Sec. 4.5 - Elastic Potential Energy and Hooke's Law

Learning Goal: By the end of today I will be able to determine the potential energy stored in a spring, and relate that value to the force applied to the spring.

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Task - Hooke's Law

You will need the following items.

1. metal stand
2. several weights of varying masses
3. meter stick
4. spring
5. recording materials (paper, pencil)

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Procedure:

1. With no mass attached to the spring, establish the zero reference point for your system.

2. Draw a free body diagram for the hanging mass and establish your positive direction for the system.

3. Add a mass to the spring, measure the displacement from the zero position, determine *the force applied by the spring to the mass*. (F_T)

4. Repeat for several masses, record your findings in a table (Force & Displacement)

5. Check your table with me, then create a graph of your data, with all appropriate labels - plot F on the y axis, and displacement on the x axis. (use Excel)

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Questions:

1. What type of relationship was found?
2. What is the slope value, including units?
3. What is the equation that models this relationship?

4. What does the AREA under the curve represent?

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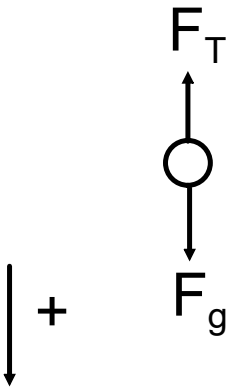
Hooke's Law

$$F_x = -k \cdot x$$

"force exerted by a spring"

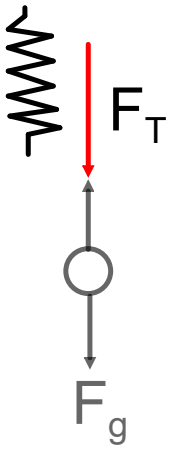
where "k" is the spring/force constant measure in N/m



(the spring opposes the motion, except at the equilibrium location)

$$F_x = k \cdot x$$

"force exerted on/to a spring"



Elastic Potential Energy

$$A = \frac{1}{2}bh$$

$$E = \frac{1}{2}F_x x$$

$$E = \frac{1}{2}(kx)x$$

$$\boxed{E = \frac{1}{2}kx^2}$$

k = N/m

x = meters

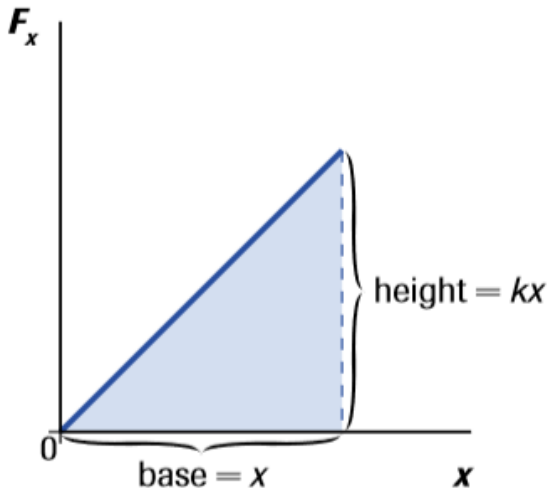
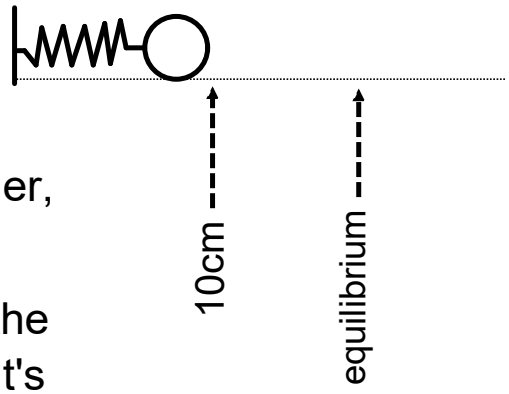


Figure 6
The magnitude of the force applied to a spring as a function of x

Example



A 50g mass is loaded into a frictionless horizontal spring launcher, with a spring constant of 12N/m.

(a) What is the potential energy in the spring when it is compressed past it's equilibrium point by 10cm?

(b) What energies are involved in this situation the instant it is released from the compressed 10cm mark? (list them)

(c) How fast is the mass travelling when it is back at the equilibrium point?

(reminder the total energy is constant)

$$E_g + E_k + E_e = E_{g'} + E_{k'} + E_{e'}$$

Homework

Read pages 203-211

Read Sample problem 2 - page 205

page 206 #3, 4

page 211 #9, 10, 12

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