Experiment HM-5: Flexibility and Range of Motion (ROM)

Equipment Required

PC or Mac Computer

IXTA, USB cable, IXTA power supply

GN-100 Single-axis goniometer

Velcro straps

Protractor

Small weight (optional)

Goniometer Set Up and Calibration

1. Locate the GN-100 single-axis goniometer.
2. Insert the DIN-8 connector on the GN-100 goniometer into Channel A5 of the IXTA.
3. Place the GN-100 Goniometer on the table with the 2 arms in the closed position. Use a protractor to measure the angle between each arm.

Figure HM-5-S1: The GN-100 goniometer.

4. Type **Closed** and the angle (in degrees) between the two arms in the Mark box.
5. Make sure the GN-100 goniometer arms are in the closed position. Click the Record button.
6. Record with the GN-100 goniometer in the closed position for 5 seconds. Click on the Mark button to label the recording. Continue recording.
7. Open the arms of the GN-100 as far as possible. Use a protractor to measure the angle between each arm.
8. Type **Open** and the angle (in degrees) between the two arms in the Mark box. The open angle should be 180 degrees or greater.
9. Make sure the GN-100 goniometer arms are in the fully open position. Record for 5 seconds. Click on the Mark button when the trace reaches a plateau.

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10. Click the Stop button.
11. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

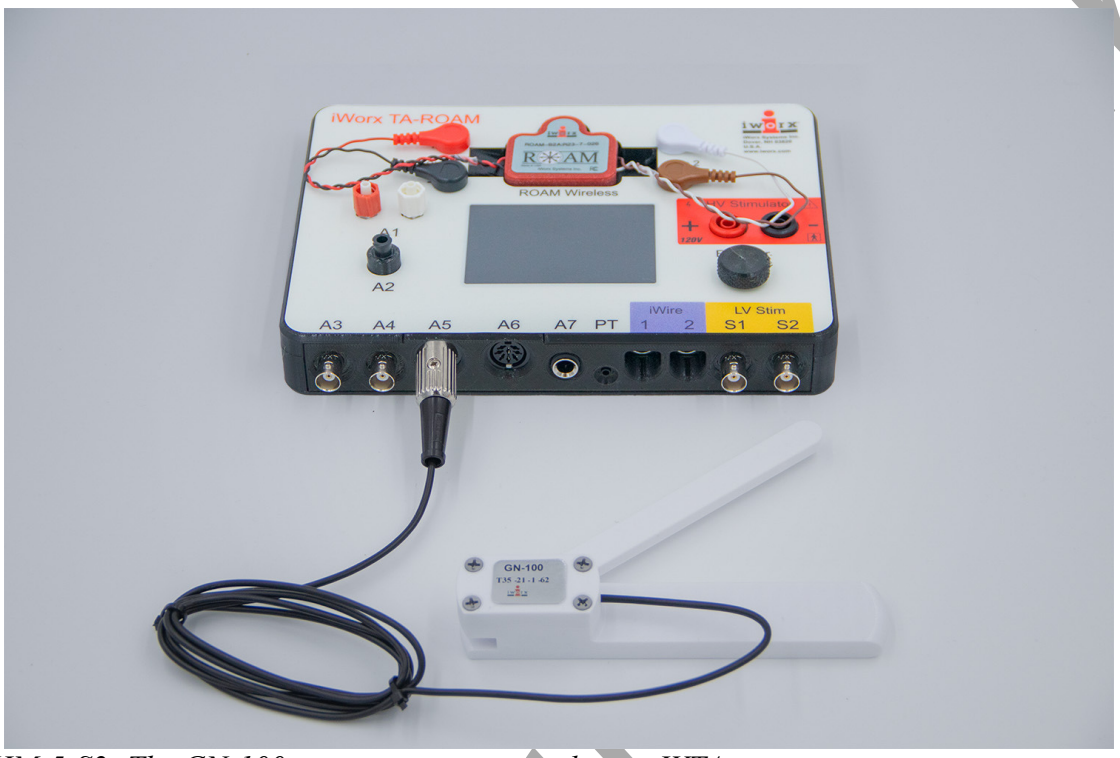

Figure HM-5-S2: The GN-100 goniometer connected to an IXTA.

Units Conversion

1. Scroll to the beginning of the calibration data for the GN-100 single-axis goniometer.
2. Use the Display Time icons to adjust the Display Time of the Main window to show the complete calibration data on the same window. The required data can also be selected by:
    - Placing the cursors on either side of data required;
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the calibration data to the width of the Main window.
6. Click the 2-Cursor icon on the LabScribe toolbar so that two cursors appear.

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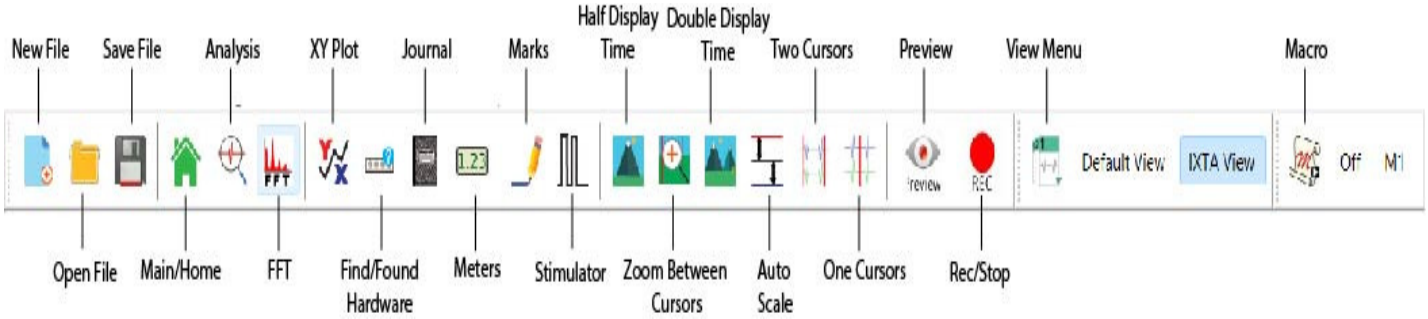

Figure HM-5-S3: The LabScribe Toolbar.

