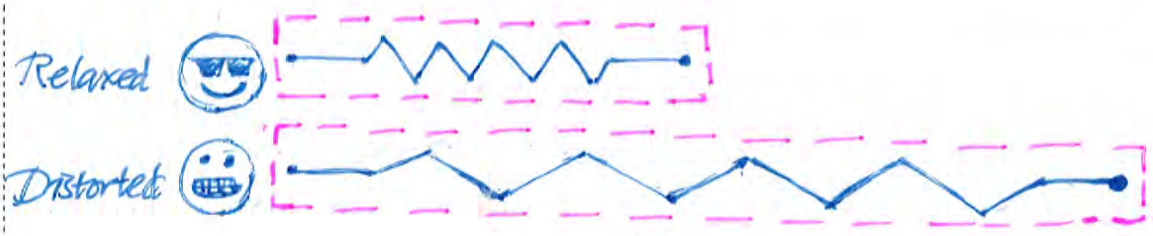
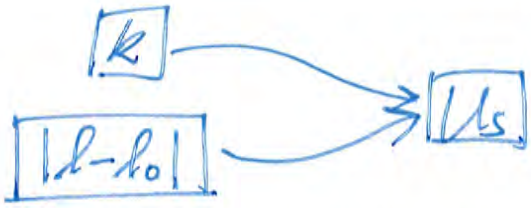
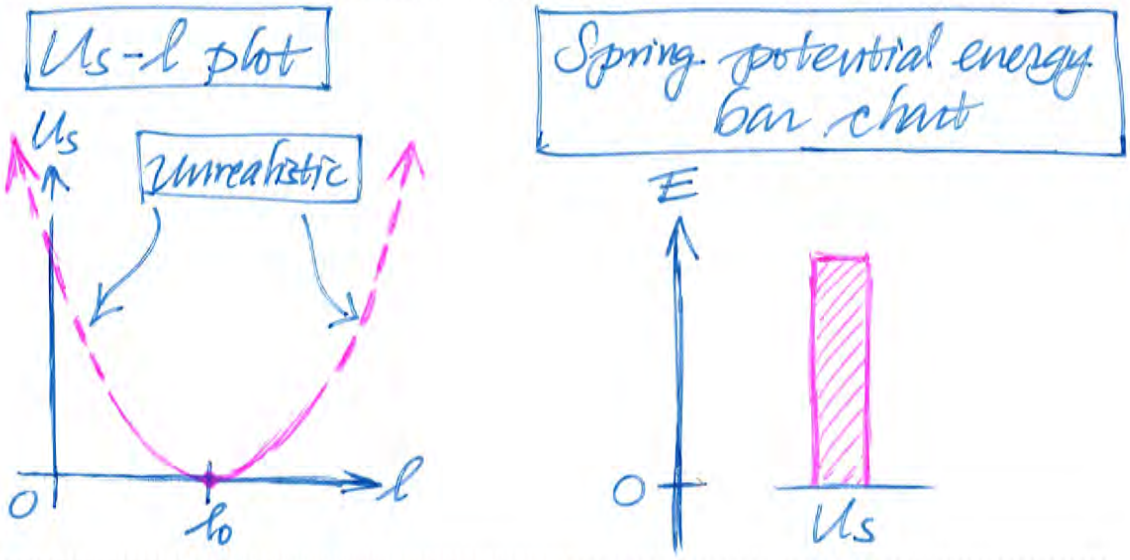
Title Spring potential energy — E4

Ingredients

Sketch	
At/Through	t
Owner	Spring
Quantity	Spring constant; Relaxed length; Length; Spring potential energy
Variable	k; l_0; l; U_s
Giver	

Recipe

Diagram the relationship	
Graphically present quantities	
Mathematical relationship	$U_s = \frac{1}{2}k(l-l_0)^2$

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Page E4
Title: Spring potential energy

The top half of this sheet consists of an "**Ingredients**" section with a row labeled "Sketch", a row labeled "At/Through", a row labeled "Owner", a row labeled "Quantity", a row labeled "Variable", and a row labeled "Giver."

Sketch: Title of first panel: Relaxed. Emoji of cool face wearing sunglasses. Spring with ends marked by dots. Title of second panel: Distorted. Emoji of grimacing face. Same spring, but noticeably stretched. Surround each sketch of the spring with a dashed bubble to indicate that the spring belongs to the system.

Remaining rows of Ingredients section are used for a flowchart illustrating the following:
The Owner is the Spring, which belongs to the System. At time t, the Spring owns the Quantity Spring constant, denoted by the Variable k. At time t, the Spring owns the Quantity Relaxed length, denoted by the Variable cursive-l-naught. At time t, the Spring owns the Quantity Length, denoted by the Variable cursive-l. At time t, the Spring also owns the Quantity Spring potential energy, denoted by the Variable U-sub-S.

The bottom half of this sheet consists of a "**Recipe**" section with a row labeled "Diagram the relationship", a row labeled "Graphically present quantities", and a row labeled "Mathematical relationship".

Diagram the relationship
A flowchart arrows shows that spring constant k contributes to spring potential energy U-sub-S.
Another arrow shows that the absolute value of the difference cursive-l minus cursive-l-naught also contributes to the spring potential energy U-sub-S.

Graphically present quantities
Title of first section: U-sub-S-cursive-l plot
Plot U-sub-S on the vertical axis and cursive-l on the horizontal axis. At a positive value of cursive-l on the horizontal axis an appreciable distance away from the vertical axis, draw a tickmark labeled cursive-l-naught. Draw an upwards-opening parabola with its vertex on the horizontal axis at cursive-l = cursive-l-naught. Use a solid line style for the portion of the graph near the vertex. For regions of the graph far to the left and far to the right of the vertex, make the line style dashed. All portions of the graph near the vertical U-sub-S axis and to the left of that vertical axis should be made to be dashed, if they aren't already. Write a caption that reads, "Unrealistic" in a box with arrows pointing from this caption to the dashed portions of the graph.

Title of second section: Spring potential energy bar chart
Plot E on the vertical axis. Draw a tickmark labeled 0. At the height of this tickmark, draw a horizontal segment to the right, labeled underneath as U-sub-S. From and extending upward from this labeled segment, draw a shaded rectangular bar.

Mathematical relationship
U-sub-S = one-half k times the square of the difference cursive-l minus cursive-l-naught