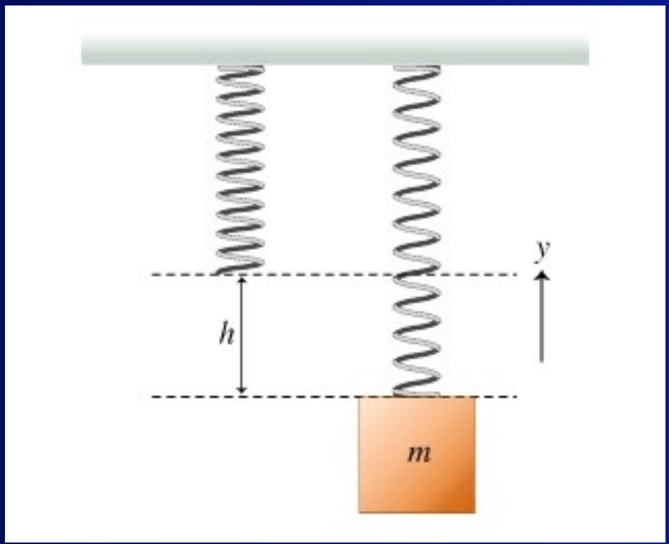
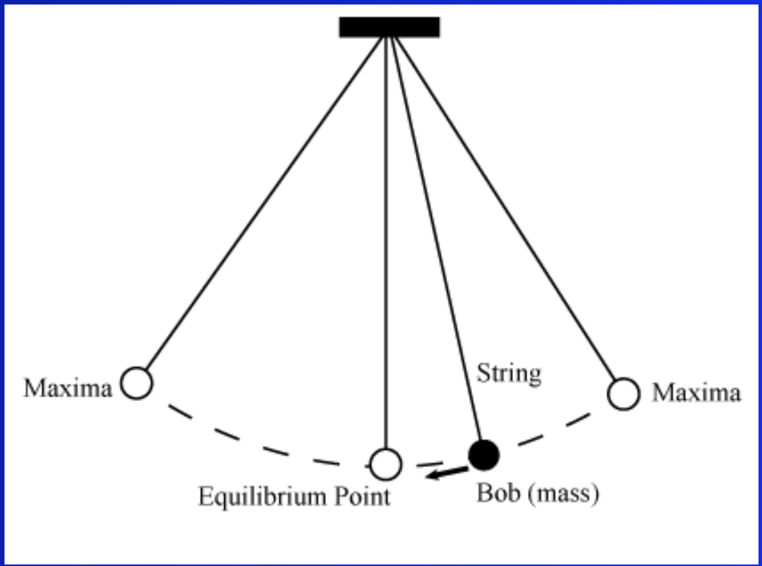
Physics 1C: Simple Harmonic Motion

Wednesday, 1 April 2015





Reminders

- Me: **Ramin Skibba**

  <u>rskibba@ucsd.edu</u>, 429 SERF building

  office hours on Mondays at 3-5pm or by appointment

- TA: **Bili Dong, leads PBs on Thursdays at 8pm**

  <u>b2dong@ucsd.edu</u>

- lab TA coordinators: Paul Hemphill, Hsi-Ming Chan

- remember: only pen/pencil & paper are allowed in class; no smartphones, tablets, laptops

Reminders

- course website: `http://ted.ucsd.edu`
- backup course website: `http://cass.ucsd.edu/~rskibba/work/Teaching.html`
- `http://www.webassign.net`