7. Place one cursor on the section of data collected when the goniometer was in the closed position, and the second cursor on the section of data collected when the goniometer was in the open position.

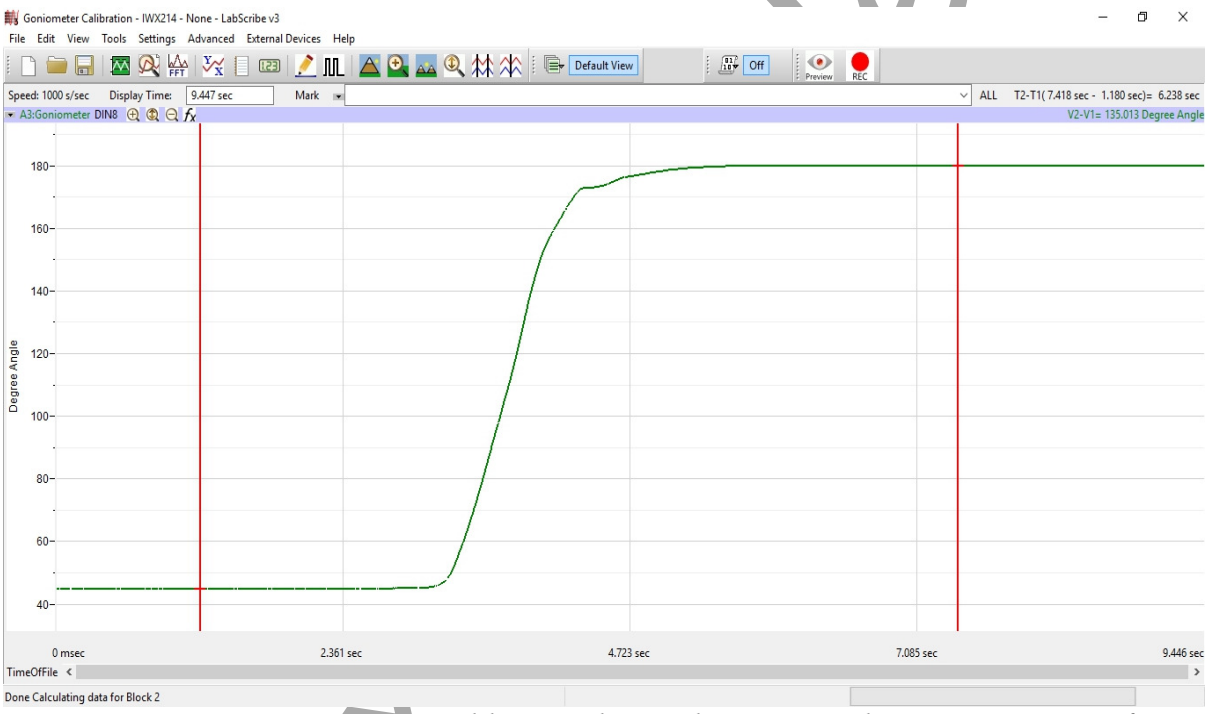

Figure HM-5-S4: GN-100 goniometer calibration data with cursors in the correct positions for converting the Y-axis angle of deflection (in degrees).

5. Open the Channel menu of the Goniometer Angle channel by clicking V2-V1 to the right of the channel. Select Simple.

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6. On the Simple Units Conversion dialogue window, make sure 2 point calibration is selected in the pull-down menu in the upper left corner of the window. Put check marks in the boxes next to Apply Units to new data and Apply Units to all blocks.
7. Notice that the voltages from the positions of the cursors are automatically entered into the value equations. Enter the values for the two angles used in the calibration recording in the corresponding boxes on the right side of the conversion equations.
    - For Cursor 1, the value is the angle when the goniometer is closed.
    - For Cursor 2, the value is the angle when the goniometer is fully open.
    - Enter the name of the units, Degrees, in box below the values.
    - Click on the OK button in the lower right corner of the window to activate the units conversion.

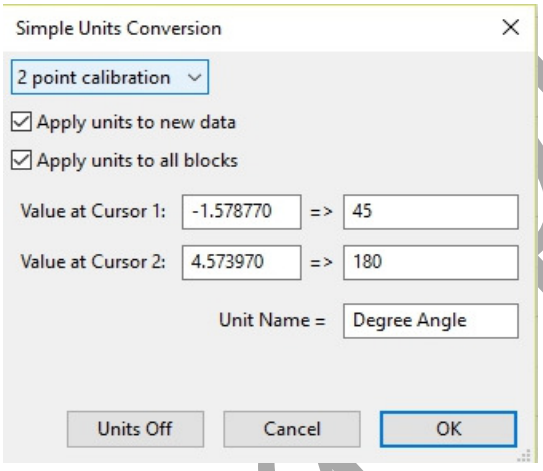

Figure HM-5-S5: The Simple Units Conversion dialogue window with the voltages at the cursors set to equal the closed and open angles of the GN-100 goniometer.

8. Click on the Save button to save the data file.

IWorx Sample Lab

Experiment HM-5: Flexibility and Range of Motion (ROM)

Exercise 1: Palmar Flexion and Extension of the Wrist

Aim: To study the range of motion (ROM) in the wrist.

