Announcements 1 May 09

- **Homework #12**
  - **Written homework due on Monday in class**
  - **Online homework due on Tuesday by 8 am**
  - **Set your calculator to work with angles in radians**
  - **6th problem (fish scale): Angular frequency** $\omega = 2\pi f$
    Take max spring compression = length of spring
  - **Problem 14.16: solve using energy conservation**
- **Exam 3**
  - **Wednesday May 6 from 7 to 9 pm**
  - **Make-up exams need to be scheduled this week!**
  - **Brief review on Monday…**

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Velocity and acceleration amplitude problem

We think of butterflies and moths as gently fluttering their wings, but this is not always the case. Tomato hornworms turn into remarkable moths called hawkmoths whose flight resembles that of a hummingbird. To a good approximation, the wings move with simple harmonic motion with a very high frequency—about 26 Hz, a high enough frequency to generate an audible tone. The tips of the wings move up and down by about 5.0 cm from their central position during one cycle. Given these numbers,

A. What is the maximum velocity of the tip of a hawkmoth wing?

B. What is the maximum acceleration of the tip of a hawkmoth wing?

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Velocity and acceleration amplitude problem

Wing frequency f = 26 Hz, amplitude A = 5.0 cm

A. What is the maximum velocity of the tip of a hawkmoth wing?

B. What is the maximum acceleration of the tip of a hawkmoth wing?

$$x(t) = A\cos(2\pi f t)$$
$$v_x(t) = -(2\pi f)A\sin(2\pi f t)$$
$$a_x(t) = -(2\pi f)^2 A\cos(2\pi f t)$$

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Gibbon question

The gibbon will swing more rapidly and move more quickly through the trees if it raises its feet. How can we model the gibbon's motion to understand this observation?

Velocity and acceleration amplitude problem

The deflection of the end of a diving board produces a linear restoring force. A diving board dips by 15 cm when a 65 kg person stands on its end. Now, this person jumps and lands on the end of the board, depressing the end by another 10 cm, after which they move up and down with the oscillations of the end of the board.

A. Treating the person on the end of the diving board as a mass on a spring, what is the spring constant?

B. For a 65 kg diver, what will be the oscillation period?

C. For the noted oscillation, what will be the maximum speed?

D. What amplitude would lead to an acceleration greater than that of gravity—meaning the person would leave the board at some point during the cycle?

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Velocity and acceleration amplitude problem

Find: k, T, v_{max}, A_{min}

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Spring problem

Know :

$m = 65\ kg$

$\Delta L = 15\ cm = 0.15\ m$

$A = 10\ cm = 0.10\ m$

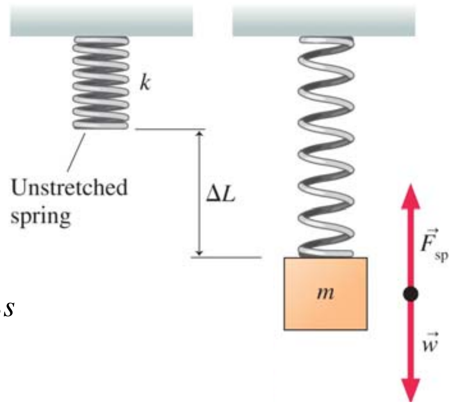
Find: $k,\ T,\ v_{max},\ A_{min}$

A. spring constant k = ?

mass at rest implies $F_{sp} = w$,

i.e. $k\Delta L = mg$

$$\Rightarrow k = \frac{mg}{\Delta L} = \frac{(65kg)\times(9.8m/s^2)}{0.15m} = 4247N/m$$



B. oscillation period T = ?

$$T = 2\pi\sqrt{\frac{m}{k}} = 2\pi\sqrt{\frac{65kg}{4247N/m}} = 0.78s$$

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Spring problem

Know :

$m = 65\ kg$

$\Delta L = 15\ cm = 0.15\ m$

$A = 10\ cm = 0.10\ m$

Find: $k,\ T,\ v_{max},\ A_{min}$

C. maximum velocity v_{max} = ?

$$v_{max} = (2\pi f)A = \frac{2\pi}{T}A = \frac{2\pi}{0.78s}(0.10m) = 0.806m/s$$

D. minimum amplitude for lift off A_{min} = ?

$$a_{max} = (2\pi f)^2 A$$

$$\Rightarrow (2\pi f)^2 A_{min} = g$$

$$\Rightarrow A_{min} = \frac{g}{(2\pi f)^2} = 0.151m$$

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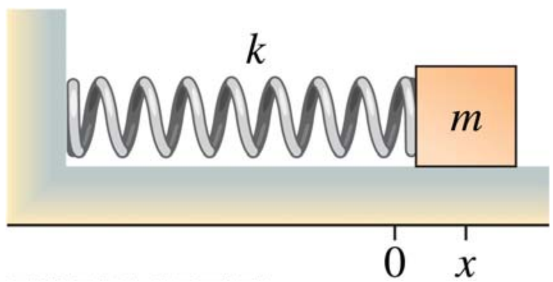
Problem with conservation of energy