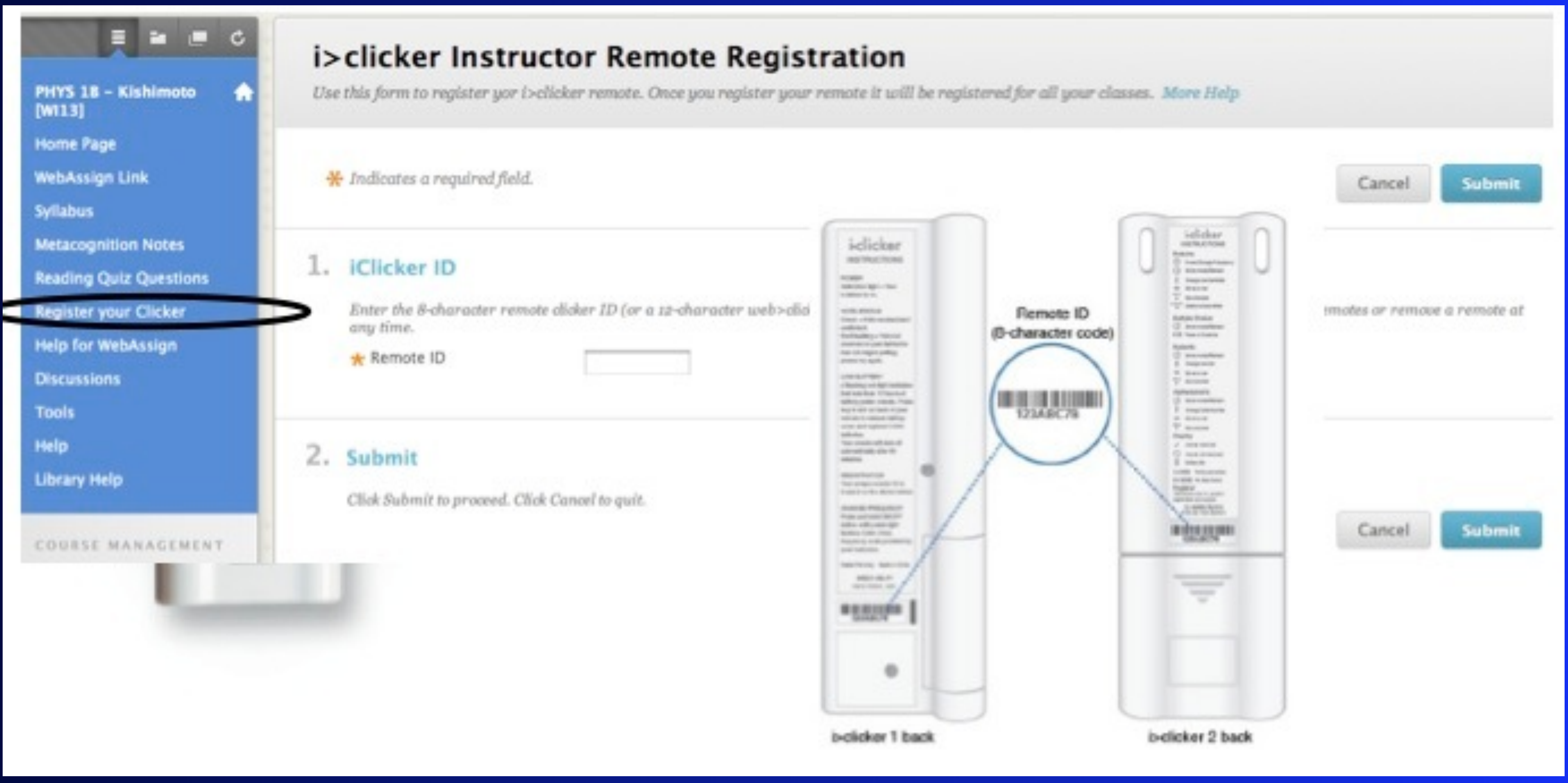
  self-enroll with our 1C class key: `ucsd 2397 3544`

  The 2-week trial period will be extended for the whole quarter.

This week's homework problems/questions for chapter 12:
Obj.Q. #1, Conc.Q. #1 & #4, Problems #1, 3, 17, 33

Plus a couple reading quiz questions for chapter 12. (Neither are graded this week, but I ***strongly*** recommend you work on them.)