Approximate Time: 20 minutes

Procedure

1. Strap the GN-100 goniometer to the right wrist of the subject using the Velcro straps so that the goniometer axis is located at the joint of the carpals with the radius and ulna. The straps should hold the goniometer firmly to the wrist but not restrict any movement.

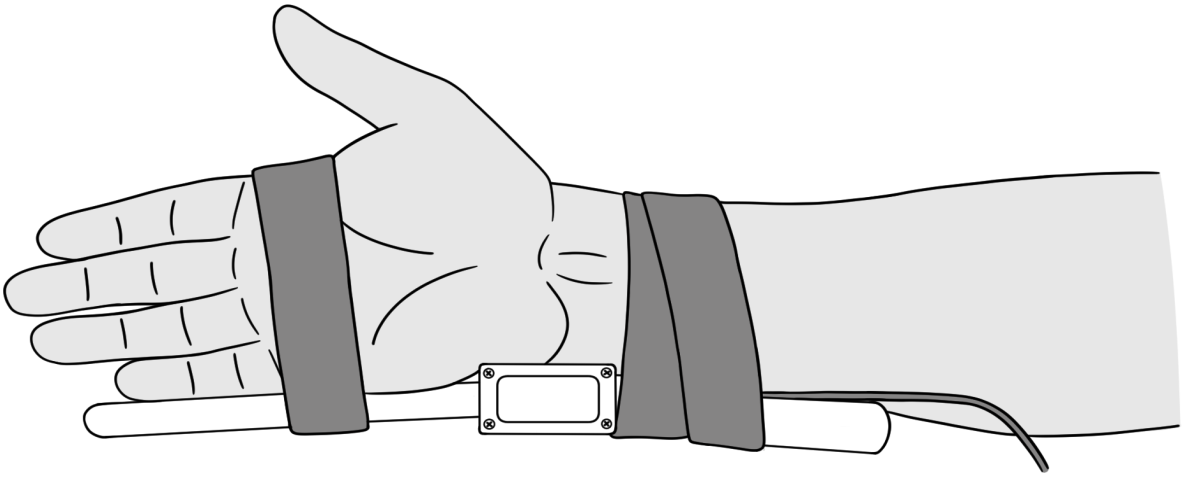

Figure HM-5-L1: Position of the GN-100 on the right wrist.

It may be easier to hold the goniometer in place with an ace bandage.

2. Instruct the subject that he or she will be doing the following during this exercise:
    - Before the recording begins, the subject extends their arm in front of their body with the palm facing upward. This position is defined as the *neutral position*.
    - Keep their hand open (fingers extended) during the recording.
    - Move their hand upward (palmar flexion) from the neutral position as far as possible and hold it in this position for five seconds.
    - Return the hand to the neutral position (extension) for five seconds.
    - Continue recording as the subject repeats the cycle of flexion and extension two more times.

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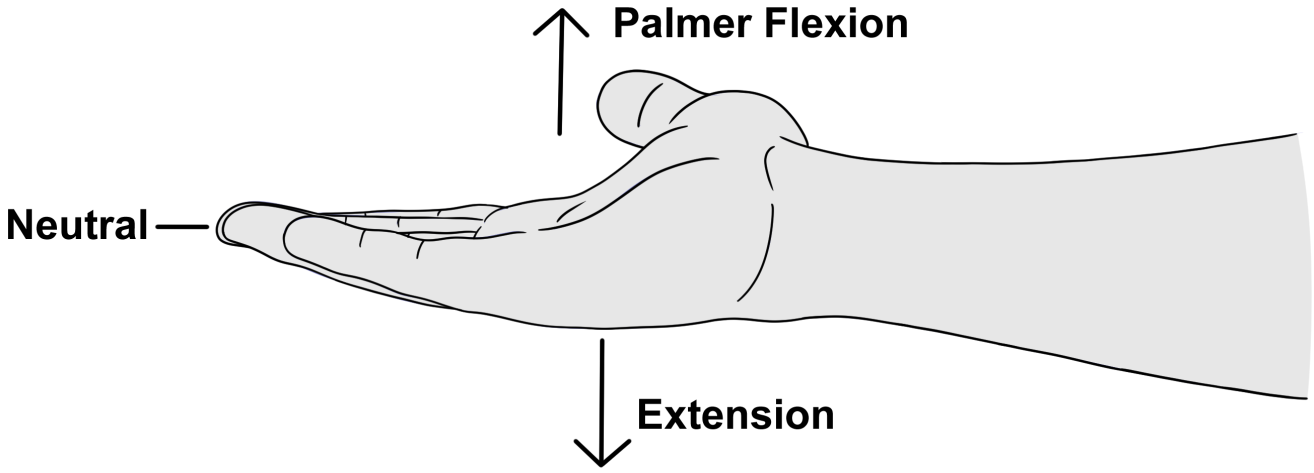

Figure HM-5-L2: Movements performed while recording palmar flexion and extension of the wrist.

3. Click the Record button.
4. Type **Neutral** in the Mark box and then click the Mark button.
5. While the subject's hand is in the neutral position, type **Palmar Flexion-Open** in the Mark box.
6. Instruct the subject to flex their hand. When the subject's hand reaches the flexed position, click the Mark button.
7. While the subject's hand is in the flexed position, type **Neutral** in the Mark box.
8. Instruct the subject to extend their hand back to neutral. When the subject's hand reaches the neutral position, click the Mark button.
9. Repeat Steps 3 through 8 for two more cycles of palmar flexion and extension.
10. Instruct the subject to curl their fingers into a tight fist. Repeat Steps 3 through 8 three times while the subject the subject is forming a tight fist. Mark the recording with appropriate comments to indicate when the subject's fist underwent palmar flexion or extension to the neutral position.
11. When the last cycle is completed, click the Stop button.
12. Select Save As in the File menu, type a name for the file. Click on the Save button to save the data file.

