7.2 – Work: Variable Force

Spring Review

Springs have a constant 'k' (units: N/m) that measures the force it takes to alter them.

Remember Hooke's Law:

$$F_s = kx$$

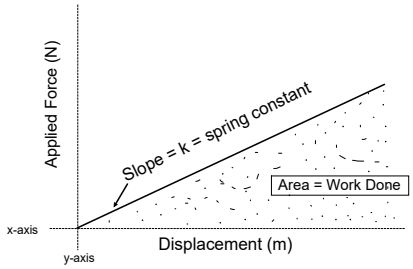
Spring Work

Potential energy (U - more later) contained in a spring (thus work done on it) depends on displacement:

$U_s = \frac{1}{2}kx^2$ AP Equation	k = spring constant (N/m) x = displacement (m)

Spring Work Graphing

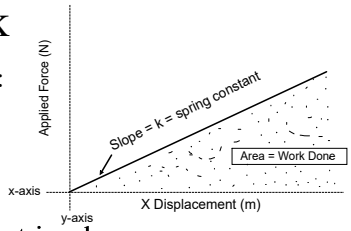
In a linear graph of Force vs. Displacement, work equals area under the curve.



The slope equals k (rise/run = N/m).

Spring Work

Mathematical Proof:



$$\text{Area} = \frac{1}{2}b \cdot h \quad \text{for a triangle}$$

$$W = \frac{1}{2}x \cdot F \quad \text{from figure}$$

(Substitution: $F_{Spring} = kx$)

$$= \frac{1}{2}x \cdot (k \cdot x) \quad = \frac{1}{2}kx^2$$

1. Example

A spring with constant of 15.0 N/m is compressed 18.0 cm.

A. What force is necessary to achieve this?

B. How much work is done on the spring?

1.A Answer

A. What force is necessary to compress the spring?

The applied force is equal and opposite the spring force.

$F_s = kx$

$= (15\ N/m)(0.18m)$ Convert to meters!

$= 2.7\ N$

1. B Answer

B. How much work is done on the spring?

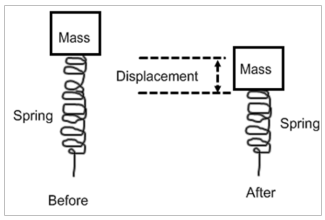
$W_{spring} = 1/2\ kx^2$
$= 1/2(15.0\ N/m)(0.180\ m)^2$
$= 0.24\ J$

2. Example

Two masses ($m_1 = 0.15$ kg, $m_2 = 0.50$ kg) are placed on a spring. If the displacement with only m_1 is 4.6 cm:

A. What will be the displacement with both masses combined?

B. What work is done on the spring by both masses combined (what's its potential energy?)?



2.A Answer

A. Solve for k: gravity opposes the spring force:

$$F_g = F_s$$
$$m \bullet g = k \bullet x$$
$$k = \frac{m \bullet g}{x} = \frac{0.15kg \bullet 9.81m/s^2}{0.046m} = 32N/m$$

2.A Answer - Slide 2

A. We can now plug the total mass into the spring's force equation to calculate displacement.

$$F_g = F_s$$
$$m \bullet g = k \bullet x$$
$$x = \frac{m \bullet g}{k} = \frac{(0.15kg + 0.50kg) \bullet 9.81m/s^2}{0.046m} = 0.20m = 20.cm$$

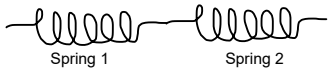
2.B Answer

B. Work done on the spring:

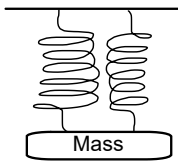
$$U_s = \frac{1}{2}kx^2$$
$$= \frac{1}{2} \bullet 32N/m \bullet (0.20m)^2$$
$$= 0.64J$$

Serial vs. Parallel Springs

An applied force affects serial springs independently: stored energy equals the sum of the individual springs' energies.



In parallel, force is divided proportionally to the different spring constants: stored energy equals the sum of individual energies.



Homework

Read 5.3 in your book
7.2 Problems in your Booklet
Due: next class

Attachments

Mousetrap Movie.MOV

Mousetrap 2.MOV