Register your clicker

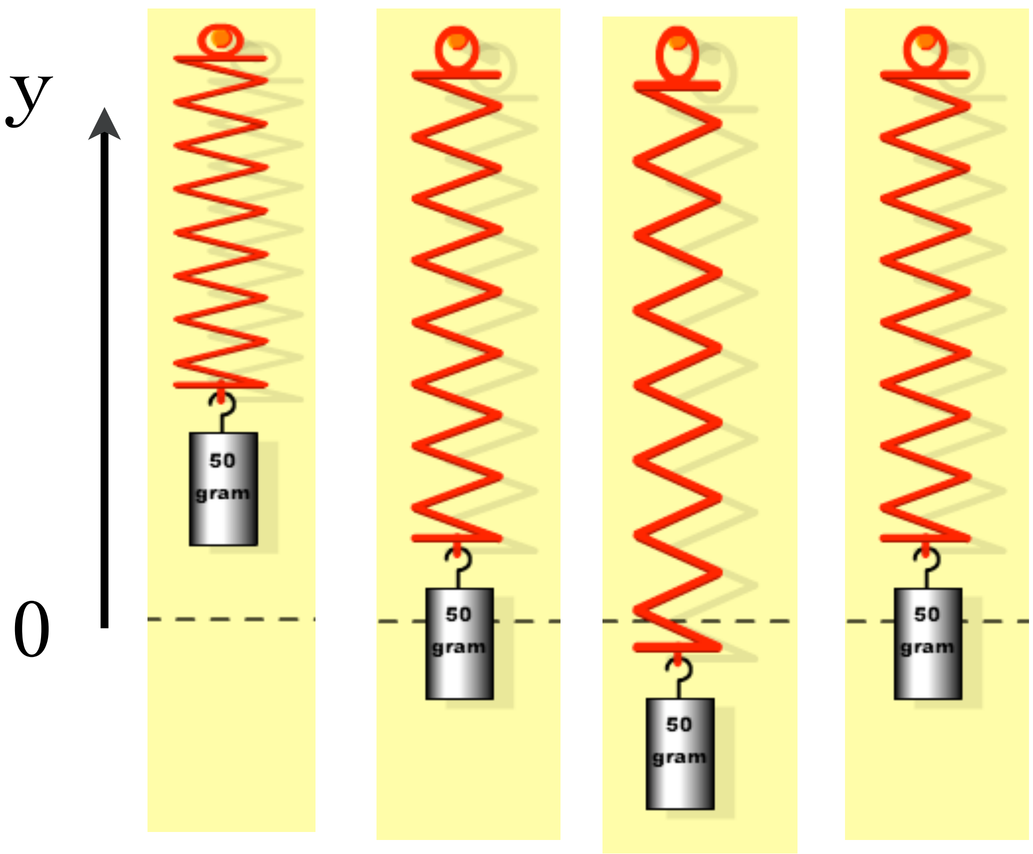


Oscillatory Motion

- Hooke's law: $F = -kx$
- and remember Newton's second law: $F = ma$
- a point mass on a spring exhibits "simple harmonic motion"
- a simple pendulum at small angles approximately does too
- for a mass on a spring, the position as a function of time can be modeled as $x(t) = A\cos(\omega t+\phi)$, where A, ω, and ϕ are the amplitude, frequency, and phase, respectively
- Note how position, velocity, acceleration, and periods of masses on springs and pendular are similar

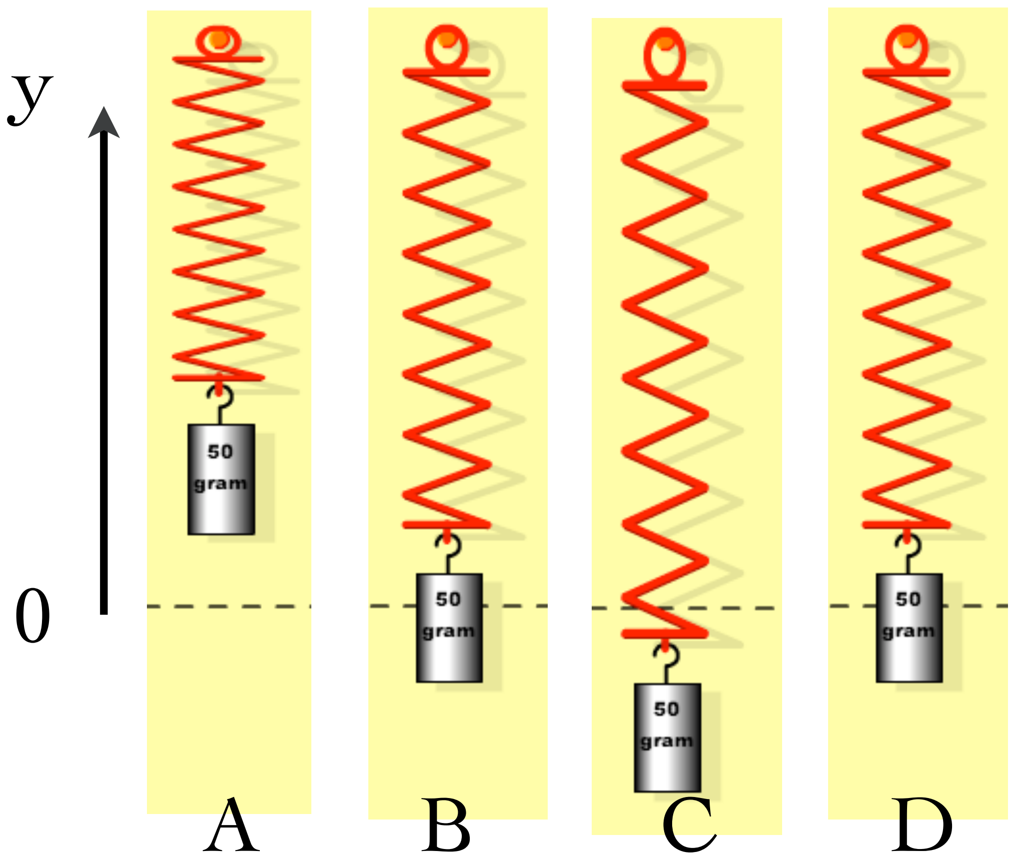
Mass on a Spring

Sketch the motion of the mass. When is the position positive/negative? When is the velocity positive/negative? When is the acceleration positive/negative?