Optional Exercise 1: Repeat Steps 3 through 9 while the subject is holding a one pound weight in their right hand.

Optional Exercise 2: Attach the goniometer to the inside of the subject's left wrist. On this wrist, the moveable arm of the GN-100 can go below the neutral position. Use the same techniques used in Steps 3 through 9 to measure the range of motion of the subject's left hand as it undergoes hyperextension.

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Data Analysis

1. Scroll through the recording and find the section of data recorded while the subject was flexing and extending their hand.
2. Use the Display Time icons to adjust the Display Time of the Main window so that the extension-flexion cycles performed while the subject's hand was open appear on the Main window. The extension-flexion cycles can also be selected by:
    - Placing the cursors on either side of a few adjacent cycles; and
    - Clicking the Zoom between Cursors button on the LabScribe toolbar to expand the segment with the three cycles to the width of the Main window.

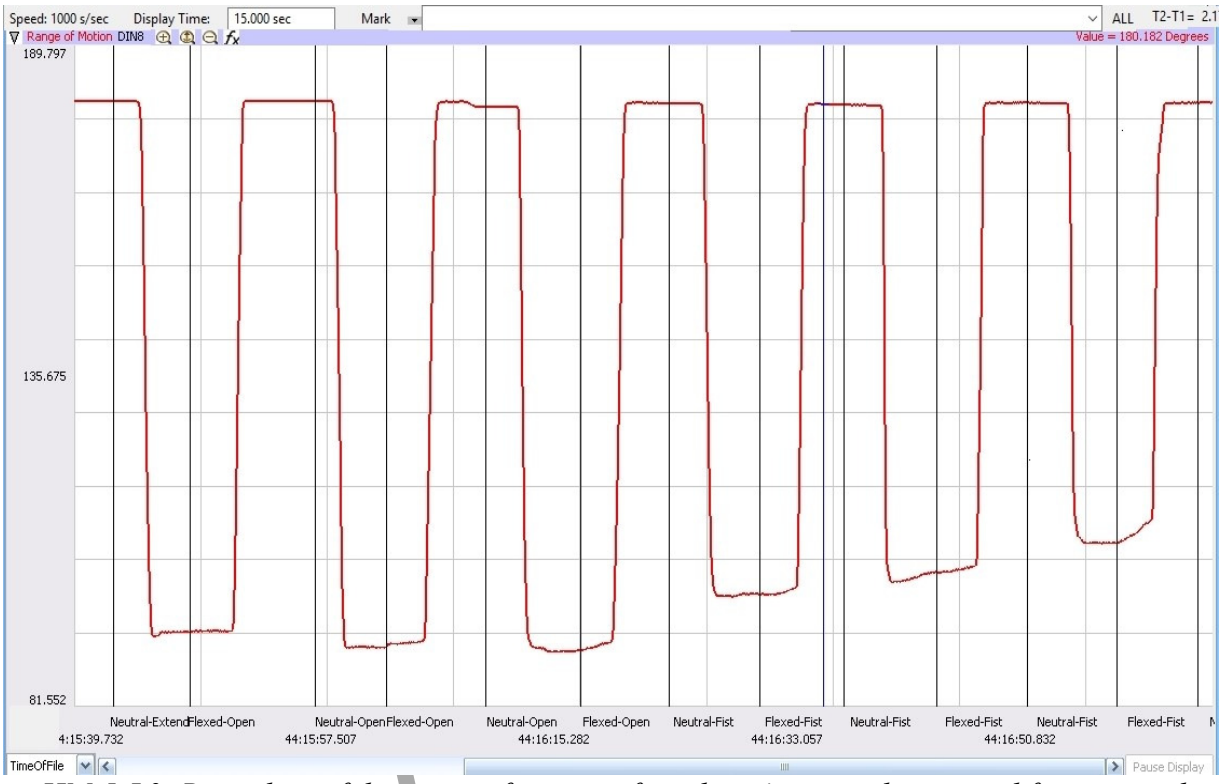

Figure HM-5-L3: Recording of the range of motion of a subject's wrist when moved from neutral to full flexion, while the subject's hand was open (first three flexions) and then curled into a tight fist (last three flexions).

3. Click on the Analysis window icon in the LabScribe toolbar.

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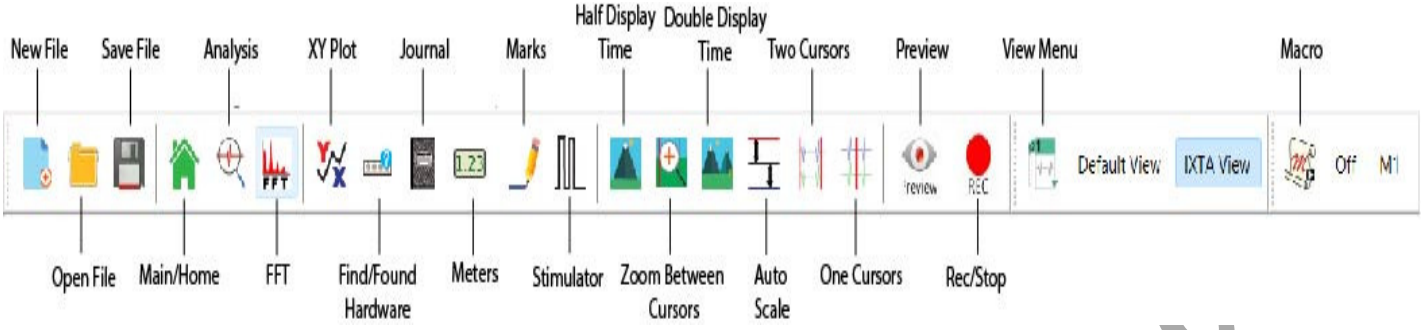

Figure HM-5-L4: The LabScribe toolbar.

