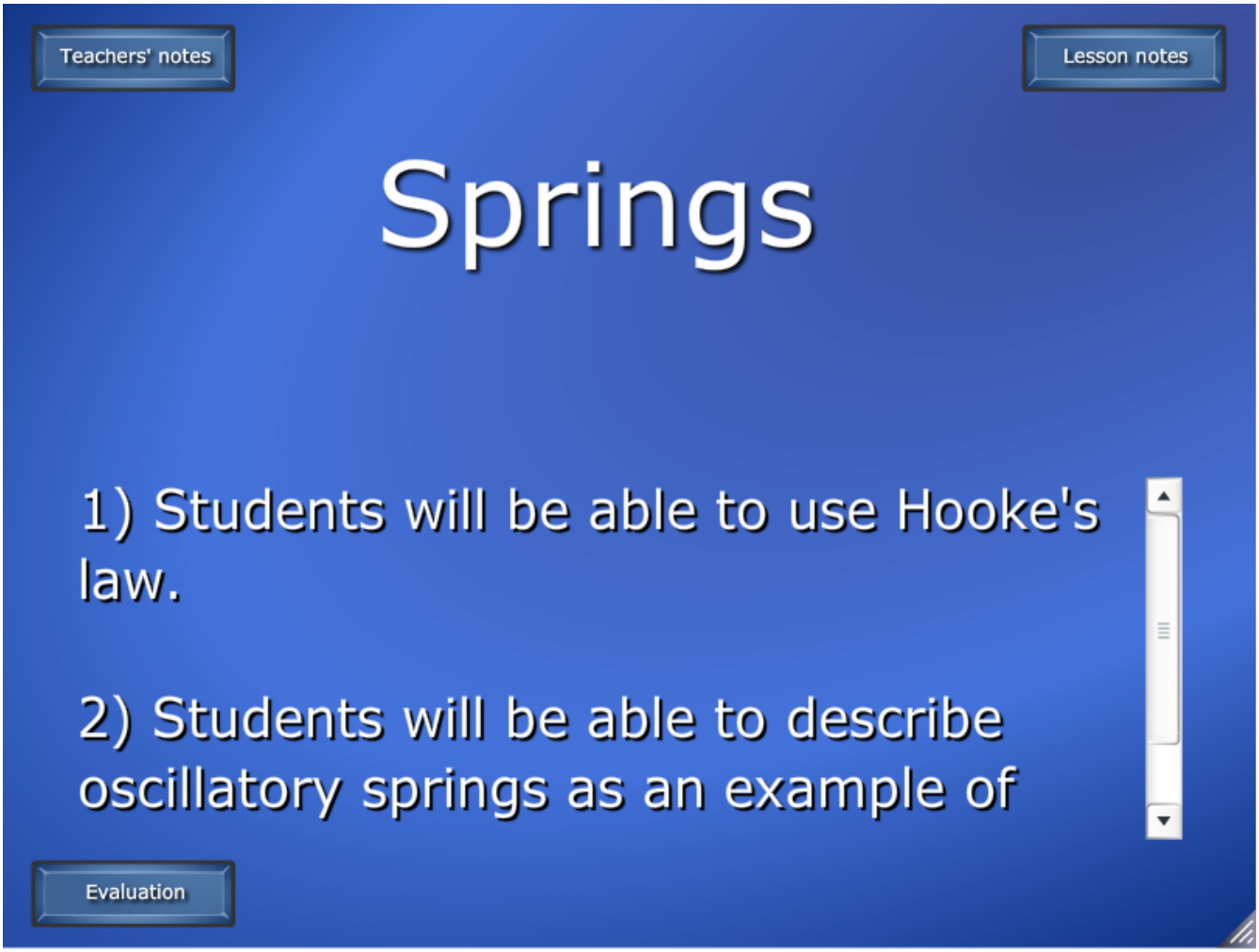

Teachers' notes
Lesson notes
Springs
1) Students will be able to use Hooke's law.
2) Students will be able to describe oscillatory springs as an example of
Evaluation

Activity: Determining the Stiffness of a Spring

Problem: How does the force applied to a spring affec its displacement?

