Lecture 2

Applications of SHM

and

Energy

Pre-reading: §14.1–14.3

Simple Harmonic Motion

- Suppose the restoring force varies linearly with displacement from equilibrium

  $$F(t) = -k\,x(t)$$

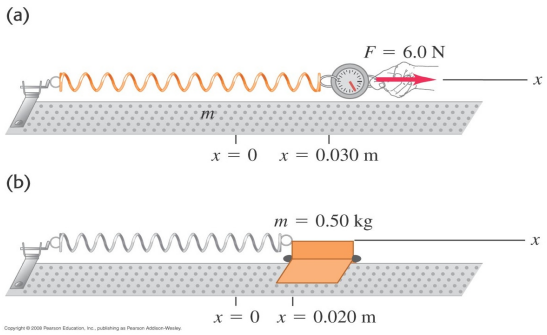
- Then the displacement, velocity, and acceleration are all sinusoidal functions of time
  - This defines Simple Harmonic Motion (SHM)
- Period/frequency depend only on k and m with

  $$\omega = \sqrt{(k/m)}$$

  (does not depend on amplitude!)

§14.2

Example 14.2



a) What is the force constant of the spring?

b) What is the angular frequency, frequency, and period of oscillation?

Energy and SHM

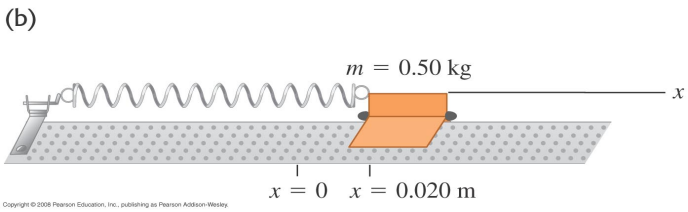
- Total energy in an SHM system is conserved
  - does not change with time
- Components of energy oscillate between kinetic and potential

$$E = \frac{1}{2}mv_x^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2 = \text{constant}$$

- Offers alternative approach to find x, v, a

§14.3

Example 14.4



Same spring, k=200 N/m

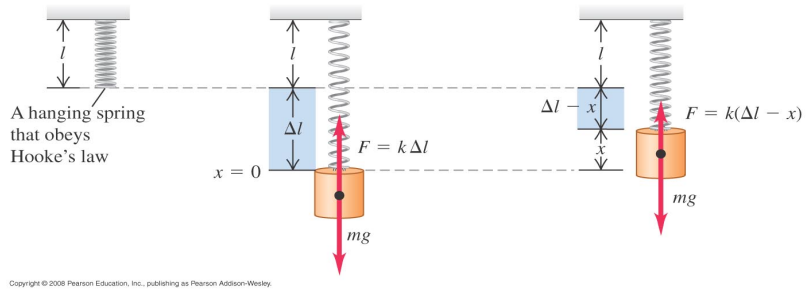
What is max/min velocity? acceleration?

What is v, a when x = +0.010 m?

What is total, potential, and kinetic energy at x = +0.010 m?

§14.3

SHM: Vertical Springs



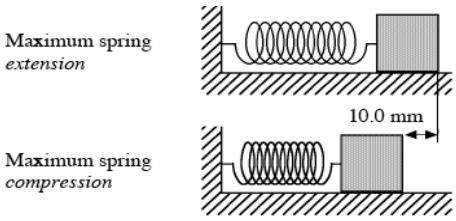
- IMPORTANT: Set up coordinate system!!
- Motion of vertical spring **is** described by simple harmonic motion with

$$\omega = \sqrt{(k/m)}$$

§14.4

2006 exam

Question 11



A spring of negligible mass with an unknown force constant k is attached to a block of mass 0.250 kg. The other end of the spring is attached to a rigid wall. The mass is pulled and allowed to oscillate horizontally on a frictionless surface. The frequency of oscillation is 10.0 Hz. The distance between the positions of the mass when at maximum spring extension and maximum spring compression is 10.0 mm. Assume air resistance is negligible.

(a) What is the force constant k of the spring?

(b) What is the total mechanical energy of the mass/spring system?

(c) What is the speed of the oscillating mass when it is exactly halfway between the positions of maximum extension and compression?

(d) If the spring is replaced with another with a force constant which is n times larger, what will be the new frequency of oscillation?

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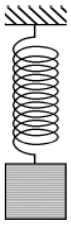
2006 exam

Now the mass is allowed to hang vertically (using the *original* spring from part a)



(e) What effect will the force of gravity have on the frequency of oscillation? Explain in 2 or 3 sentences.

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Next lecture

Pendulums, and Resonance

Read §14.5–14.8