4. Look at the Function Table that is above the channel displayed in the Analysis window. The mathematical functions, Value1, Value 2, and V2-V1 should appear in this table. The values for Value1, Value 2, and V2-V1 are seen in the table across the top margin of the channel.
5. Use the mouse to click and drag the cursors to the first extension-palmar flexion cycle. Place one cursor on the data recorded during the extension and the other cursor on the data recorded during the palmar flexion. The angles of extension (Value1), palmar flexion (Value2), and range of motion (V2-V1) are listed in the table under the names of these parameters. Record the names of the parameters and the angles in the Journal using the one of the techniques described earlier in this exercise, and on Table 1.
6. Once the cursors are placed in the correct positions for measuring the angles for extension, flexion, and range of motion of the wrist, the values for these angles can be recorded in the on-line notebook of LabScribe by typing the names and values directly into the Journal.
7. The functions in the channel pull-down menus of the Analysis window can also be used to enter the names and values of the angles in the Journal. To use these functions:
    - Place the cursors at the locations used to measure the angles.
    - Transfer the names of the mathematical functions used to determine the angles to the Journal using the Add Title to Journal function in the Range of Motion channel pull-down menu.
    - Transfer the values for the angles to the Journal using the Add All Data to Journal function in the Range of Motion channel pull-down menu.

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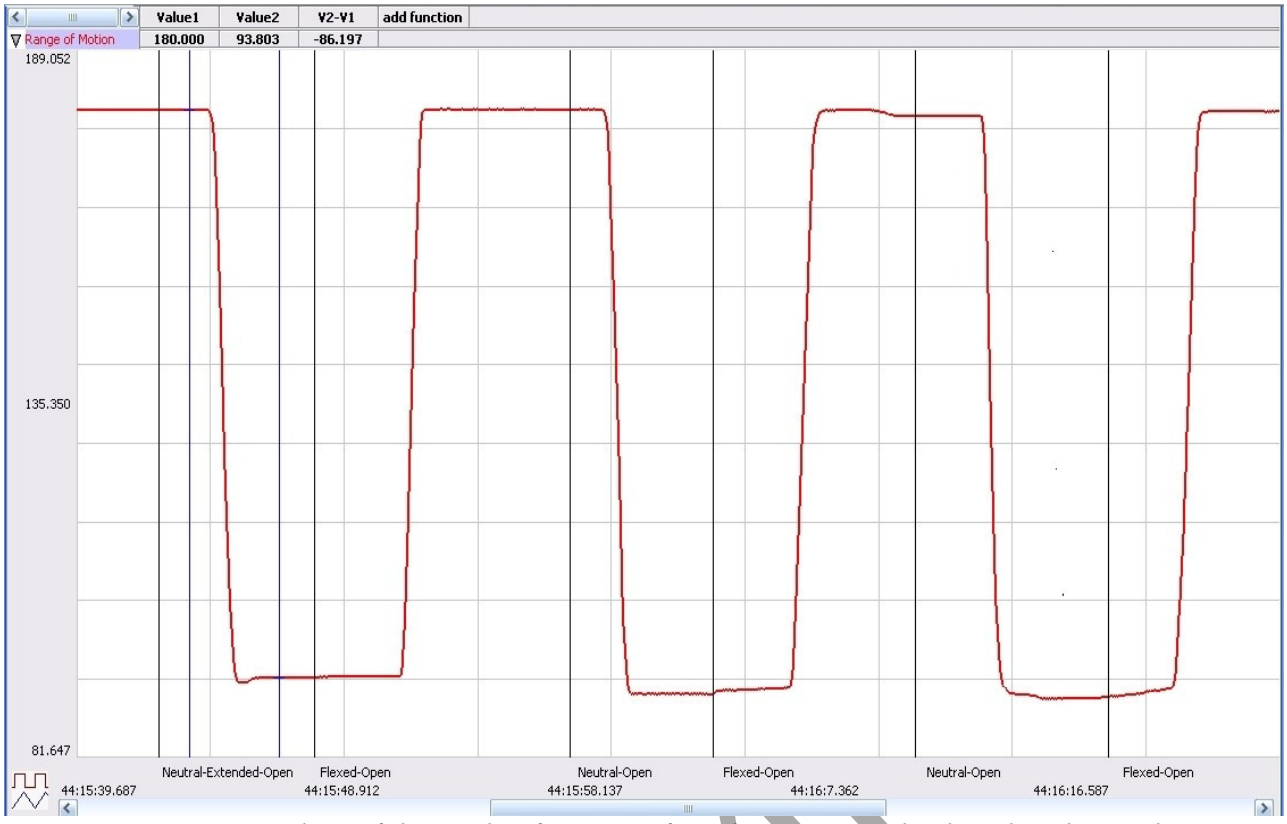

Figure HM-5-L5: Recording of the angle of motion of a subject's wrist displayed in the Analysis window. The range of motion for the first flexion, while the subject's hand was open, was 93.803 degrees (V2-V1)

8. Repeat Steps 5 through 7 on the other two cycles of extension and palmar flexion recorded while the subject's hand was open.
9. Scroll to the data recorded while the subject was flexing and extending their hand when it was formed into a tight fist. Use the same techniques to measure and record the angles of extension, palmar flexion, and range of motion for the three extension-palmar flexion cycles.
10. Select Save in the File menu.
11. Determine the averages of the angles of extension, palmar flexion, and range of motion for the wrist when the hand is open and closed. Record the averages in the Journal and Table 1.