Mass on a Spring: velocity

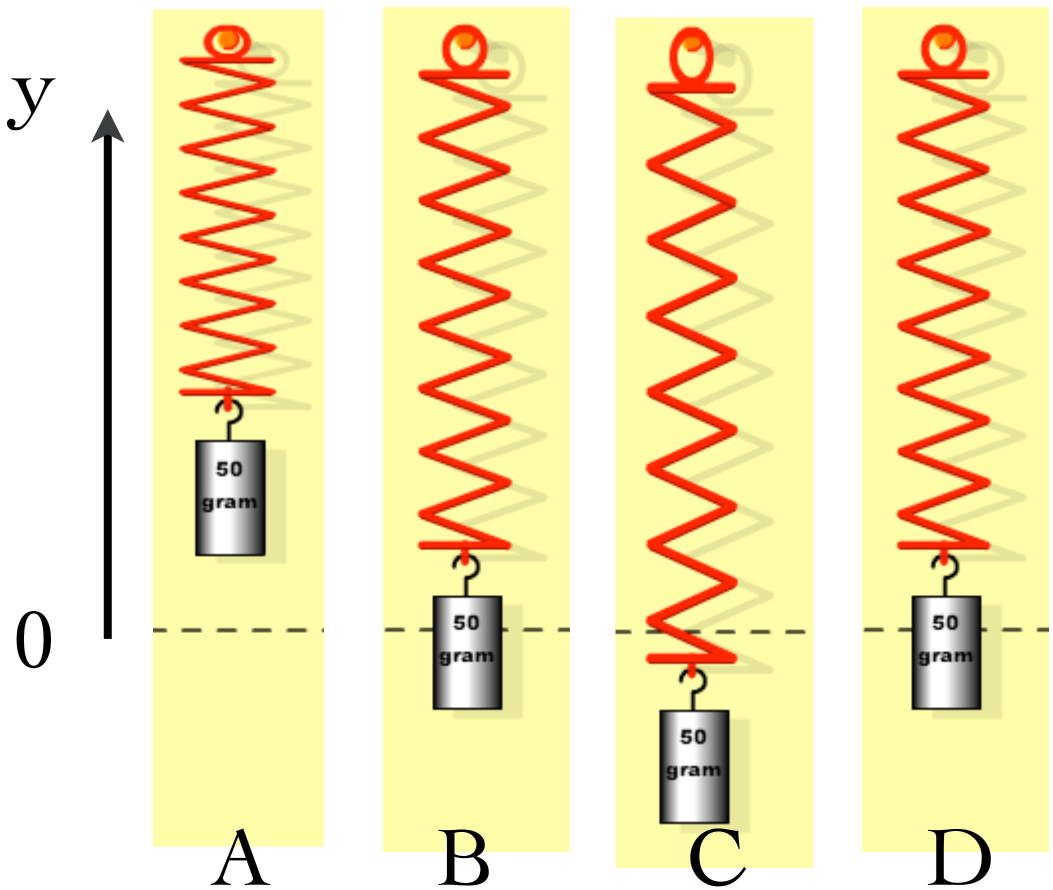
Points A & C represent the highest and lowest points of the motion, respectively. Choices A-D show sequential moments in the oscillation of the mass shown. At which point(s) is the mass' velocity positive?



