This *Biomechanics Education Activity* developed for the STEM Outreach Expo at the 40th Annual Meeting of the American Society of Biomechanics (ASB40)

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Topic	**Take home points**
Muscle Moment Arm	**Moment arm:** Perpendicular distance from the **line of action** (muscle) to the **pivot point** (elbow joint). The length of the bicep's muscle moment arm, dictates the amount of force the muscle has to generate to lift something. Longer moment arm= Less muscle force needed Shorter moment arm= More muscle force needed

YouTube Video

Title: ASB40: Awesome Moment Arm Demo and Lab Activity
Link: https://www.youtube.com/sample

Supplies

Demo: Oversized Arm Model

- (1) ¾" x 48" dowel rod or broomsticks
- (2) 5lb. bag of flour
- 10 ft Rope
- Electrical tape
- Tape measure

Estimated Cost: $29.29

Lab Activity: Desk Sized-Arm Model

- (4) Rulers
- (2) Machine screws (we used 10-32 x ¾)
- (3) Nuts (we used 10-32)
- (3) Small binder clips
- (1) Medium binder clip
- 40" String or yarn
- 200g weight (alternative: a ziplock bag filled with ~80 pennies)

Estimated Cost: $23.34

Directions

Demo: Oversized Arm Model

1. Secure 5lb bag of flour to the end of the dowel rod using electrical tape.
2. Tie rope to the dowel rod.
3. Place one foot on the end of the dowel rod opposite the flour to form the pivot point.
4. Hold the free end of the rope at the waist.
5. Indicate what each of the following represent in the demonstration:
   Flour- a load in the hand; Dowel rod- Forearm; Standing on the end of the dowel rod- Elbow joint (pivot point); Rope: Biceps muscle (line of action)
6. Have a volunteer measure the moment arm (distance from the rope (line of action) to the pivot point (foot on top of the dowel rod). Be sure to orient the tape measure perpendicular to the rope when making this measurement.

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7. Pull the rope (to model contracting the biceps muscle) to show how hard or easy it is to lift the load with a certain muscle moment arm length (longer moment arm= easier; shorter moment arm= harder)
8. Move the attachment point of the rope on the dowel rod.
9. Repeat steps 6 & 7.

Lab Activity: Desk Sized-Arm Model

1. Construct the Desk Sized Arm Model (see above YouTube video @ 1:33)
   - Using 1 screw and a nut, screw 3 rulers together at least 1” from the end of the rulers. Reserve the fourth ruler to make measurements.
   - Pivot center ruler 90° to form a right angle. The center ruler will represent the forearm.
   - At the end opposite the pivot point, screw the two outside rulers together, with two nuts between them to form the upper arm
   - Place the small binder clips on the bottom of the center ruler, at Position A:3” inches past the pivot point, Position B: 5” past the pivot point and Position C: 7” past the pivot point past the pivot point. Flip the arms of each upward.
   - Clamp the medium binder clip to the ruler ends below the pivot point to form a base.
   - Thread the string through the Position A binder clip and the space between the two outside rulers such that the string sits on the bolts separating the two outside rulers.
2. Measure the muscle moment arm length (perpendicular distance from the string (biceps muscle) to the pivot point (elbow joint))
3. Set the model upright on the edge of a desk. Pull the end of the string straight back so the string is parallel to the table top to evaluate how difficult it is to lift the 200g load
4. Repeat steps 3 and 4 for the binder clips at Position B and Position C.
5. Rank how much muscle force needed to move the load at each position as: least, middle, and most.

Recommendations for Classroom Implementation

Hook: Show students the **Oversized Arm Model** and explain the definition of a muscle moment arm. Do not actually pull on the rope to attempt to lift the load with different muscle moment arm lengths (Steps 1-6 only). Instead pose the scientific question: “How does muscle moment arm length change the amount of muscle force needed to lift an object?”
Hypothesis Forming: Ask students to make a hypothesis for this question.
Ex: I hypothesize that as muscle moment arm length increases/decreases it will take less/more muscle force to lift an abject.
Lab Activity: Have students test their hypothesis by making the **Desk Sized-Arm Model**, measuring the different muscle moment arm length based on the 3 small binder clip attachment points, and ranking each how much muscle force (least, middle, most) is required to raise the load at each position. Have students decide whether their hypothesis is accepted or rejected based on their results, and draw final conclusions.
Class Discussion: Discuss results of the lab activity as a class and whether or not their hypotheses were correct.
Closing: Once again show **Oversized Arm Model.** Have students give their hypothesis for which muscle moment arm length will require more force or be more difficult to lift the 5lb. load (short moment arm or close rope attachment vs. long moment arm or farther rope attachment). Complete the demo to show that: <u>Longer</u> moment arm= <u>Less</u> muscle force needed <u>Shorter</u> moment arm= <u>More</u> muscle force needed.

Additional Information *(Optional)*
Despite cheetahs and greyhounds being similar in size, cheetahs can reach much faster top speeds (~65 mph) compared to greyhounds (~38mph). This disparity can be partially explained by the finding that most leg muscle moment arms are longer in cheetahs than in greyhounds. Hudson, P. E., et al. (2011). Journal of Anatomy 218(4): 363-374.

Estimated Cost Justification:

Demo: Oversized Arm Model		**Lab Activity: Desk Sized-Arm Model**	
Item	*Subtotal*	*Item*	*Subtotal*
(1) ¾" x 48" dowel rod or broomsticks	$2.82	(4) Wooden rulers	$2.00
(2) 5lb. bag of flour	$4.80	(2) Screws (we used 10-32 x ¾)	$1.28
10 ft. rope	$6.80	(3) Nuts (we used 10-32)	$9.57 (30 pack)
Electrical tape	$3.88	(3) Small binder clips	$1.39 (12 pack)
Tape measure	$6.99	(1) Medium binder clip	$1.47 (12 pack)
(1) ¾" x 48" dowel rod or broomsticks	$4.00	40" String or yarn	$2.88 (whole spoll)
		200g weight	$4.75
Total	**$29.29**	**Total**	**$23.34**

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