## Activity #4: Pace Yourself (Teacher Notes)

**Purpose:**

This activity is an example of inexpensive ways to collect and analyze some data about motion. Two different methods will be used and compared.

**Materials and Procedures:**

We need a way to measure time. Expensive stopwatches are out because we are doing this on a budget. So let's borrow the music department's metronome. The metronome repeats its motion in a very regular way[1]. Assuming that we have a clock of some kind available, how can we find the time interval between ticks on the metronome?

1. Write down the idea you and your partner developed. *Use the clock to measure the time for several ticks of the metronome, and then divide by the number of time intervals.*

   Discuss as a group to see what kinds of ideas are available. Discuss the limitations that dictate how many ticks should be timed.

2. Write down different ideas that you heard in the discussion. *Results will vary.*

3. Pick one of the methods and use it to determine the time that elapses between ticks. Make a data table in the space below and explain how you decided what the time interval is between ticks.

   *The results here may be similar to the data table, analysis, and result for Activity #4, Investigation of Flashing light.*

4. What do you have to do to the metronome to change the time between ticks? *Move the rider up (slower) or down. This is similar to an inverted pendulum.*

5. What quantitative effect do you think the change would have on the time interval? *Moving the rider up make the metronome swing slower, and thus the time interval is smaller.*

6. How can you test your hypothesis? *Make the measurements.*

[1] If a metronome is not available, you can set up a simple pendulum and clap to the beat of the pendulum.

7. Try it and write a conclusion based upon the data you collect and analyze.

*Graphs will be similar to the graphs for Activity #4, Investigation of a Flashing Light.*

Attach your data table(s) and analysis of the data. Title it, One Factor That Affects the Period of the Metronome.

Set the metronome on a setting that you have studied and clap with the tick. Discuss with your partner how you can use the tick pattern to study something about your rate of walking.

8. Write down one idea that you two thought about and discussed.

*Use the metronome as a clock. Anything that repeats at a regular rate can be used as a clock.*

9. What other equipment do you need to use to carry out your idea?

*Something to measure distance*

10. Describe the kind of motion that you think would be the easiest to study for the first try.

*Student walking at a constant speed. Student walking with constant can carry a supply of sugar packets and drop one each time the metronome ticks.*

Discuss with the class what the motion should be like for this first exercise and some methods that different groups think they would like to try to measure the motion.

11. Assume that you would like to compare the results from one group to another. What considerations have to be discussed before you begin in order to do that? Why? *Each group needs to use the same metronome or account for different ticking rate. This is an example of standardization.*

Form a team of four to six and collect enough data to convince the class that you have measured something about the rate of motion of one of the people in your group. Attach your data, analysis, and conclusion. Title it, One Person's Rate of Motion.

Bring your paper work to the class discussion to share with the group. Listen to the other group reports and write a note about the best method one of the groups used.

12. Tell why you think that it was one of the best methods.

Go back to the metronome. We found the time between repeating events. This is called the period of the metronome.

13. What do you have to do differently to find the number of events (i.e., ticks) that occur in a given interval of time? *Number of event is frequency and this can be found by measuring the number of ticks in a certain time (e.g., minute) or by calculating the reciprocal of the period.*

14. Discuss with your partner and write down a method that could be used to find the number of ticks in a given interval of time (i.e., frequency) of the metronome using the same setting that you used for the previous motion analysis exercise.

In your laboratory group of four to six work out a method, collect data, analyze the data, and reach a conclusion about the frequency of the metronome. Attach your evidence and concluding remarks. Title it, The Frequency of the Metronome.

Compare your results with the class results in the large group discussion. Then meet with your group of four to six again. Have someone in your group match his or her pace rate with the frequency of the metronome and walk with a constant gait. Discuss how you could measure the pace-length (i.e., gait) of the walker.

15. Write down a method to use to measure pace-length. *One method would be to make several paces measure distance and divide by the number of paces.*

Collect sufficient data to determine the pace-length of your walker. Attach your data chart, the analysis of your data, and the value you have determined. Title it, One Walker's Pace-length.

If your walker's pace frequency is the same as the frequency of the metronome, then how can you use the pace-length data with the pace frequency to determine how fast the person is walking? What is the person's rate of motion?

16. Describe what you would do mathematically to find the person's speed using the pace-frequency (f) and the pace-length (L) and explain why it works. *speed equals pace-frequency times pace-length or $v = fL$. Speed is distance divided by corresponding time., $v = d/t$ for one pace this becomes $v = L/T$ and since frequency is reciprocal of time $f = 1/T$, then $v = fL$.*

17. Determine the value of the walker's speed. Show your mathematical method.

**Conclusion:**

18. Look at the purpose of the activity. Write a conclusion describing two ways to collect and analyze data about motion. Include a comment on the limitations of each method and which one you think is more reliable. If you do not think there is a more reliable method, then explain why you think that there is no difference.

A comfortable setting for the metronome is 84 beats per minute. This is equal to frequency of 1.4 Hz and a period of 0.71 s.

Note the similarity of picking a unit of time and then counting the number of beats versus measuring the time for a number of beats. In one case you pick the beats and then measure, in the other case you pick the time and count the beats. This is much like pick the number of paces and measure the distance, versus pick the distance and count the paces.