ENERGY — DAY 4 LAB: SPRINGS

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 N·m = 1 J

Compute W:

Result: W = ____________________ J

Does your number feel reasonable? (bigger stretch → more work)

PART D — A CLEANER EXPRESSION

If your graph is close to a straight line through the origin, then the force is approximately $F = kx$ — the linear spring model. Yesterday you derived what the accumulated work must be: $W = \int_0^x kx'\,dx' = \frac{1}{2}kx^2$, the triangle's area. Today your data gets to check that claim.

COMPARE Data vs. Model

Use your k value to compute the work using the **linear spring model** — the $\frac{1}{2}kx^2$ you derived yesterday from the work integral:

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

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 $0.30\,\mathrm{m}$. At that stretch, the force required to hold it is $12\,\mathrm{N}$. (Assume linear.)

a. Calculate the magnitude of work using the triangle area idea: $|W| =$ __________ J

b. Work done **on the spring** (by you): positive / negative / zero $\rightarrow W =$ __________ J

c. Work done **by the spring** (on you): positive / negative / zero $\rightarrow W =$ __________ J