E. more than one of these choices have a positive velocity

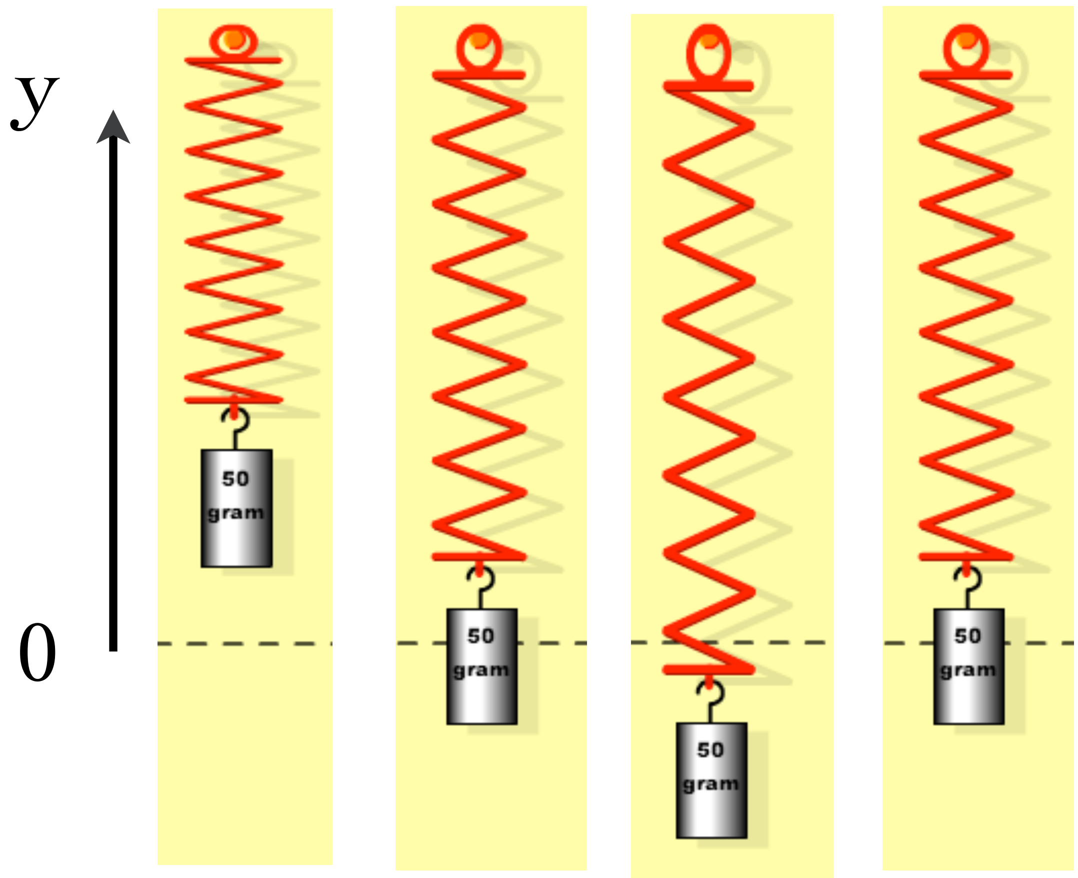
Mass on a Spring: acceleration

Points A & C represent the highest and lowest points of the motion, respectively. Choices A-D show sequential moments in the oscillation of the mass shown. At Point A the acceleration is



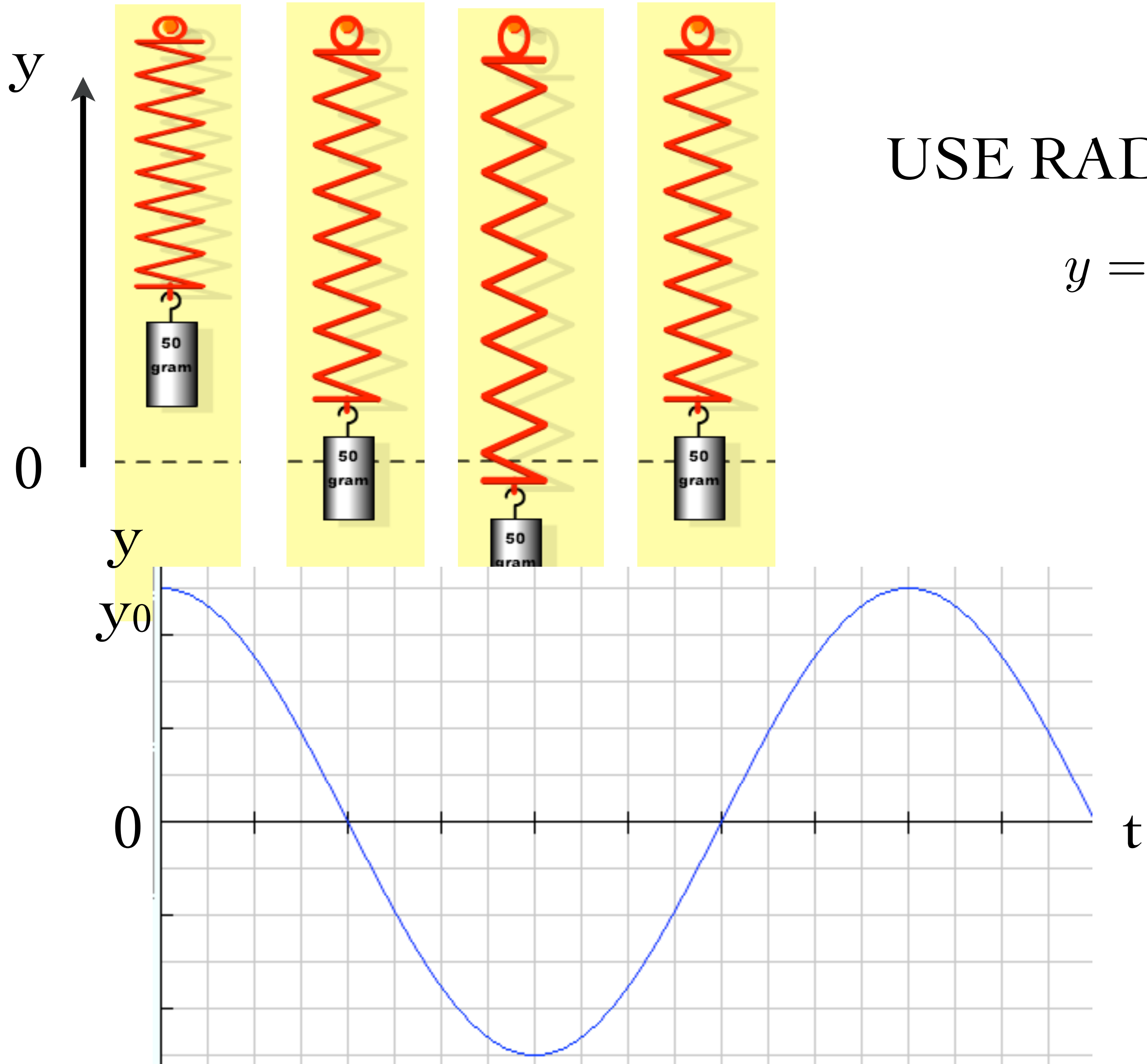
A. positive
B. negative
C. zero
D. huh?