Experimental Design: A spring is suspended vertically A variety of masses are placed on the spring and the displacement measured.

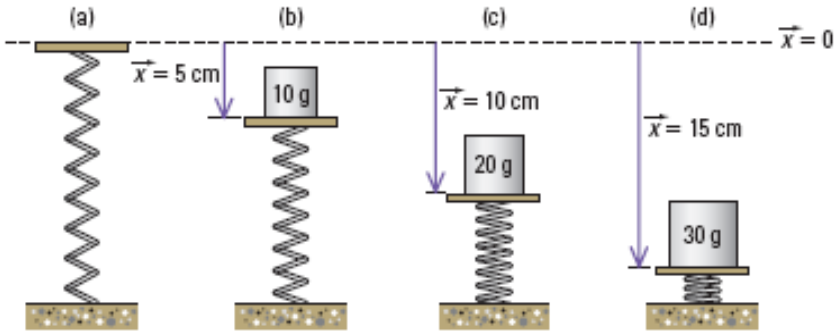
Analysis: Graph your results.

## Hooke's Law

Hooke recognized that the more stress (force) is applied to an object, the more strain (deformation) it undergoes.

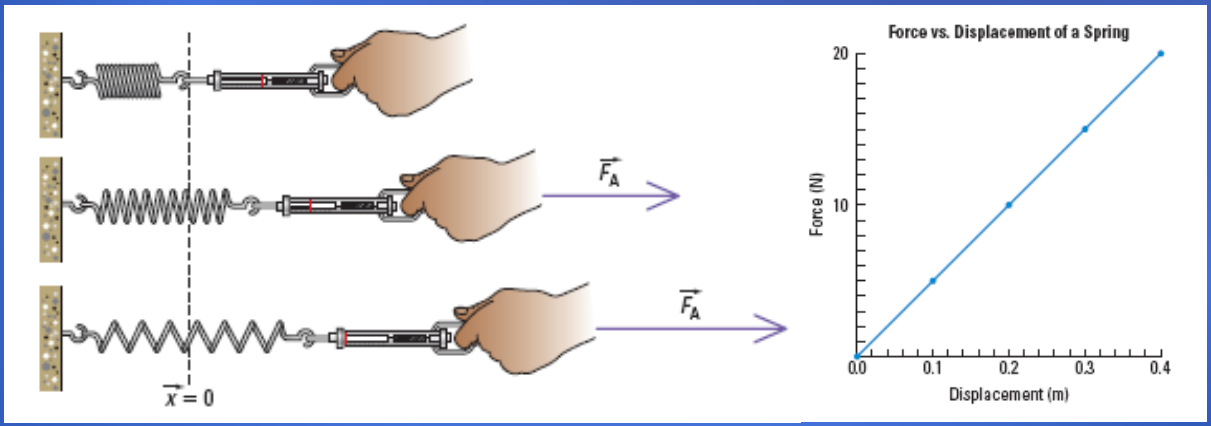
When that force is applied to a spring, the deformation is proportional to the applied force.

$$\vec{F} = k\,\vec{x}$$



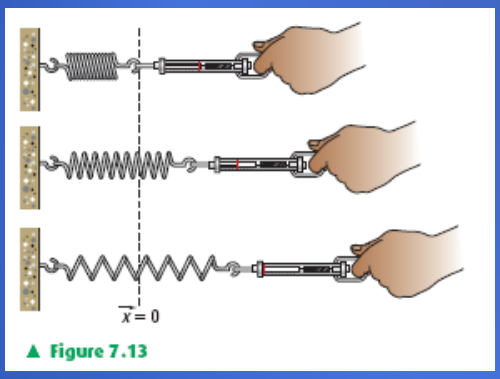

▲ **Figure 7.9** The spring pictured above conforms to Hooke's law. If the mass is doubled, the displacement will also double, as seen in (b) and (c). If the force (mass) is tripled, the displacement will triple, as seen in (b) and (d).

In a slightly different experiment, displacement is manipulated and the force required is responding.



## Example 7.2, p. 352

To determine the spring constant of a spring, a student attaches a force meter to one end of the spring, and the other end to a wall. She pulls the spring incrementally to successive displacements, and records the values of displacement and force. Determine the spring constant of the spring.




