

## WORK & ENERGY – DAY 3 LAB

### LAB QUESTION

**How much work does it take to stretch a spring?** Today you will measure how the force changes as a spring stretches, then use the **area under an F–x graph** to calculate the work.

### GOALS

- Collect a Force vs. position data set for a spring.
- Graph Force vs. position and determine the spring constant  $k$  (slope).
- Compute work as accumulated force over displacement (area under the curve).
- Connect your work calculation to a “stored work” idea (we will name it later).

**Safety / setup:** Do not overstretch the spring. Keep your face away from the spring line of motion. Add masses slowly and hold the meter stick steady.

### LAB Apparatus Sketch

Sketch your setup. Label the spring, a reference point for  $x = 0$ , the direction of positive  $x$ , and how you measure force.



### ROLES Divide & Conquer (optional)

**Measurer:** reads  $x$

**Force reader:** reads  $F$

**Recorder:** table + graph

## PART A — DATA COLLECTION

**Definition reminder:** Work is energy transferred by a force through a displacement in the force's direction. For variable forces, we compute work by **adding up small chunks** (area under the  $F$ - $x$  curve).

### **DATA** Spring Force vs. Stretch (Force vs. position)

Choose **6–8** stretches  $x$  (meters) including  $x = 0$ . Record the corresponding force  $F$  (newtons).

| Trial | $x$ (m) | $F$ (N) | Notes (wiggles? level?) |
|-------|---------|---------|-------------------------|
| 0     |         |         |                         |
| 1     |         |         |                         |
| 2     |         |         |                         |
| 3     |         |         |                         |
| 4     |         |         |                         |
| 5     |         |         |                         |
| 6     |         |         |                         |
| 7     |         |         |                         |

### **CHECK** Does the pattern look linear?

Based on your table, does  $F$  increase by about the same amount when  $x$  increases by the same amount?

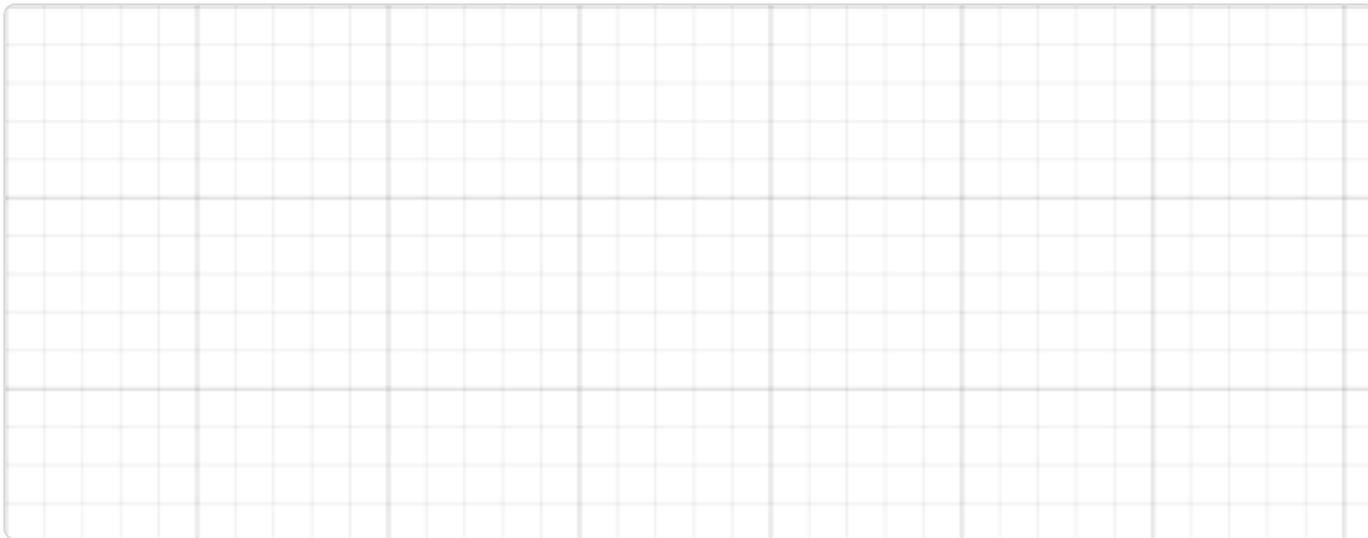
### **PREDICT** Before graphing

If the spring is stretched to **double** the displacement, do you expect the force to double, more than double, or less than double? Why?

## PART B — GRAPH & MODEL

### GRAPH Plot Force vs. Position

On the graph, put  $x$  on the horizontal axis and  $F$  on the vertical axis. Plot your points and draw a best-fit line.



Best-fit line equation:  $F =$  \_\_\_\_\_

y-intercept (should be near 0):  $b =$  \_\_\_\_\_ N

Slope (spring constant):  $k =$  \_\_\_\_\_ N/m

One source of error:

## PART C — WORK AS AREA UNDER THE CURVE

### IDEA

For a variable force, the work from  $x = 0$  to some final stretch is the **area under the  $F$ - $x$  graph**:

$$W = \text{area under } F(x) \text{ vs. } x$$

### AREA Estimate the Work

Choose a final stretch (one of your data points). Find the area under your  $F$ - $x$  curve from 0 to that point.

Final stretch:  $x =$  \_\_\_\_\_ m

Work units check:  $1 \text{ N}\cdot\text{m} = 1 \text{ J}$

Compute  $W$ :

Result:  $W =$  \_\_\_\_\_ J

Does your number feel reasonable? (bigger stretch  $\rightarrow$  more work)

## PART D — A CLEANER EXPRESSION

If your graph is close to a straight line through the origin, then the force is approximately  $F = kx$ . That means the area under the line is a triangle.

### COMPARE Data vs. Model

Use your  $k$  value to compute the work using the **linear spring model** (triangle area under  $F = kx$ ):

$$W = \frac{1}{2} kx^2$$

Compute  $W$  using the formula:

**Compare:** Are your two  $W$  values close? What might explain any difference?

### INTERPRET What did your work become?

You did positive work to stretch the spring. When you release it, what do you think happens to that “stored work”?

**Prediction:** If you stretch to *twice* the displacement, how should the work change?

### EXIT 1-minute check

A spring is stretched to 0.30 m. At that stretch, the force required to hold it is 12 N. (Assume linear.)

- Calculate the magnitude of work using the triangle area idea:  $|W| = \underline{\hspace{2cm}} \text{ J}$
- Work done **on the spring** (by you): positive / negative / zero  $\rightarrow W = \underline{\hspace{2cm}} \text{ J}$
- Work done **by the spring** (on you): positive / negative / zero  $\rightarrow W = \underline{\hspace{2cm}} \text{ J}$