Oscillations!
(Today: Springs)


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Movie Projects

• Movie project grade =
  \((0.3 \times \text{DRAFT}\% + 0.6 \times \text{FINAL}\%)/90\)

• READ COMMENTS EMBEDDED IN YOUR eCAMPUS DRAFT.
  If you're lost, discuss project with me or TAs.

• Closely read rubric for final project! Due 30 Nov.

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Homework due each of next 2 Sundays...

Check online schedule.
https://tinyurl.com/phys101-fall2018-schedule
The rest of this semester.

Familiar concepts...
- Forces/free body diagrams!
- Newton's laws!
  \[ \Sigma F = ma = 0 \]
- Work and energy conservation!
  \[ PE_g = mgh \]
  \[ All \ converted \ to \ spring \ potential \]

Let's think about springs.

\[ F_s = -kx \]
spring constant [Units: N/m]

“Hooke’s Law!”
F_{s} = -k \ x

spring constant [Units: \text{N/m}]

Low k (soft spring)  High k (stiff spring)

Familiar problem #1: Newton’s second (and third) laws

A 2.5 kg object is hanging vertically on a spring, which is stretched by the weight by a distance \( d \). What is the magnitude of the force the spring is applying to the object?

A. 6.3 N  
B. 16 N  
C. 25 N  
D. Not enough information

b) If the string stretches by 2.76 cm due to this mass, what is the spring constant?

A. 0.55 N/m  
B. 77 N/m  
C. 888 N/m  
D. 5 \times 10^{5} \text{ N/m}

c) What is the spring force if you stretch the spring to 8 cm?
Springs as harmonic oscillators.

Spring (Elastic) Potential Energy


Work:
Energy associated with a force and its action.
How Do We Find Spring Potential Energy?

\[ F_s = -kx \quad \text{(Hooke’s Law)} \]

\[ W = F_s \Delta x \quad \text{(Work done by spring)} \]

\[ W_s = -\Delta PE_s \quad \text{(Work done by spring)} \]

Conservation of energy applies to springs, too!

\[ PE_s = \frac{1}{2} kx^2 \]

All final energies

\[ (KE + PE_g + PE_s)_f = (KE + PE_g + PE_s)_i \]

(if no friction)

\[ W_{nc} = (KE + PE_g + PE_s)_f - (KE + PE_g + PE_s)_i \]

(if friction or other non-conservative/dissipating forces are present)

Energy lost to non-conservative/dissipating forces

Where does an oscillating spring provide a maximum kinetic energy?

A. 

B. 

C. 

D. 

E. Both B and D

\[ (KE + PE_g + PE_s)_f = (KE + PE_g + PE_s)_i \quad PE_s = \frac{1}{2} kx^2 \]
Kinetic and Potential

A weight is suspended by a spring. The spring is then stretched until the weight is just above some eggs, and then it is released. The weight springs upward and then comes back down due to gravity. Ignoring air resistance, what happens?

A. the weight bounces back well above the eggs
B. the weight bounces back just before it reaches the eggs
C. it smashes the eggs!

Total energy in an oscillator

Total energy = KE + PE

At max displacement, energy is all in PE!

$\frac{1}{2} kA^2$

at $x = A$
Velocity as a Function of Position

\[ \frac{1}{2} m v^2 + \frac{1}{2} k x^2 = \frac{1}{2} k A^2 \]

- We can derive the velocity of the object at any position

\[ v = \pm \sqrt{\frac{k}{m} \left( A^2 - x^2 \right)} \]

- Speed is a maximum at \( x = 0 \)
- Speed is zero at \( x = \pm A \)
- The \( \pm \) indicates the object can be traveling in either direction

A block whose mass is 0.5 kg is retracted against a release spring with spring constant 75 N/m. If the spring is initially stretched \( A = 0.25 \) m, what is the velocity of the block when the spring returns to its equilibrium position? (assume a flat, frictionless release surface)

\[ v = \pm \sqrt{\frac{k}{m} \left( A^2 - x^2 \right)} \]