Announcements

- Video HW2 due tonight!
- New WebWorK 4 released and due Wednesday at midnight
- Today is the last day to add / drop if you were debating that
- First test on Friday already!
  - I'm posting study materials to the website
  - Just over chapters 1 and 2
  - Study materials include copy of old test and solutions
  - You get a 3x5 inch index card for notes (handwritten) on test day
  - A scientific calculator may be useful on test day, though I have some I can loan. (Graphing calcs are fine.)
- Teddy hours:
  - Fridays from 6:30 – 7:30 pm in Hearth
  - Otherwise contact to make other 1-on-1 meeting times
- Polling: `rembold-class.ddns.net`

Warm Up

What is the correct ordering of the 3 step process to use iterative methods to predict future motion?

A

1. Update $\vec{\mathbf{p}}$ from momentum principle
2. Update net force
3. Update position using $\vec{\mathbf{v}}_{avg}$ approximation

B

1. Update net force
2. Update position using $\vec{\mathbf{v}}_{avg}$ approximation
3. Update $\vec{\mathbf{p}}$ from momentum principle

C

1. Update net force
2. Update $\vec{\mathbf{p}}$ from momentum principle
3. Update position using $\vec{\mathbf{v}}_{avg}$ approximation

D

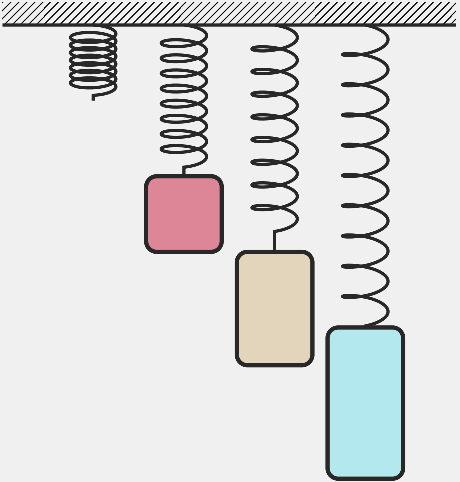
1. Update position using $\vec{\mathbf{v}}_{avg}$ approximation
2. Update net force
3. Update $\vec{\mathbf{p}}$ from momentum principle

Upcoming:

The Spring Force

Spring Experimentation

- Springs have a certain “resting” length
- Adding mass or a force stretches or compresses them from that length
- The strength of the force the spring applies in response depends on the distance is is stretched or compressed
- Different springs stretch different amounts



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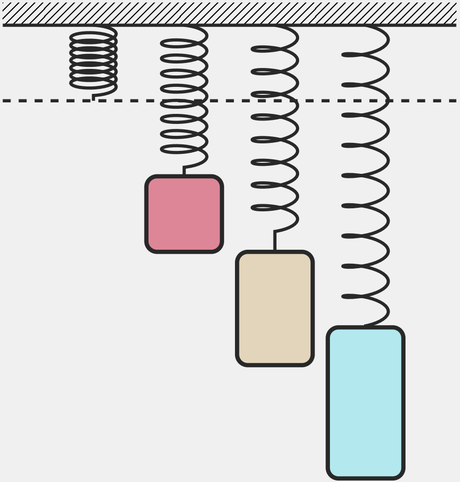

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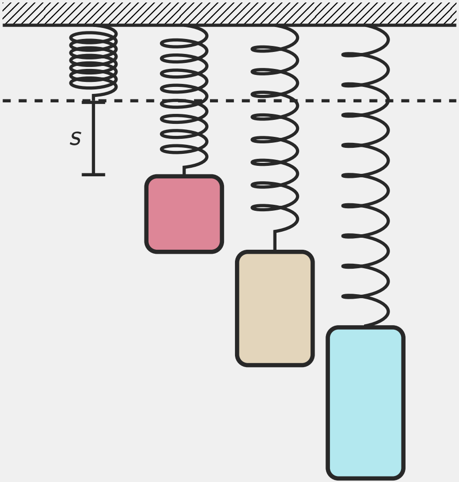

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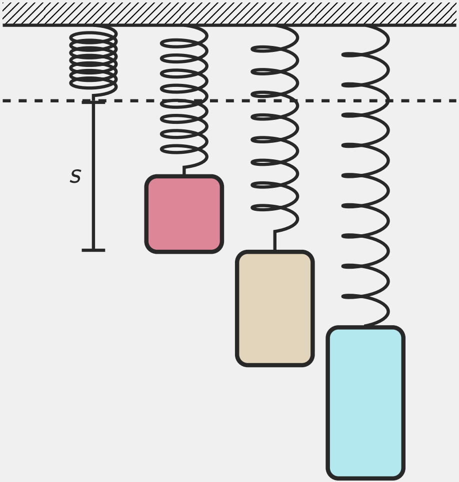

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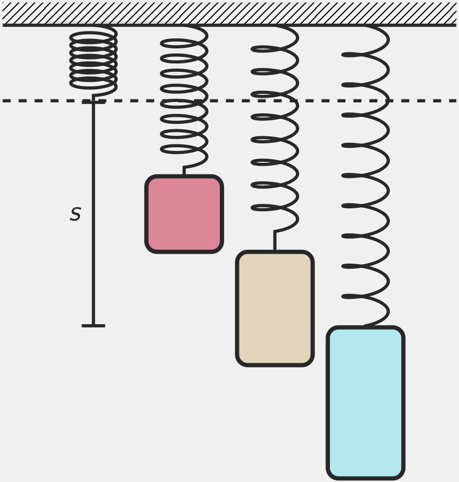

