two).

2. Tell each Materials Manager to collect weights, masking tape and a meter stick for her/his group.

3. Instruct one student in each group to hold the meter stick horizontally by supporting it with one index finger at each end. Have the student move his/her fingers slowly toward each other, keeping the stick balanced until the fingers meet. Explain that the point where the fingers meet is the balance point for the stick. In other words, the balance point is the place

To keep from toppling over, an object's center of gravity must stay above the area outlined by the object's base. This is why you will fall over if you lean too far forward. Once your center of gravity is beyond the limits of the base defined by your feet, you lose your balance and stability. This is why people will stand with their feet farther apart (and thus widen their "base") to keep their balance in a moving bus or train.

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NASA scientists find it crucial to have a weightless environment for some of their experiments. They use tall towers, long tubes, rockets and airplanes, as well as spacecraft, to create artificial weightless environments.

Astronaut Mary Ellen Weber, STS-101 mission specialist, is shown onboard KC-135 during a brief period of weightlessness afforded by one of the parabola patterns flown repeatedly by the NASA aircraft. Weber is testing a device for stabilizing herself when she operates the robotic arm aboard the Space Shuttle Atlantis.

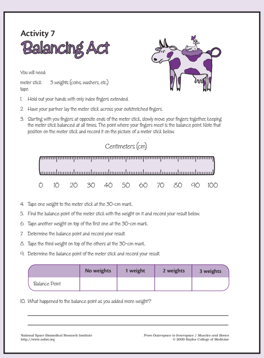
(Photo courtesy of NASA)

where the weight on each side is equal and the object is balanced. Have the students in each team record the balance point for their meter stick.

4. Next have students tape one weight on the 30-cm mark of the meter stick. Ask students to predict where the new balance point will be and to record their predictions. Have them determine the new balance point of the meter stick as before and record it.

5. Have students add another weight to the one already on the meter stick and repeat the process. They should repeat the experiment one more time with three weights on the meter stick.

6. Direct students' attention to their data sheets and ask, *What happened to the balance point of the meter stick as more weight was added?* [the balance point moved toward the added weight]. *What would have happened if you had not moved your finger to find a new balance point?* [meter stick would have fallen]. Help students understand that, in order to stay balanced, the weight of each end of the meter stick had to be equal. The only way to achieve this when more weight is added is to move the balance point.



Activity 7

Balancing Act

You will need:

meter stick   3 weights (coins, washers, etc.)
tape

1. Hold out your hands with only index fingers extended.
2. Have your partner lay the meter stick across your outstretched fingers.
3. Starting with you fingers at opposite ends of the meter stick, slowly move your fingers together, keeping the meter stick balanced at all times. The point where your fingers meet is the balance point. Note that position on the meter stick and record it on the picture of a meter stick below.

Centimeters (cm)

0 10 20 30 40 50 60 70 80 90 100

4. Tape one weight to the meter stick at the 30-cm mark.
5. Find the balance point of the meter stick with the weight on it and record your result below.
6. Tape another weight on top of the first one at the 30-cm mark.
7. Determine the balance point and record your result.
8. Tape the third weight on top of the others at the 30-cm mark.
9. Determine the balance point of the meter stick and record your result.

	No weights	1 weight	2 weights	3 weights
Balance Point				

10. What happened to the balance point as you added more weight?

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Part 2. Maintaining Balance

1. Ask students to think about whether maintaining their own balance is as simple as moving their fingers on the meter stick. Follow by asking them to think about whether their center of gravity ever changes. Ask, *What do you do to keep yourself from falling when you trip over something? How about when you are standing in a moving train or bus?* Tell students that they will be exploring their own centers of gravity in two different ways.

2. First, have students in each group take turns standing up from a seated position in a chair. They should record the results on their data sheets. Ask, *How easy was it to stand up?* (very easy).

3. Follow by having students try again to stand up from a seated position in a chair. This time, however, have them do so without leaning their back and shoulders forward. Have them record their results.

4 Next, instruct one student to stand with feet shoulder-width apart. Have

Free Fall

Objects falling with an acceleration equal to that caused by gravity alone experience "free fall," or weightlessness. The acceleration required to achieve free fall is 9.8 meters per second squared or 1 g at the Earth's surface. Free fall is the lightness that you feel on some amusement park rides. Astronauts orbiting the Earth also experience weightlessness for the same reason.

Under these conditions, many movements can be accomplished with minimal effort. However, after long space flights, astronauts may demonstrate changes in their posture upon return to Earth. These changes are believed to be related to adaptation by the body to microgravity conditions.

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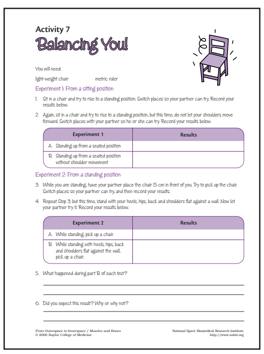
the second student place a lightweight chair 15 cm in front of the feet of the first student. Instruct the first student to try to pick up the chair and to record his/her results. Then have the other student in each group try it and record his/her results.

5. Tell students to move to the periphery of the room and take turns repeating the process again, but this time with their heels, hips, back and shoulders against the wall and with feet flat on the floor. Again, have them record their results.

6. Discuss the students' results. Ask them to identify the differences between the two trials of each experiment. Ask, *Why do you think it was not possible to stand up when you didn't move your shoulders? Why was it impossible to pick up the chair when you stood against the wall?* Help students understand that in both cases, their body movement was limited.



Activity 7

Balancing You!