▲ Figure 7.13

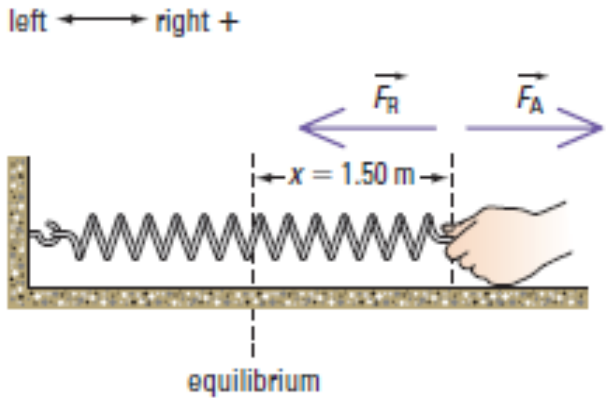
▼ Table 7.4 Data for Figure 7.14

| Displacement (m) | Force (N) |
|---|---|
| 0.00 | 0.00 |
| 0.10 | 0.25 |
| 0.20 | 0.35 |
| 0.30 | 0.55 |
| 0.40 | 0.85 |


The restoring force is the force exerted by the spring toward equilibrium (i.e. the direction is opposite the displacement). Hooke's law is more properly written as $\vec{F} = -k\vec{x}$.

# Example 7.3, p. 354

A spring has a spring constant of 30.0 N/m. This spring is pulled to a distance of 1.50 m from equilibrium. What is the restoring force?