Questions

1. Compare the values of palmar flexion and extension of the wrist from your subject to the values on Table 3. Does your subject have average, above average, or below average range of motion?
2. Does extension or flexion of the fingers (open hand or tight fist) affect the range of motion of the joint?
3. If the subject used a weight, was there any difference in palmar flexion or extension while holding the one pound weight?

WorX Sample

4. What happens if the subject keeps their elbow stationary and rotates the palm of the hand so that it is facing the midline of the body rather than upward? Is there any difference in the range of motion during palmar flexion when the palm is up or inward? During dorsiflexion?

Exercise 2: Flexion and Extension of the Elbow

Aim: To study the flexibility and range of motion (ROM) in the elbow.

Approximate Time: 20 minutes

Procedure

1. Firmly strap the GN-100 goniometer to the inside of the subject's right elbow using the Velcro straps. Make sure:
    - The axis of the goniometer is on the inside of the elbow joint;
    - The stationary arm, with the sensor, is on the inside of the upper arm;
    - The moving arm is on the inside of the forearm.
    - The motion of the elbow is not restricted.
2. Type **Extension** in the Mark box to the right of the Mark button. Instruct the subject to stand with their arm in an extended position so that the elbow joint is as close to an angle of 180 degrees as possible.
3. Click the Record button and then click on the Mark button.

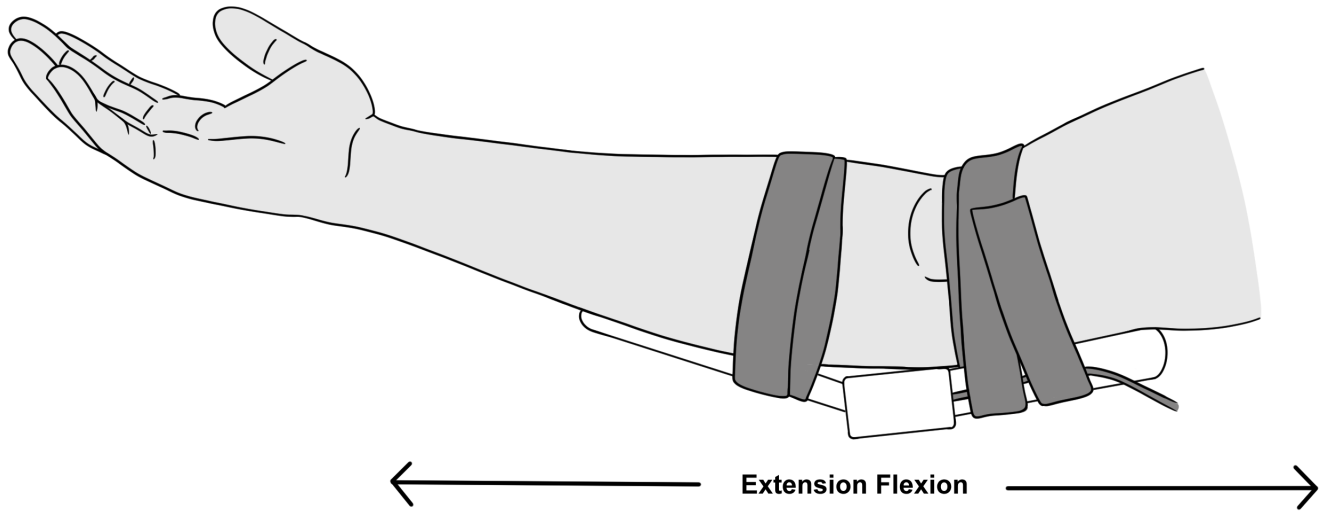

Figure HM-5-L6: Position of the GN-100 on the right elbow.

4. While the subject's arm is in the extended position, type **Flexion** in the Mark box.

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5. Instruct the subject to slowly flex their elbow by bringing the forearm as close to the upper arm as possible. When the subject's elbow reaches the flexed position, click on the Mark button to label the recording.
6. While the subject's elbow is in the flexed position, type **Extension** in the Mark box.
7. Instruct the subject to fully extend their forearm. When the subject's arm reaches the extended position, click on the Mark button to label the recording.
8. Repeat Steps 5 through 8 for two more cycles of flexions and extensions.
9. Click Stop to halt the recording. Select Save in the File menu.

Warning: Not everyone can hyperextend their elbows. Subjects who cannot hyperextend their elbows should not attempt this optional exercise.

Optional Exercise: Ask the subject if he or she can hyperextend the elbow past 180 degrees. If he or she can, use the same techniques used in Steps 2 through 8 to measure the range of motion of the subject's elbow as it undergoes hyperextension.

Data Analysis

1. Scroll through the recording and find the section of data recorded from the elbow.
2. Use the same techniques used in Exercise 1 to measure and record the angles of extension (Value1), flexion (Value2), and range of motion (V2-V1) during flexion and extension.
3. Select Save from the File menu.
4. Determine the averages of the angles of extension, flexion, and range of motion for the elbow. Record the averages in the Journal and Table 1.

Questions

1. What anatomical parameters allow the elbow joint to be hyperextended, but not the wrist?
2. Would holding a weight have any effect on the way the elbow flexes or extends?
3. Compare your subject's values to those on Table 3. How does your subject compare to these known values?

IworX Sample Lab

Table HM-5-L1: Angles of Flexion and Extension of the Wrist and Elbow.