Mass on a Spring: vel. & accel.



v	0	–	0	+
a	–		+	

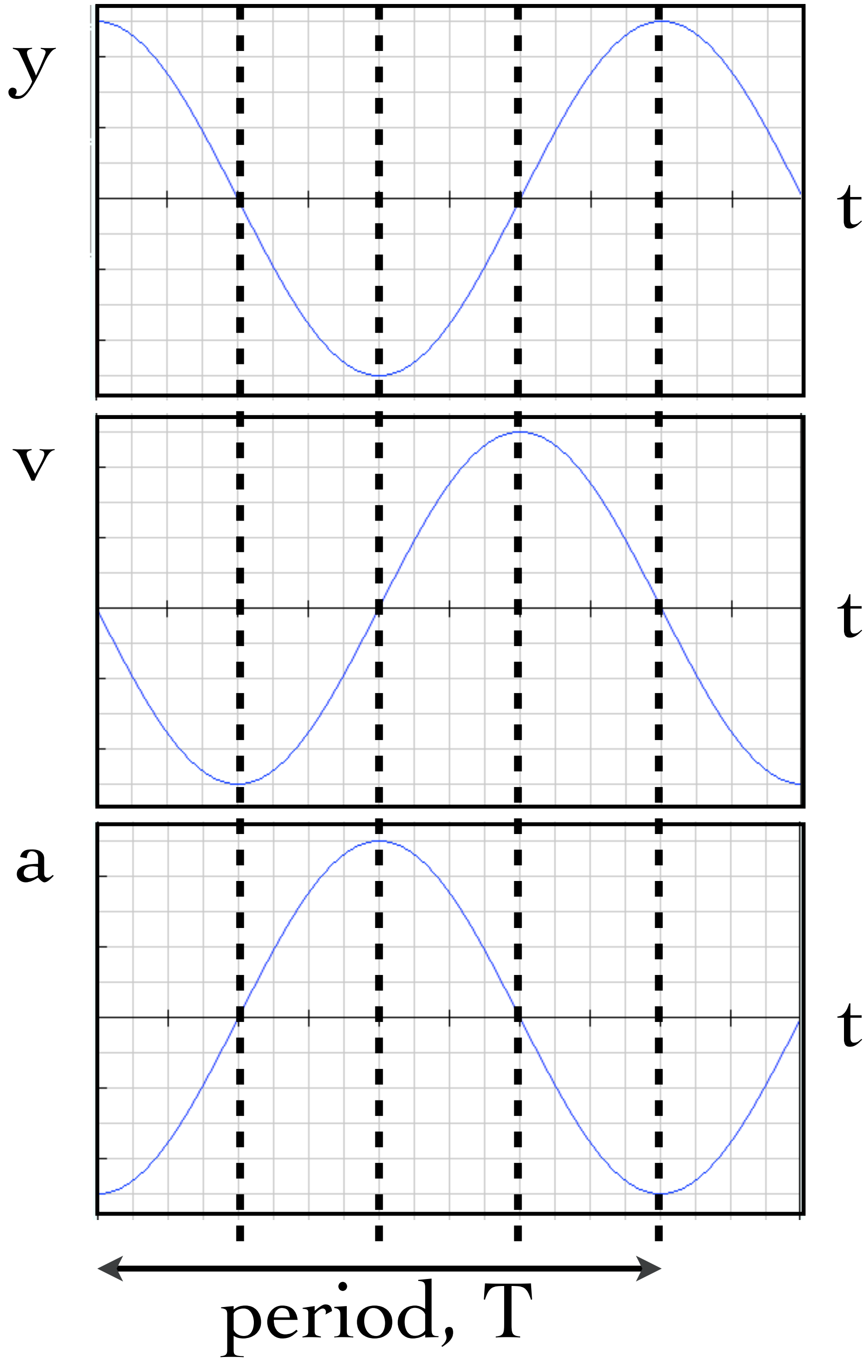
Mass's Position as a Function of Time



USE RADIANS!!

$$y = y_0 \cos(\omega t)$$

position ⇒ infer velocity & accel.



