CENTRE OF GRAVITY & SYMMETRY

Materials

- Students performing activities BLM 7.2.1
- Levers - BLM 7.2.2
- Levers Worksheet - BLM 7.2.3
- Symmetry - BLM 7.2.4
- Airplane Fan Test - BLM 7.2.5
- paper
- scissors
- thin sheets of Styrofoam
- fan
- teasing needle from a dissection kit
- plasticine
- metre sticks
- solid triangular prisms
- non-standard weights (e.g. pucks, bean bags)

Overall Expectations: 2. Design and construct a variety of structures, and investigate the relationship between the design and function of these structures and the forces that act on them (7s21); 3. Demonstrate an understanding of the relationship between structural forms and the forces that act on and within them (7s22).

Structures and Mechanisms – Forms and Function -
– Centre of Gravity & Symmetry –

Description: This subtask will consist of four 40 minute activities which investigate the concepts of centre of gravity and symmetry. The first activity will be a series of hands-on demonstrations linking the concept "centre of gravity" to our bodies. Balancing our bodies on a daily basis is quite an amazing process, particularly because it is performed on two sticks called legs.

ACTIVITY #1: Centre of Gravity

1. Using a long ruler (any length will do) ask students to predict the balancing point of the ruler. Have a volunteer test these predictions by balancing the ruler for the class. In groups or as individuals, have the students make predictions and balance a variety of objects (pencils, erasers, books). Make note of any special observations.
2. Ask students to sit in their chairs. In order to stand up, students must lean forward to shift the centre of gravity over their feet. Challenge them to stand up without using their hands and without leaning forward. It's not possible because their centre of gravity is over the chair. In order to shift the centre of gravity over their feet, which is where it needs to be, they will need to lean forward. (See picture in BLM 7.2.1 - Activity 1.2)
3. Our ears and eyes help us balance. Canals in the ears are filled with fluid that detects any tilting of your head and feeds the information to the brain. Have students determine how our eyes contribute to balance by having them attempt to balance on one leg, first with their eyes closed, them with their eyes open. Ask students to place their right arm at their side. Have students lean against a wall so their right arm and the side of their right foot are against the wall. Have them attempt to lift their left leg while maintaining their balance. (See pictures in BLM 7.2.1 - Activity 1.3)
4. Stand with the right side of your body touching the wall or specifically, your entire right arm and the side of your right foot. Try to lift up your left leg and remain balanced. You won't be able to do it. To balance on your right foot you would have to shift the centre of gravity over that foot. In order to do that you have to lean in that direction. Since you cannot lean through the wall, you will need your left foot on the ground in order to keep your balance. (See pictures in BLM 7.2.1 - Activity 1.4)
5. With their feet together, have the students bend over and grab their toes with both hands. Ask the students to hop forward. In order to hop, the students must lean forward to shift their centre of gravity ahead of their feet. They will not be able to do this because they are hanging onto their toes. (See pictures in BLM 7.2.1 - Activity 1.5)
6. Encourage students to perform this activity at home with their parents. Before class try to find two adult volunteers (one who can perform the task and one who cannot). Generally adult females have an easier time with this task. Place a chair against a wall with the back legs touching the wall. Have a volunteer mark a spot two paces (heel to toe) from the wall. Have the volunteer stand facing the chair with their feet touching the marked spot. With feet shoulder width apart, have the volunteer pick up the chair. Have a volunteer attempt this task a second time. This time ask them to lean forward so their head rests against the wall. Ask them to reach down, grab the chair and stand upright. While some people will be successfully, most will not. Most people will have the sensation that their head is stuck to the wall. (See pictures in BLM 7.2.1 - Activity 1.6)
7. Using a gym mat, have the students kneel on the floor with their knees together. Next, have them put their arms on the floor in front of them, with their elbows against their knees. Put a domino on the floor at their outstretched fingertips. While still kneeling, have students take their arms off of the ground (therefore their upper body is upright) and clasp their hands behind their backs. While holding their hands behind their backs the students will try to lean forward and push over the domino with their noses. This activity is a lot of fun and a real icebreaker. However, watch their noses, we don't want anyone to get hurt. (See pictures in BLM 7.2.1 - Activity 1.7)

Structures and Mechanisms – Forms and Function -
– Centre of Gravity & Symmetry –

Description: This subtask will consist of four 40 minute activities which investigate the concepts of centre of gravity and symmetry. The second activity is based on the lever. In small groups, students will adjust the fulcrum of the lever to find the centre of gravity when unequal weights are placed on either end.