You will need:

light-weight chair metric ruler

Experiment 1: From a sitting position

1. Sit in a chair and try to rise to a standing position. Switch places so your partner can try. Record your results below.
2. Again, sit in a chair and try to rise to a standing position, but this time, do not let your shoulders move forward. Switch places with your partner so he or she can try. Record your results below.

Experiment 1	Results
A. Standing up from a seated position	
B. Standing up from a seated position without shoulder movement	

Experiment 2: From a standing position

3. While you are standing, have your partner place the chair 15 cm in front of you. Try to pick up the chair. Switch places so your partner can try, and then record your results.
4. Repeat Step 3, but this time, stand with your heels, hips, back and shoulders flat against a wall. Now let your partner try it. Record your results below.

Experiment 2	Results
A. While standing, pick up a chair.	
B. While standing with heels, hips, back and shoulders flat against the wall, pick up a chair.	

5. What happened during part B of each test?

6. Did you expect this result? Why or why not?

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7. Discuss gravity again. Ask, *Does gravity affect people? Do people have a center of gravity?* The meter stick center of gravity changed as students added more weight. Ask, *Have you been able to observe whether a person's center of gravity changes?* Have students think about where their centers of gravity are when they are sitting in chairs and how their centers shift when they begin to stand up. Their weight shifts from their seats to their feet; thus, their centers of gravity must change also. Have students think about where their centers of gravity are when they lift a chair. The chair adds extra weight to the body, so the body must compensate for that weight by moving the center of gravity. The body changes the center of gravity and achieves balance by moving the hips backward. This is why students were not able to pick up the chairs with their backs against a wall. Have students try these two experiments again, and this time have them watch their partners' body movements.

Extensions

- The body constantly makes adjustments to compensate for the pull of gravity. Some of these adjustments are large, as when we pick up a chair, but many of the adjustments are very subtle. The muscles make minor adjustments constantly to maintain balance and posture. Have students work in pairs and observe the movements made by their partners as they perform certain tasks. The tasks can be: moving from standing on two feet to standing on one foot, walking heel-to-toe, squatting or standing on tip toes.

Muscle Control!

The brain and nervous system coordinate muscle movements necessary to maintain balance.

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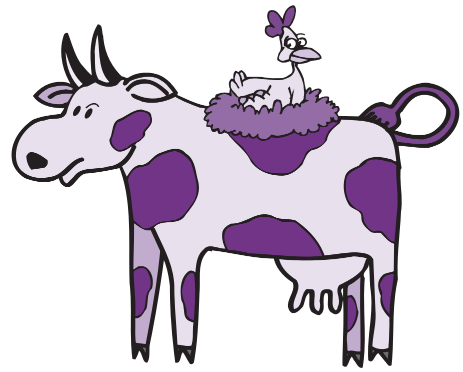
Activity 7

Balancing Act



You will need:

meter stick   3 weights (coins, washers, etc.)
tape

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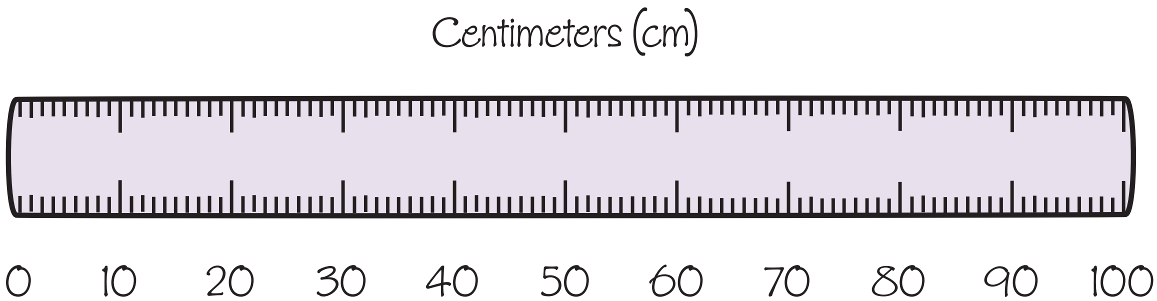

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7. Determine the balance point and record your result.
8. Tape the third weight on top of the others at the 30-cm mark.
9. Determine the balance point of the meter stick and record your result.

	No weights	1 weight	2 weights	3 weights
Balance Point				

10. What happened to the balance point as you added more weight?

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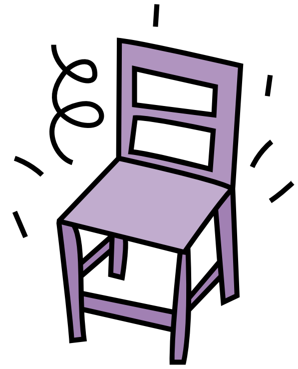
Activity 7

Balancing You!



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light-weight chair metric ruler

Experiment 1: From a sitting position

1. Sit in a chair and try to rise to a standing position. Switch places so your partner can try. Record your results below.
2. Again, sit in a chair and try to rise to a standing position, but this time, do not let your shoulders move forward. Switch places with your partner so he or she can try. Record your results below.

Experiment 1	Results
A. Standing up from a seated position	
B. Standing up from a seated position without shoulder movement	

Experiment 2: From a standing position

3. While you are standing, have your partner place the chair 15 cm in front of you. Try to pick up the chair. Switch places so your partner can try, and then record your results.
4. Repeat Step 3, but this time, stand with your heels, hips, back and shoulders flat against a wall. Now let your partner try it. Record your results below.

Experiment 2	Results
A. While standing, pick up a chair.	
B. While standing with heels, hips, back and shoulders flat against the wall, pick up a chair.	

5. What happened during part B of each test?

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6. Did you expect this result? Why or why not?

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