A 204 g block is suspended from a vertical spring, causing the spring to stretch by 20 cm. The block is then placed on a horizontal frictionless surface and pulled 10 cm from its equilibrium position and released. What is the speed of the block when it is 5.0 cm away from its equilibrium position?



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Problem with conservation of energy

A. spring constant k = ?

mass at rest implies $F_{sp} = w$,

i.e. $k\Delta L = mg$

$$\Rightarrow k = \frac{mg}{\Delta L} = \frac{(0.204kg)\times(9.8m/s^2)}{0.20m} = 10.0N/m$$

Know:

$m = 0.204\ kg$

$\Delta L = 0.20\ m$

$A = 0.10\ m$

Find: v at x = 0.05 m

B. Total energy

$E = K + U = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$ at any point

$E = 0 + \frac{1}{2}kA^2$ at the point of greatest displacement

Energy conservation implies that

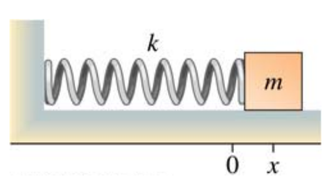
$\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}kA^2$

$\Rightarrow \frac{1}{2}mv^2 = \frac{1}{2}kA^2 - \frac{1}{2}kx^2$

$\Rightarrow mv^2 = kA^2 - kx^2$

$$\Rightarrow v^2 = \frac{kA^2 - kx^2}{m} = 0.368m^2/s^2$$

$\Rightarrow v = 0.606m/s$



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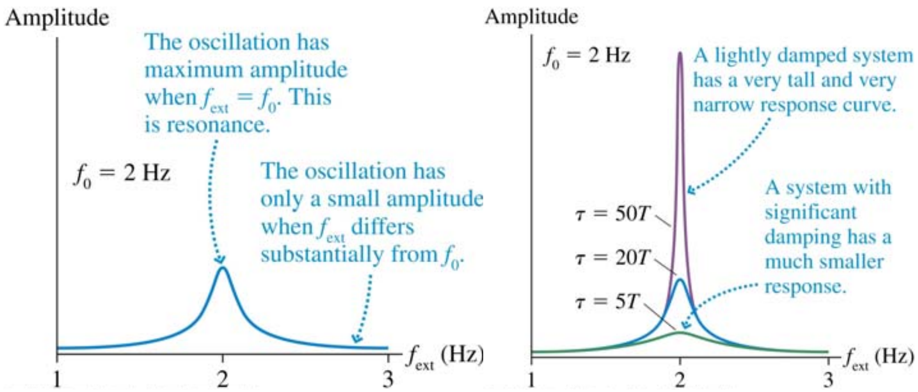
Resonance



- A system displaced from its equilibrium position will oscillate with a *natural frequency f_0* if left to oscillate freely.
- If an oscillating external force is exerted with a *driving frequency f_{ext}* then the system will also oscillate at frequency f_{ext}. The amplitude of this oscillation is amplified when f_{ext} is close to f_0. *We then talk about a resonance.*

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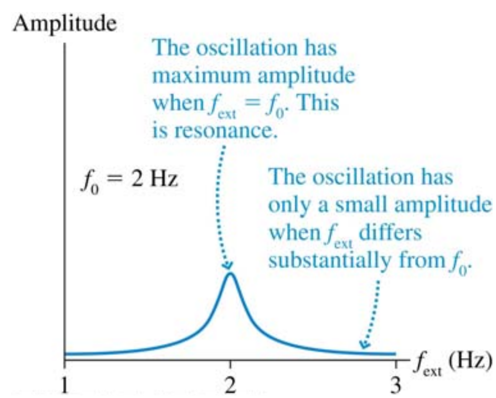
Resonance



DEMOS:

- 2-meter stick
- mass on a vertical spring
- spun hollow tube
- glass beaker with sound

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