ACTIVITY #2 - Balancing A Lever

1. Create a first class lever using a metre stick and a triangular prism.
2. Balance the metre stick on a solid triangular prism with a weight (pop can, bean bag, hockey puck, metric weights, etc.) at each end. (See Levers - BLM 7.2.2 - diagram 1). Determine the weight of each of the object's used for weight 1 (w1) and weight 2 (w2). Note: The objects should be of equal weight for this activity. Measure distance 1 (d1) and distance 2 (d2). Record all the results on Levers Worksheet - BLM 7.2.3.
3. Hold on to the metre stick, and add another weight to one end. Slide the meter stick along over the triangular prism until it balances. (See BLM 7.2.2 - diagram 2).
4. Add another weight to the double-weighted end of the metre stick, balance it, determine w1 and w2, and measure d1 and d2 as before. (See BLM 7.2.2 - diagram 4). Record your results Levers Worksheet - BLM 7.2.3.
5. Predict what the distances d1 and d2 will be if you add another weight. Add the weight and check your prediction. Record the results for w1, w2, d1 and d2 on the Levers Worksheet - BLM 7.2.3.
6. Predict what the distances d1 and d2 would be with two weights one one end, and three weights on the other. Then check your prediction. Record your results using the table found on Levers Worksheet - BLM 7.2.3.
7. Based on the observations and data collected from this experiment have students develop a rule for balancing weight and counterweight?

Notes: In order to balance equal masses, the fulcrum must be exactly in the middle of the lever arm. In order to balance unequal masses, you have two variables (distance from the fulcrum and mass) to consider. Once you place a specific mass on one side of the lever arm, you need to measure the distance between that mass and the fulcrum. Once you have this measurement, you have two choices in relation to the opposite lever arm in order to achieve balance.

a) double the original distance measured (always measure from the fulcrum) and half the original mass. Example: If a mass of 100g was placed at a distance of 5m from the fulcrum, then a placement of a 50g mass at a distance of 10m from the fulcrum on the opposite arm, would balance the lever. OR
b) half the original distance measured and double the original mass. Example : If a mass of 100g was placed at a distance of 5m from the fulcrum, then a placement of a 200g mass at a distance of 2.5m from the fulcrum on the opposite arm, would balance the lever.

Structures and Mechanisms – Forms and Function -
– Centre of Gravity & Symmetry –

Description: This subtask will consist of four 40 minute activities which investigate the concepts of centre of gravity and symmetry. The third activity involves small groups in creating a symmetrical flying structure from a thin sheet of Styrofoam. Students will be required to test the stability of their flying structure and observe the effect a change of symmetry has on its stability or function.

ACTIVITY #3 - Airplane Symmetry

1. Have the students fold a piece of paper in half, then cut out a design. Have the students unfold their paper. They will have created a symmetrical design with the fold being the line of symmetry. (see Symmetry - BLM 7.2.4 - diagrams 1 and 2).
2. Ask students for examples of symmetry that occur in the outside world. Some examples might include: butterflies, birds, the CN tower, a daisy, a spider, insects, a bed, forks, spoons, etc. Most students have a knowledge of bridge construction which was a grade 5 unit. They should understand that bridges are symmetrical in design so that they bear the load evenly.
3. Have students discuss examples of symmetry in nature. Lead students to the idea that birds could not fly if they were not symmetrical.
4. To further their knowledge of symmetry, have students design and build an airplane from a thin sheet of Styrofoam (See Symmetry - BLM 7.2.4 - diagrams 3 & 4).
5. The students should test the stability of the airplane in flight (See Airplane Fan Test - BLM 7.2.5). Note: A well designed plane should remain relatively stable in the wind created by the fan. If the plane is not stable, the students should attempt to alter the design. Encourage students to keep a record of each alteration and to observe the effects each alteration has on the flight of the airplane. Remind students that they are attempting to maintain "symmetry" in their design. From this activity students should conclude that symmetry and centre of gravity help determine whether a structure is stable or not.
6. Each student should complete a response journal. The journal should include the following:
    a. a definition of symmetry, including examples
    b. a sketch of their flying structure (airplane)
    c. sketchers to illustrate any alterations they made to their airplane, with a description of the effect of each alteration
    d. a summary of what they learned

