Drexel-SDP GK-12 ACTIVITY

Activity Template

Subject Area(s)
Data analysis & Probability, Measurement, Number & Operations, Physical Science

Associated Unit

Simple Machines

Activity Title:

"Arm Power"

Grade Level:

7th-8th

Time Required:

1 hour

Group Size:

3 students per group

Expendable Cost per Group

US $5

Summary
In this activity students learn how to use Physics equations to calculate the amount of work their muscles do during an exercise. Specifically, by doing an arm curl activity and measuring the distance that the weight travels students can calculate the work and power that their biceps and triceps output. Then the students will graph the class' results in a bar graph to determine who is the strongest.

Engineering Connection
Engineers often think of power when speaking of the work output of a machine. They must know how to calculate power and work in order to properly design machines. In many ways, the human body acts like a machine. So many of the principles of mechanical engineering and physics can be applied to the body. Furthermore, It is important for biomedical engineers to understand how muscles output work and power for many physiological applications.

Keywords
Work, power, biceps, triceps, flexion, extension, lever, resistance, fulcrum, effort, joint

Educational Standards
- Science: 3.4.10.C
- Math 2.2.8.A
- Math: 2.6.5.A
- Math: 2.7.8. B
- Math: 2.8.3.G, H

Pre-Requisite Knowledge
- Understanding the three classes of levers
- Making a Bar graph

Learning Objectives
After this lesson, students should be able to:
- Recognize the three different types of levers in the human body
- Convert measurements between the English System and the Metric System
- Calculate work and power exerted during an arm curl exercise

Materials List
Each group needs:
- Ruler or tape measure
- Stopwatch
- Weight (dumbbells 2-5 lbs)

To share with the entire class:
- Weighing Scale

Introduction / Motivation
Who thinks they are the strongest in the class? We are going to settle this once and for all today by doing a common weightlifting technique. If you have ever lifted weights for fun or for exercise you probably have done an arm curl. It is one of the most basic

exercises that help strengthen your arm muscles. When you flex your arm you are working out your biceps and when you extend your arm back to the starting position you are working out your triceps. In fact, whenever you do any type of exercise you are working out some part of your muscle.
But why do we call it a “work out”? It turns out that whenever we do an exercise your muscles are literally doing physical work. Work is a value that engineers use to quantify the amount of force moved in a particular direction. The body is truly a well-tuned machine that exerts force and power every time it moves. For example, if you think of the arm as a lever, you have a fulcrum at the elbow, you have a resistance coming from the weight at your hand and you have the effort at your muscles (Figure 1). Just like a third class lever, the distance between the weight and your muscles allows you to easily lift the weight up to your shoulder. By counting the number of repetitions in 30 seconds we can calculate the power that your arm uses to complete the exercise. This will give you an idea of how strong you are.

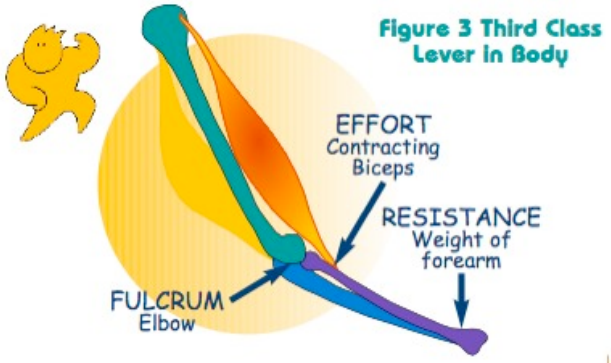

Figure 1: The arm works like a third class lever with a fulcrum, effort and resistance at the elbow, biceps and hand, respectively.