	Wrist Angles (degrees)			
Action	1st	2nd	3rd	Average
Extension Hand Open (V1)				
Palmar Flexion, Hand Open (V2)				
Range of Motion, Open (V2-V1)				
Extension Hand Closed (V1)				
Palmar Flexion Hand Closed (V2)				
Range of Motion, Closed (V2-V1)				
Extension Weight (V1)				
Palmar Flexion Weight (V2)				
Range of Motion Weight (V2-V1)				
Dorsiflexion (V1)				
	Elbow Angles (degrees)			
Action	1st	2nd	3rd	Average
Extension (V1)				
Flexion (V2)				
Range of Motion (V2-V1)				
Hyperextension (V1)				

Work Sample Lab

Exercise 3: Dorsiflexion and Plantar Flexion of the Ankle

Aim: To study the flexibility and range of motion (ROM) of the ankle.

Approximate Time: 20 minutes

Procedure

1. Firmly strap the GN-100 goniometer to the inside of the subject's right ankle using the Velcro straps. Make sure:
    - The axis of the goniometer is on the inside of the ankle joint;
    - The stationary arm, with the sensor, is on the inside of the lower leg;
    - The moving arm is on the inside of the foot.
    - The motion of the ankle is not restricted.
2. Before starting the recording, type **Neutral** in the Mark box. Instruct the subject to sit with the lower leg not touching the floor. The angle of the ankle should be approximately 90 degrees.

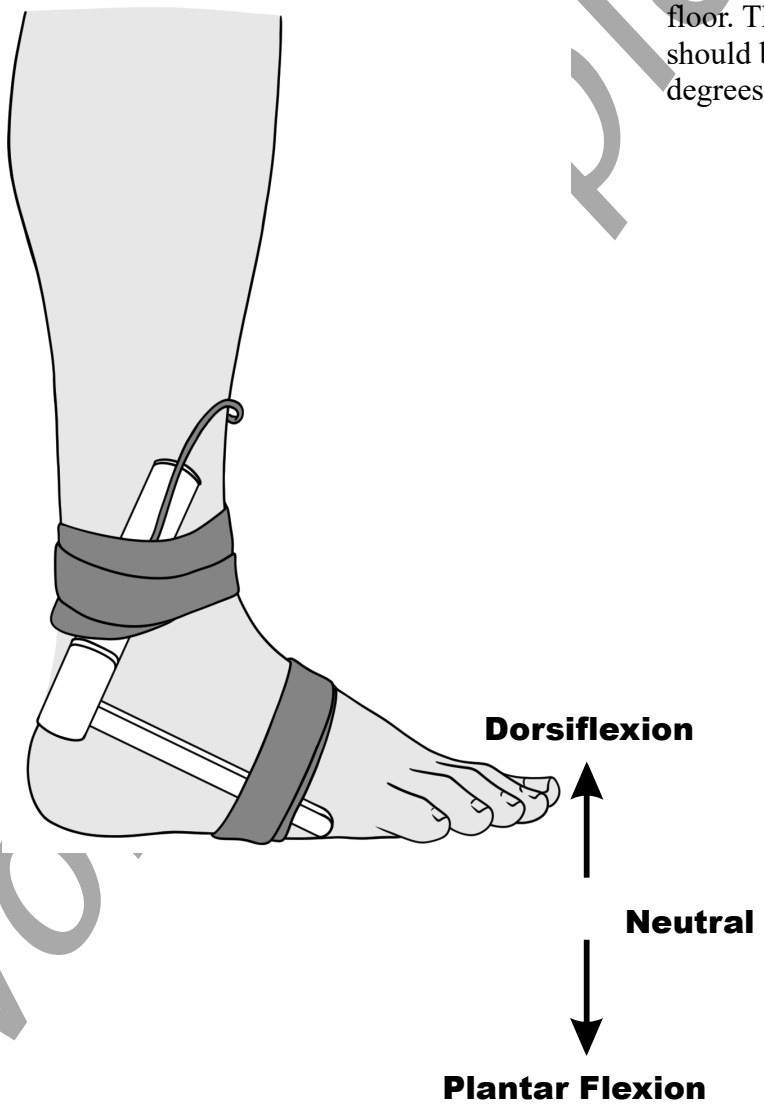

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Figure HM-5-L7: Position of the GN-100 on the right ankle.

3. Click the Record button. Click on the Mark button.
4. While the subject's ankle is in the neutral position, type **Plantar Flexion** in the Mark box.
5. Instruct the subject to slowly point their foot towards the floor as far as possible. When the subject's foot reaches the plantar flexed position, click on the Mark button.
6. Instruct the subject to return their foot to the neutral position.
7. While the subject's foot is in the neutral position, type **Dorsiflexion** in the Mark box.
8. Instruct the subject to slowly pull his or foot upward towards the shin as near as possible. When the subject's foot reaches the dorsiflexed position, click on the Mark button.
9. Instruct the subject to return their foot to the neutral position.
10. Repeat Steps 4 through 9 for two more cycles of plantar flexion and dorsiflexion.
11. Click Stop to halt the recording.
12. Select Save in the File menu.

Data Analysis

1. Scroll through the recording and find the section of data recorded from the ankle.
2. Use the same techniques used in Exercise 1 to measure and record the angles of full plantar flexion (Value1), full dorsiflexion (Value2), and the complete range of motion (V2-V1) from full plantar flexion to full dorsiflexion.
3. Select Save from the File menu.
4. Determine the averages of the angles of full plantar flexion, full dorsiflexion, and the complete range of motion for the ankle. Record the averages in the Journal and Table 2.