Structures and Mechanisms – Forms and Function -
– Centre of Gravity & Symmetry –

Description: This subtask will consist of four 40 minute activities which investigate the concepts of centre of gravity and symmetry. The final activity requires students to apply what they have learned about symmetry and centre of gravity and the effect they have on the stability of a structure.

ACTIVITY #4 - Symmetry and Centre Of Gravity

1. Have the students work in small groups to build towers using wooden blocks. Give each group ten blocks and instruct each group to build a tall, stable structure. Remind the students that symmetry and centre of gravity will have an effect on the stability of a structure.
2. Give each group ten blocks more. Repeat as above.
3. Give each group another twenty blocks. Repeat as above.
4. Discuss with the students what they have learned, and have them record their observations in their response journals.
    - How does the symmetry of the tower effect its stability?
    - How does the centre of gravity of the tower effect its stability?
    - How do symmetry and centre of gravity effect the height of the tower?
    - What factors need to be considered in order to make a tall, stable tower?

Centre of Gravity

BLM 7.2.1

Activity 1.2

Try and stand

Activity 1.3

Balance on one leg

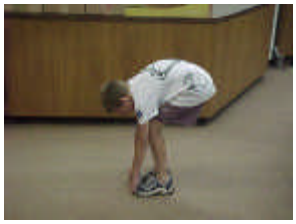
Eyes Open

Eyes Closed

Activity 1.4

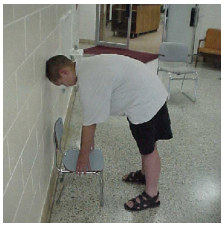
Lean against the wall

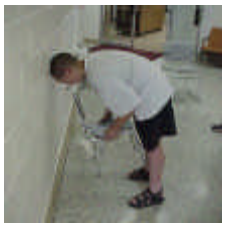
Acti vity 1.5



Hop holding onto toes

Activity 1.6



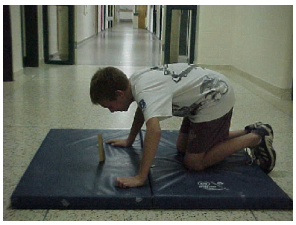


Pick up chair, stand up with head on the wall

BLM 7.2.1 page 2

Activity 1.7

Push over domino with your nose



Levers

BLM 7.2.2

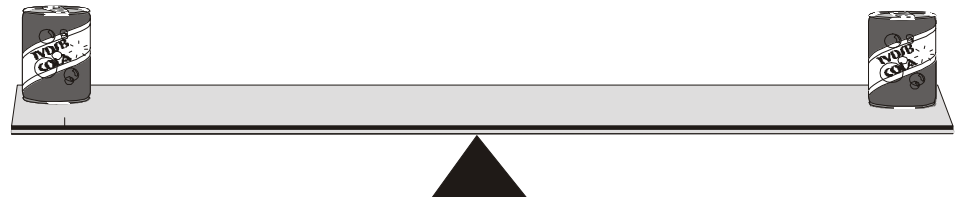
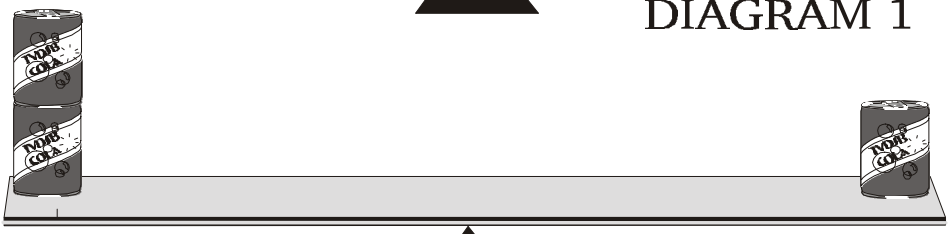