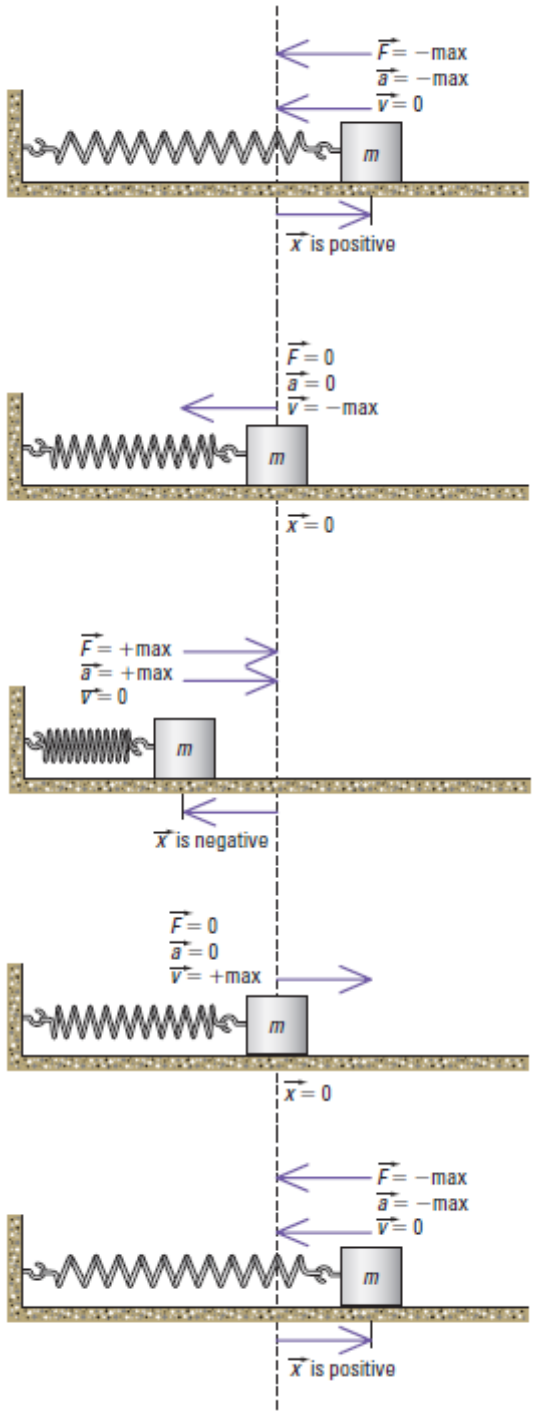



▲ Figure 7.17

Practice Problems, p. 354, #1-2

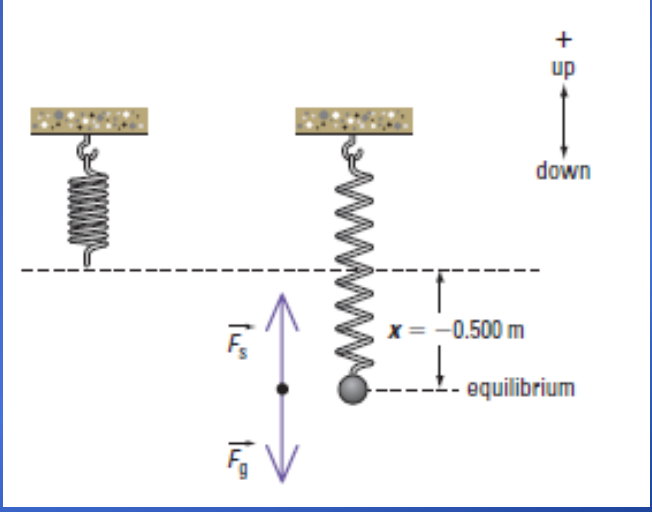
p. 355

An object that undergoes SHM is a simple harmonic oscillator.



## Example 7.4, p. 357

A spring is hung from a hook on a ceiling. When a mass of 510.0 kg is attached to the spring, the spring stretches a distance of 0.500 m. What is the spring constant?



Practice problems, p. 357 #1-2

## Period of a mass on an oscillating spring:

We've already seen that an oscillating mass and a pendulum are examples of simple harmonic oscillators. How do the relationships governing the periods compare?

Period of a pendulum

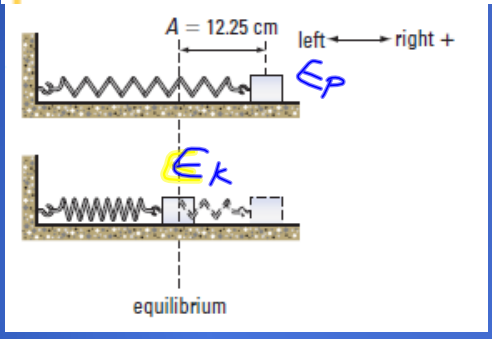
$$T = 2\pi\sqrt{\frac{l}{g}}$$

Period of a mass on a spring

## Example 7.7

p376

What is the period of oscillation of a mass-spring system that is oscillating with an amplitude of 12.25 cm and has a maximum speed of 5.13 m/s? The spring constant ($k$) is 5.03 N/m.




$T = ?$
$k = 5.03\ N/m$
$v = 5.13\ m/s$
$x = 0.1225\ m$

$T = 2\pi\sqrt{\frac{m}{k}}$

$m = ?$
$E_m = E_m'$
$E_k = E_p$
$\frac{1}{2}mv^2 = \frac{1}{2}kx^2$
$m = \frac{kx^2}{v^2}$
$m = \frac{(5.03\ N/m)(.1225\ m)^2}{(5.13\ m/s)^2}$
$m = 0.00287\ kg$

$\therefore T = 2\pi\sqrt{\frac{0.00287\ kg}{5.03\ N/m}}$

$T = .15\ s$

p376 #1-4

$a \rightarrow \quad F = ma$

even for

$F = kx$

$ma = kx$

4. What is the period of a vertical mass-spring system that has an amplitude of 71.3 cm and maximum speed of 7.02 m/s? The spring constant is 12.07 N/m.

$T = ?$

$x = 71.3\text{cm}$

$v_{max} = 7.02\text{m/s}$

$k = 12.07\text{N/m}$

$T = 2\pi\sqrt{\frac{m}{k}}$

$m = ?$

$E = E'$

$E_{p\,max} = E_{k\,max}$

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

$m = \frac{kx^2}{v^2}$

$m = \frac{(12.07\text{N/m})(.713\text{m})^2}{(7.02\text{m/s})^2}$

$m = 0.125\text{kg}$

$\therefore T = 2\pi\sqrt{\frac{(.125\text{kg})}{(12.07\text{N/m})}}$

$T = 0.638\text{s}$