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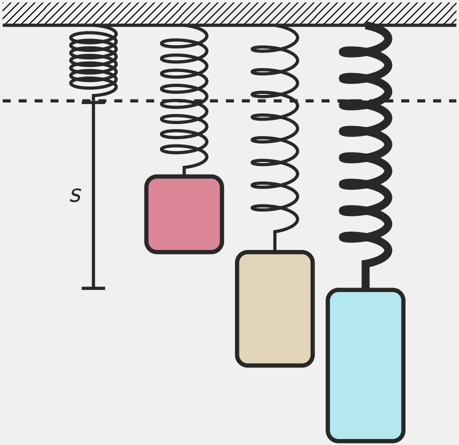

Strong Spring, Weak Spring

- Stiffer springs result in a greater force for less displacement
- Combining both spring stiffness and displacement, we arrive at

$$\left|\vec{\mathbf{F}}_{spring}\right| = k_s|s|$$

where

$$s = L - L_0$$

- L is the current spring length whereas L_0 is the spring length when relaxed

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- $k_s = \frac{mg}{s}$

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Spring Force

$$\vec{\mathbf{F}}_{spring} = -k_s s\hat{\mathbf{L}}$$

Understanding Check

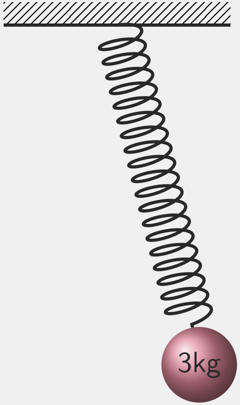
The system to the right has a 3 kg mass attached to the end of a spring with spring constant 10 N/m. The fixed end of the spring is located at $\vec{\mathbf{r}} = \langle 0, 0, 0 \rangle$ m while the mass end of the spring is as $\vec{\mathbf{r}} = \langle 1, -2, 2 \rangle$ m. If the spring has a relaxed length of 1 m, what is the spring force currently acting on the mass?

A) $\frac{1}{3}\langle 20, -40, 40 \rangle$ N

B) $\langle 20, -40, 40 \rangle$ N

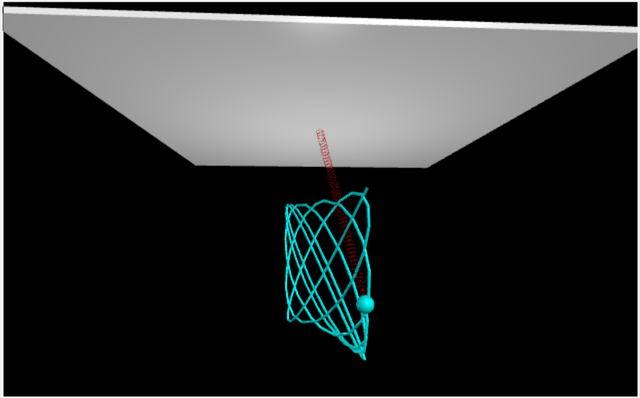
C) $\langle 6.6, 13, -13 \rangle$ N

D) $\frac{1}{3}\langle -20, 40, -40 \rangle$ N



Iterating!

This new step in making sure to calculate the new force is really all that you need to add to your iteration method!



Upcoming:

Fundamental Interactions

The Four Horsemen

- All known forces in the universe can be boiled down to about 4 fundamental forces
  - Gravitational
  - Electromagnetic
  - Weak Force
  - Strong Force
- In increasing order of strength
- The last 3 have been combined to form the Standard Model
- Often times we'll look at macro effects from these forces, but they provide a good starting location

Upcoming:

Gravity

My Final Form

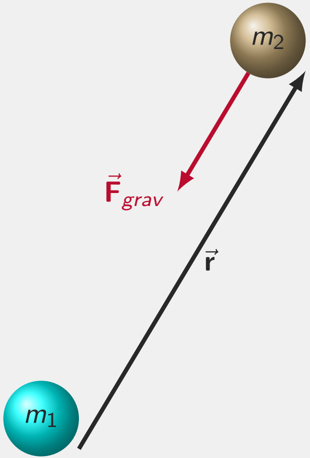
- We've seen that near the surface of the Earth the force of gravity can be approximated as

$$\vec{\mathbf{F}}_{gravity} \approx m\vec{\mathbf{g}}$$

  where $\vec{\mathbf{g}} = \langle 0, -9.8, 0 \rangle$ N/kg

- More accurately, the force of gravity is defined as

$$\vec{\mathbf{F}}_{\text{grav on 2 by 1}} = -G\frac{m_1 m_2}{|\vec{\mathbf{r}}|^2}\hat{\mathbf{r}}$$



Break it Down

$$\vec{\mathbf{F}}_{\text{grav on 2 by 1}} = -G\frac{m_1 m_2}{|\vec{\mathbf{r}}|^2}\hat{\mathbf{r}}$$

- m_1 and m_2 are the masses of the two objects
- $|\vec{\mathbf{r}}|$ is the distance between the objects
- $\hat{\mathbf{r}}$ is a direction pointing from the mass to the object it is interacting with
  - Points *to* the object of interest
- G is a measure of the strength of gravity

$$G = 6.67 \times 10^{-11}\,\mathrm{Nm^2/kg^2}$$

Dragging ya down

Let's calculate the force of the Earth on me, a 75 kg individual. For reference, the Earth has a mass of 5.972×10^{24} kg and an average radius of 6371 km. Compare this force to our earlier approximation.

Practice Time!

Suppose an astronaut aboard the International Space Station is playing with a new spring. Curious about the spring constant, the astronaut suspends a 500 g mass from the end of the spring, causing the spring to stretch 5 cm from its relaxed length and then remain motionless. The ISS orbits about 400 km above the surface of the Earth. The Earth has a mass of 5.972×10^{24} kg and an average radius of 6371 km.

- What is the spring constant?
- Suppose the astronaut stretched the spring 1 cm further and then let it go from rest. Where is the mass located 0.1 seconds later?