DIAGRAM 1



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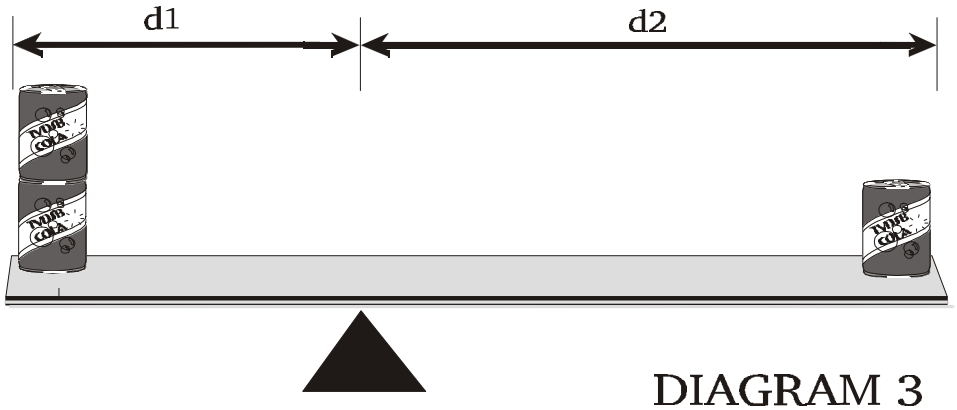

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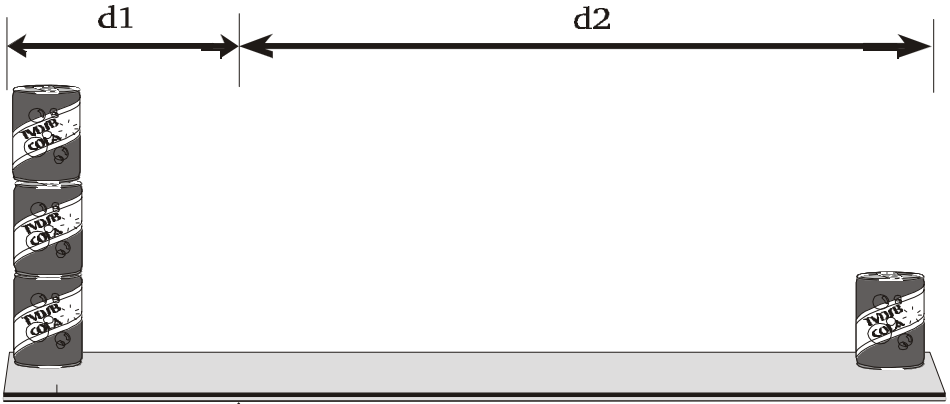


DIAGRAM 4

BLM 7.2.3

Levers Worksheet

Record your results using the following chart:

W_1 (g)	d_1 (cm)	W_2 (g)	d_2 (cm)	$W_1 \times d_1$	$W_2 \times d_2$

Based on the observations and data collected from this experiment, create a rule for balancing weight and counterweight.

Symmetry

BLM 7.2.4

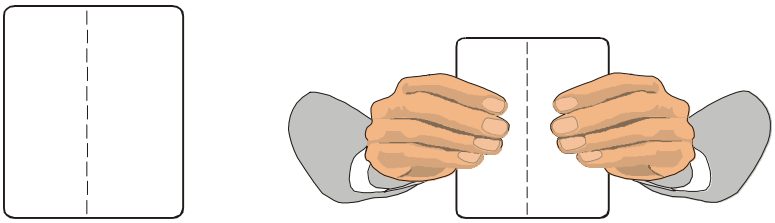
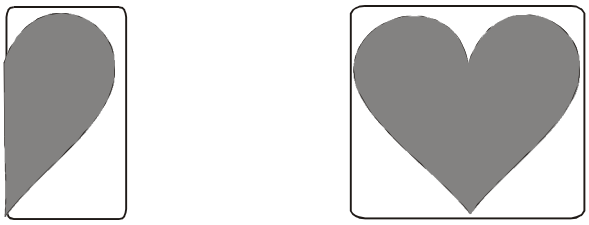