Vocabulary / Definitions

Word	Definition
Lever	A rigid bar on a pivot used to move a heavy object
Fulcrum	The point or pivot that supports the lever
Effort	The force exerted by a machine or in this case the muscle
Resistance	The load lifted by a lever
Flexion	The action of bending the arm
Extension	Action of moving the arm from a bent to straight position
Forearm	Part of the arm from the elbow to the wrist
Biceps	Large muscle in the upper arm
Triceps	Large muscle at the back of the upper arm
Joint	Part of the body where two bones meet, in the case of a lever it acts like a fulcrum
Power	The capacity to do work or the energy that is transmitted – for the point of this activity it refers to the strength of the arm
Work	The amount of force moved over a distance

Procedure
Background
The 30-second arm curl test is a good predictor of arm flexor strength. Students can calculate the power in their biceps by performing the exercise, measuring the distance their arm moves, calculating the work done and then counting the number of repetitions they can do in 30 seconds.
The force is easy to calculate since it is equal to mass x gravity, F = m x g, in other words the number of pounds of the weight multiplied by 9.8 will give you the force. From there the students can calculate the work done by their arm each time they lift the weight. W = F x d. The key here is to remember that work will only depend on the height the weight moves. So if the students are in a standing position then they should measure the length of their arm from the hand to the shoulder. Then they can multiply the force calculated earlier by the distance moved to get the work done.

Finally power is equal to the total work done divided by the time it took. P = W / t. In this case they have to multiply the work calculated by the number of repetitions and then divide that by 30 seconds. This will give the students "the power of their arm".

Before the activity
- Have worksheet prepared and enough copies for each student.
- Bring enough dumbbells for each group.

With the students:
Students will be divided into groups of 3 and each given a 5 lb dumbbell weight. Each member will have a role:
Member #1: Lifter
Member #2: Time Keeper
Member #3: Recorder

The main point of the activity is to determine how much work and power is exerted during an arm flexion exercise. A student will be given 30 second to lift a dumbbell weight as many times as they can.

Step by step directions:
1. Sit on chair with dumbbell
2. Have the lifter and recorder measure the length between the hand to the shoulder.
3. Hold weight in a handshake grip with arm fully extended to side of chair
4. Curl weight by flexing elbow while turning palm of hand toward shoulder
5. Lower until elbow is straight
6. Repeat curling until 30 seconds expires according to the timekeeper
7. Have recorder count the number of full repetitions during the allotted time and record it on your table.
8. Calculate the force by using the F=MA equation or in other words multiplying the weight of the dumbbell by 9.8 (Gravity).
9. Calculate the work done during each repetition by using the W=FD equation or in other words the force multiplied by the length of the arm.

10. Calculate the power done using the P=W*reps/time equation or in other words multiply the work done by the number of repetitions and then divide it by the time it took (30 seconds).
11. Repeat exercise 5 times to collect enough samples.
12. Take the average of each trial and give your average power to the teacher.
13. If there is time and everyone in your group has done the exercise then repeat experiment with your other arm.
14. Compare results with the class.

Table 1: Work and power done by the arm during an arm curl

Trial	Arm Length Distance (m)	Curl Distance (m)	Weight (N)	Work (N-m)	Number of Reps	Time (sec)	Power (Watts)
1							
2							
3							
4							
5							
Average							

Safety Issues

- The dumbbells should not exceed 5 lbs in weight that way no one over exerts themselves while performing the exercise.
- Use small dumbbells that are easy to grip so students do not drop them by accident.

Investigating Questions

1. What are some other ways that the human body acts like a machine?
2. Based on the values you calculated for the work, how do you get a better work out? By lifting a light weight for more repetitions or by lifting a heavy weight for a few repetitions?

Assessment

Pre-Activity Assessment

Title: Arm weight estimate

Engage the students in the class by asking them how much they think their forearm and hand weighs. The two together, should be about 2.5% of their total body weight. So if a student weighs 120 lbs then their hand and forearm will weigh 3 lbs. Make the connection that everyday their biceps and triceps are lifting about 3 lbs of weight every time they move. Have the students estimate how many times a day they lift their arms and then have them calculate the work and power that their arms do everyday.

Activity Embedded Assessment

Title: Arm Power Worksheet

During the activity, students will use their data collected (arm length, weight, number of repetitions) to calculate the work and power done by their arm and then record it on their worksheet. Power will be compared in one class graph to see who had the most power.

Post-Activity Assessment

Title: Class wrap up

Together, review the class bar graph that shows the power done by each person. Ask students who used the most power during the exercise. Ask students what was the average power used by the class.

References

Figure 1 obtained from www.teachhealthk-12.uthscsa.edu. Teacher Enrichment Initiatives - Levers Unit

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