Questions

1. Compare the values of plantar flexion and dorsiflexion of the ankle from your subject to the values on Table 3.
2. Which movement generated the greater range of motion, plantar flexion or dorsiflexion?
3. Are there any anatomical parameters that would allow a for a greater ROM in one direction or the other?

IworX Sample Lab

Exercise 4: ROM and Flexibility of the Knee

Aim: To study the ROM of the knee.

Approximate Time: 20 minutes

Procedure

1. Firmly strap the GN-100 goniometer to the outside of the subject's right knee using the Velcro straps. Make sure:
    - The axis of the goniometer is on the outside of the knee joint;
    - The stationary arm, with the sensor, is on the outside of the upper leg;
    - The moving arm is on the outside of the lower leg.
    - The motion of the knee is not restricted.

2. Before starting the recording, type **Extension** in the Mark box to the right of the Mark button. Instruct the subject to stand with their leg in an extended position so that the knee joint is as close to an angle of 180 degrees as possible.

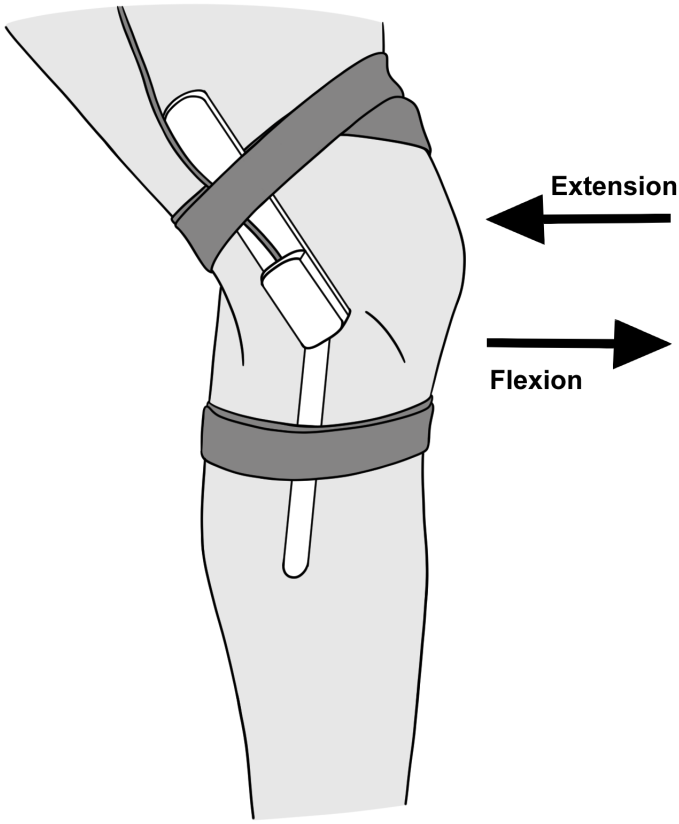

Figure HM-5-L8: Position of the GN-100 goniometer on the outside of the right knee

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3. Click the Record button. Click on the Mark button to label the recording.
4. While the subject's leg is in the extended position, type **Flexion** in the Mark box.
5. Instruct the subject to slowly flex their knee by squatting to bring the thigh as close to the lower leg as possible. The subject may hold onto the table or lab bench for balance. When the subject's knee reaches the flexed position, click on the Mark button to label the recording.
6. While the subject's knee is in the flexed position, type **Extension** in the Mark box.
7. Instruct the subject to stand up and fully extend their leg. When the subject's leg reaches the extended position, click on the Mark button to label the recording.
8. Repeat Steps 4 through 7 for two more cycles of flexions and extensions.
9. Click Stop to halt the recording.
10. Select Save in the File menu.

Warning: Not everyone can hyperextend their knees. Subjects who cannot hyperextend their knees should not attempt this optional exercise.

Optional Exercise: Ask the subject if they can hyperextend the knee past 180 degrees. If he or she can, use the same techniques used in Steps 2 through 8 to measure the range of motion of the subject's knee as it undergoes hyperextension.

Data Analysis

1. Scroll through the recording and find the section of data recorded from the knee.
2. Use the same techniques used in Exercise 1 to measure and record the angles of extension (Value1), flexion (Value2), and range of motion (V2-V1) during flexion and extension.
3. Select Save from the File menu.
4. Determine the averages of the angles of extension, flexion, and range of motion for the knee. Record the averages in the Journal and Table 2.

Questions

1. What anatomical parameters allow the knee joint to be hyperextended, but not the ankle?
2. Would a weight strapped to the lower leg have any effect on the way the knee flexes or extends?
3. Compare your subject's values to those on Table 3. How does your subject compare to these known?

IWorx Sample Lab

Table HM-5-L2: Angles of Flexion and Extension of the Ankle and Knee.

	Ankle Angle (degrees)			
Action	1st	2nd	3rd	Average
Plantar Flexion (V1)				
Dorsiflexion (V2)				
Range of Motion (V2-V1)				
	Knee Angle (degrees)			
Action	1st	2nd	3rd	Average
Extension (V1)				
Flexion (V2)				
Range of Motion (V2-V1)				
Hyperextension (V1)				

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Table HM-5-L3: Average Ranges of Motion (ROM); (Adapted from Luttgens & Hamilton, 1997 and the American Academy of Orthopaedic Surgeons, 1994)

		Source			
Joint	Movement	1*	2*	3*	4*
Wrist	Dorsiflexion	60	70	70	50
	Palmar Flexion	60	90	80	60
Elbow	Flexion	140	145	150	145
	Hyperextension	0	0	0	0-5
Knee	Flexion	150	130	135	130
	Hyperextension	0	0	0-10	5
Ankle	Plantar flexion	40	45	45	50
	Dorsiflexion	30	15	20	20

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