

INSTRUCTIONS:

This quiz is open-book and open-note, and you may work with your classmates. Please answer all questions and show all of your work.

GIVEN:

A spring inside a ballpoint pen fails catastrophically during normal use. The spring breaks and ejects violently from the pen, hitting the user in the eye, causing significant injury. We've been asked to investigate the incident to determine if this failure is due to defective design, inadequate testing or quality control, a material defect, or something else.

The helical compression spring, as designed, is made of no. 6 music wire. The outside coil diameter of the spring is 4.5 mm.

The ends are squared and there are  $14 \frac{1}{2}$  total turns. *Note that "closed" and squared" are synonyms.*

FIND:

If the spring material is yielded during normal use. We'll break that task down into the below steps:

- a) The torsional yield strength of the wire,  $S_{sy}$ .
- b) The static load corresponding to the yield strength,  $F_y$ .
- c) The spring rate,  $k$ .
- d) The deflection that would be caused by the load in (b),  $y_y$ .
- e) The solid length of the spring,  $L_s$ .
- f) What length should the spring be to ensure that when it is compressed solid and then released, there will be no permanent change in the free length?
- g) Given the length found in (f), is buckling a possibility?
- h) The pitch of the body coil,  $p$ .

BONUS:

With a pair of calibrated calipers, measure the length of a spring inside an exemplar pen. Is the free length appropriate?