

The Goniometer Lab

Introduction:

The Goniometer lab will allow students to use their own bodies as experimental apparatus. Students will be able to analyze motions such as walking, running, throwing and kicking using their own arms and legs. They can also explore the physics of rotational dynamics as well.

The Goniometer equipment measures and records the angle, angular velocity and angular acceleration of an elbow, knee or hip on your own body!

Note: The probe measures zero degrees (or radians) when fully open. A clockwise rotation of the narrow arm of the goniometer is measured as increasing angle.

Set-up:

- ◆ You can mount the goniometer on your body in two ways:
 1. Place the mounting straps on limbs, then stick the probe arms to the outside of the strap
 2. Place the mounting straps on limbs, and tuck the probe arms into the overlapping portion of the straps, to make more secure.

If strapping to the elbow, place one mounting strap on the lower part of the arm and one on the upper part of the arm, aligning so the probe's hinge is aligned with the elbow joint.

If strapping to the knee, place one mounting strap on the lower part of the leg and one on the upper part of the leg, aligning so the probe's hinge is aligned with the knee joint.

If strapping to the hip, place the large strap around the waist and the small strap (or both small straps end to end) around the upper thigh. Align the probe's hinge with the hip joint.

- ◆ Connect one goniometer probe to the angle sensor. Connect the angle sensor to a PASPORT interface. You can select units of degrees or radians in the software.
- ◆ For normal movements, the default sampling rate of 20 Hz is sufficient, but for faster movements you may wish to increase your sampling rate to 50 or 100 Hz.
- ◆ Data will have a lot of variation, so you can use the smooth function in DataStudio to make data easier to interpret.

Experimental Activities

A. The Knee and Hip

Collect angle data of the knee while walking.

1. Does it approximate simple harmonic motion? Explain what you observe.

Collect data for the following:

- ♦ Lower leg freely dangling about the knee showing simple harmonic motion. To test, have the student seated on a high surface
- ♦ Leg with unbent knee freely dangling about the hip. To test, have the student standing on the opposite foot on a low surface.
- ♦ Leg with knee bent at a right angle freely dangling about the hip.

2. Do angle, angular velocity and angular acceleration approximate simple harmonic motion?

3. Determine the period, frequency and amplitude of the oscillations

4. What is the relationship between the phases of angle, angular velocity and angular acceleration.

5. How does bending the knee affect the frequency of the dangling leg?

B. The Hip

Collect angle data of the hips during walking, fast walking and running.

1. How does the angle of forward rotation compare to the angle of backward rotation?

Compare the range of movement and period of oscillation for walking, fast walking and running.

2. What patterns do you observe?

Compare the data from walking, fast walking and running between you and your lab partner. Make graphs of range of motion and period vs. height.

3. Is there a correlation?

C. The Elbow

You will use the goniometer attached to your elbow to observe arc length vs angle. Mount your goniometer on your elbow so that flexing of the joint (bending your elbow) is measured as a positive angular displacement. Use your right arm if you're right-handed and left arm if you're left-handed.

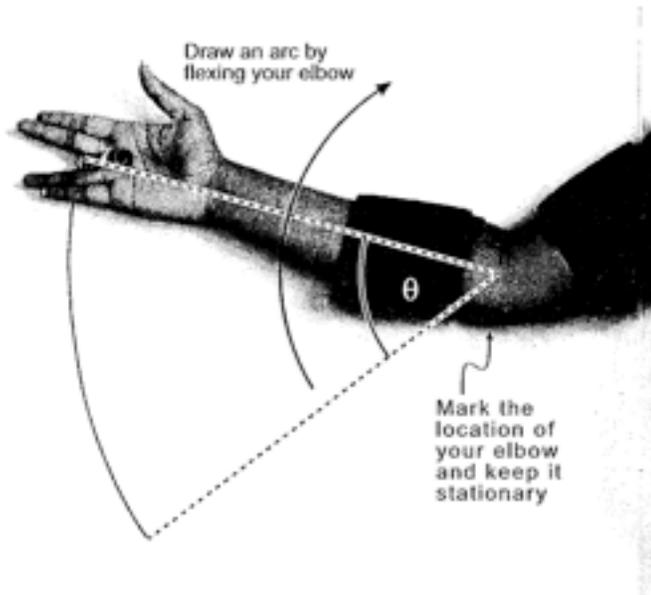
- ♦ Stand next to a white board with your arm relaxed at your side.
- ♦ Let your elbow and the *back* of your hand touch the board.
- ♦ Place a pen in your hand between your middle and ring finger so you can draw on the board while keeping the back of your hand closest to the board.
- ♦ Have your partner mark the location of your elbow on the board, and measure the distance from your elbow to the pen.

Procedure: (*See diagram*)

A. Fully extend your elbow and place the pen tip on the board

B. Start data collection

- C. Draw an arc on the board by flexing your elbow. Move only your forearm and hand, while keeping your elbow at the marked location on the board.
- D. Stop data collection



Analysis:

1. Look at the graph of **angle** vs **time**. According to the graph, what angle *in radians* did you trace out on the board? Arc angle = ??

2. When measured in radians, the arc angle (θ) is the ratio of the arc length (s) to radius (r). In this case, r is the distance from your elbow to the pen.

$$\theta = s/r$$

According to this theoretical relationship, and your measured values of θ and r , how far did your hand travel?

3. Measure the length of the arc that you drew, s_{actual} .

4. How does the theoretical value of s compare to the actual distance that your hand traveled?