DIAGRAM 1



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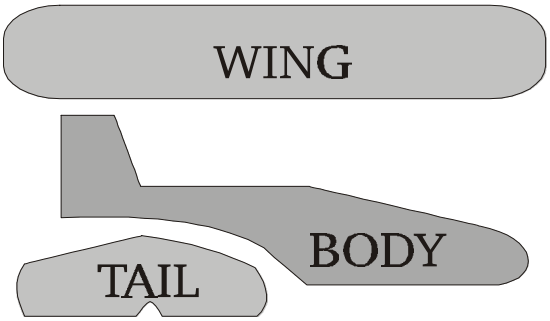

DIAGRAM 3

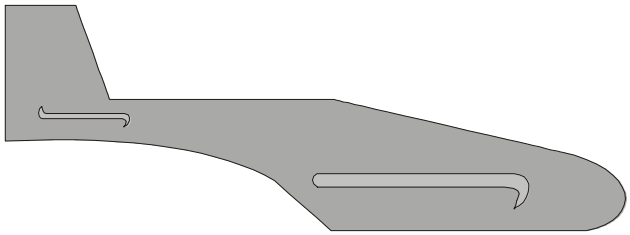

DIAGRAM 4

BLM 7.2.5

Airplane Fan Test

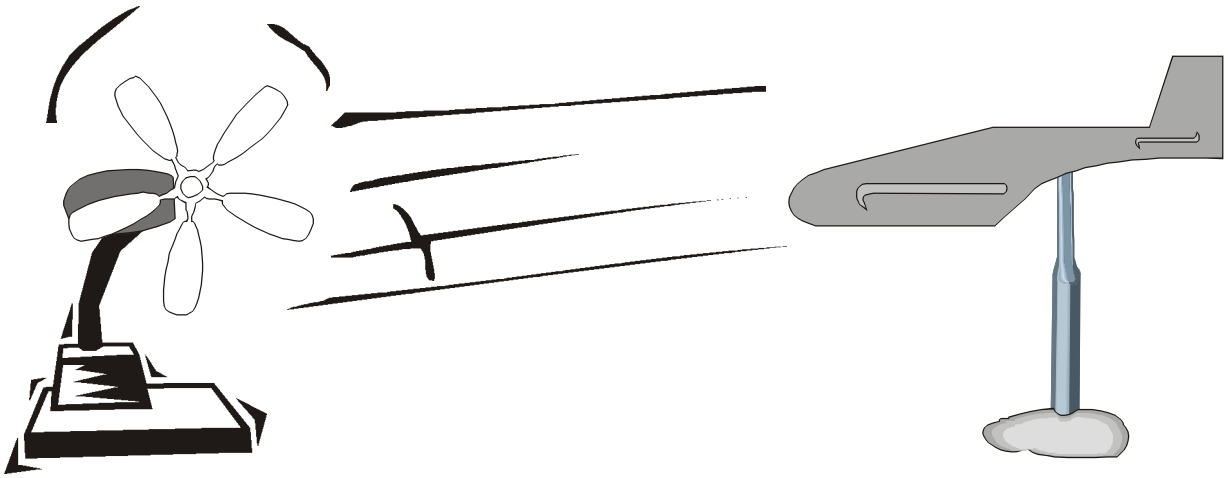

DIAGRAM 1

1. Place a clump of plasticine on a flat surface (desk, table, etc.)
2. Insert the needle into the plasticine.
3. Balance the airplane on the needle.
4. Turn on the fan.
5. Observe how the wind affects the stability of the airplane.