USE RADIANS!!

$$y = y_0 \cos(\omega t)$$
$$v_y = -y_0 \omega \sin(\omega t)$$
$$a_y = -y_0 \omega^2 \cos(\omega t)$$

once we have position as a function of time, velocity and acceleration are determined using derivatives

Period of Oscillation

If we increase the amplitude—that is, increase the initial displacement—then the period of oscillation:

A. increases

B. decreases

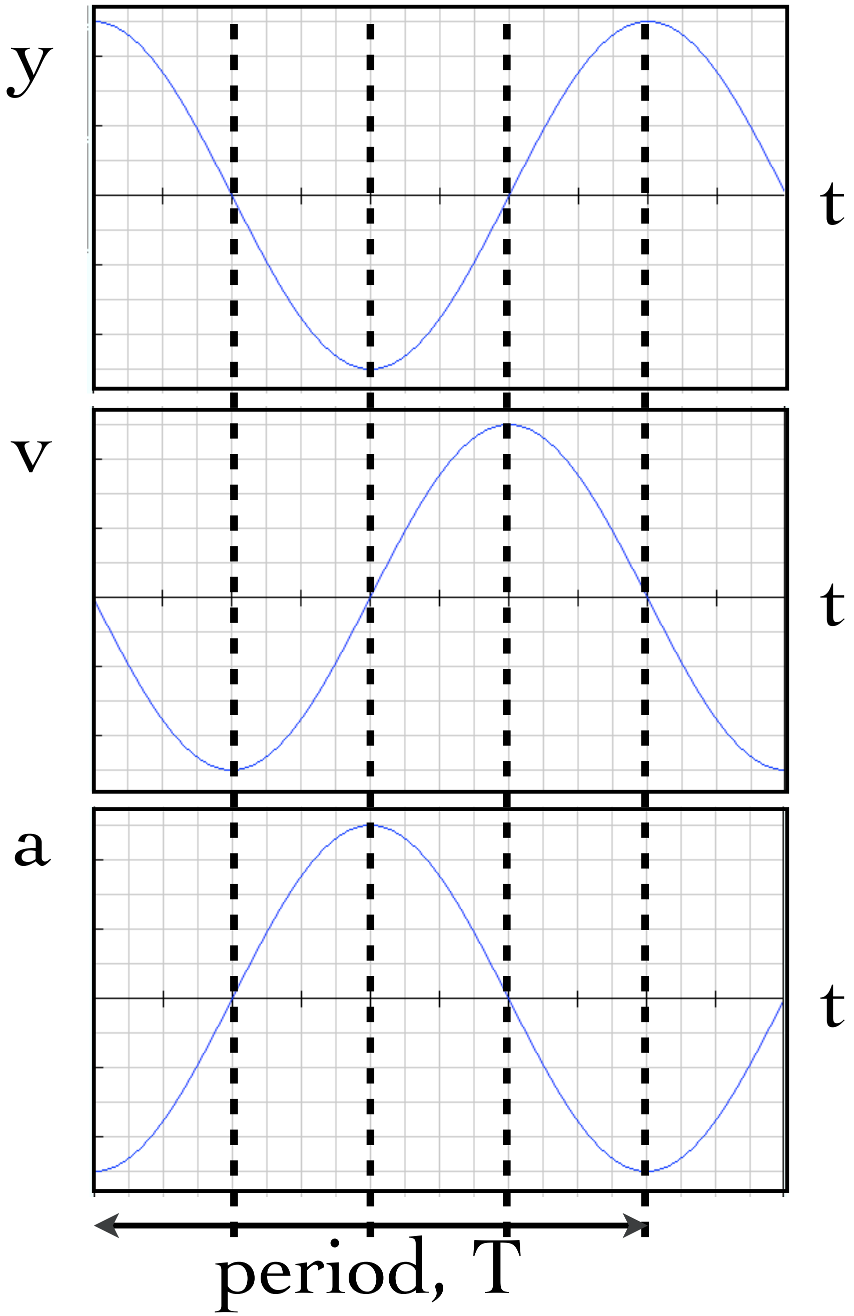
C. remains the same

Period of Oscillation

If we halve the mass, the period of oscillation:

A. decreases by a factor of two
B. decreases by a factor less than two
C. remains constant
D. increases by a factor less than two
E. increases by a factor of two

Review: position, velocity, acceleration



USE RADIANS!!

$$y = y_0 \cos(\omega t)$$
$$v_y = -y_0 \omega \sin(\omega t)$$
$$a_y = -y_0 \omega^2 \cos(\omega t)$$

ω: angular frequency
radians per second

$$\omega T = 2\pi$$

$$\omega = \frac{2\pi}{T}$$

demo: mass on spring

https://phet.colorado.edu/sims/mass-spring-lab/mass-spring-lab_en.html

(Credit: U. of Colorado, Physics Education Technology)

Simple Harmonic Motion (SHM)

position $$x = A\cos(\omega t + \phi_0)$$

velocity $$\frac{dx}{dt} = -A\omega\sin(\omega t + \phi_0)$$

acceleration $$\frac{d^2x}{dt^2} = -A\omega^2\cos(\omega t + \phi_0)$$

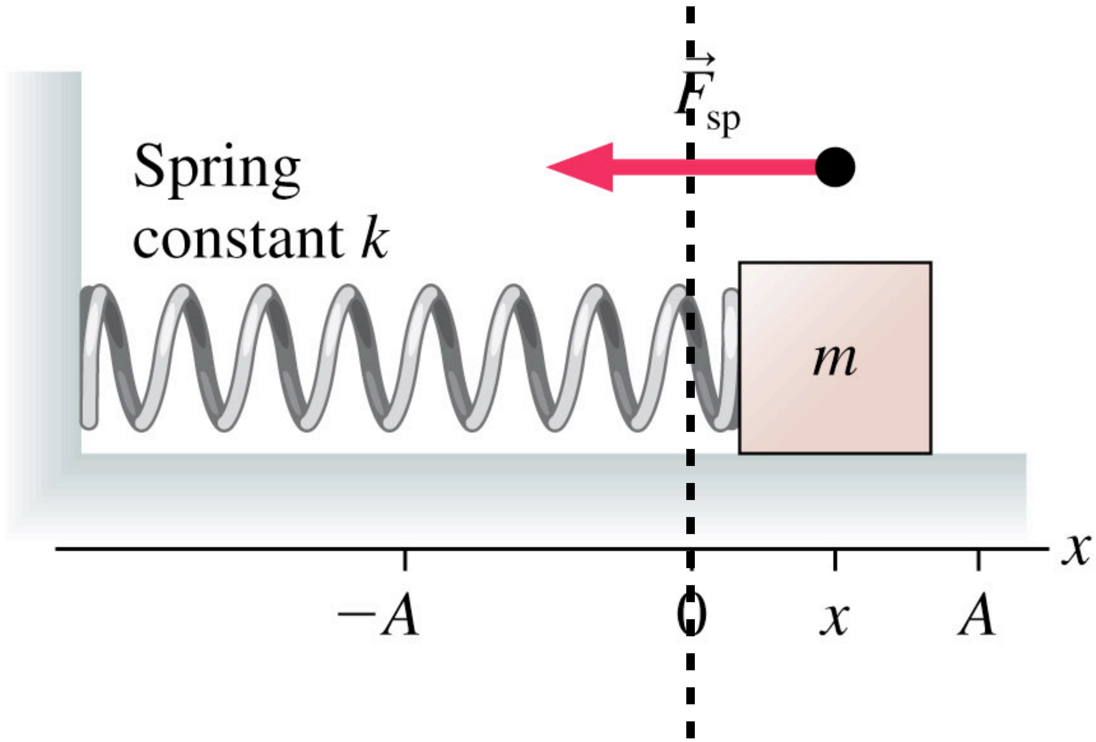
$$\frac{d^2x}{dt^2} = -\omega^2 x$$

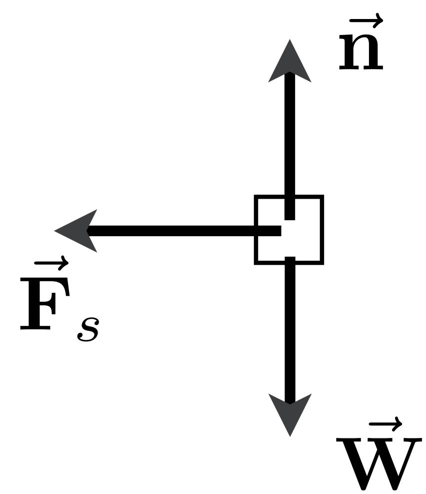
$$F_{\text{net}} = m\frac{d^2x}{dt^2} = -m\omega^2 x$$

"linear restoring force"

Simple Harmonic Motion

$$F_{\text{net}} = -m\omega^2 x$$





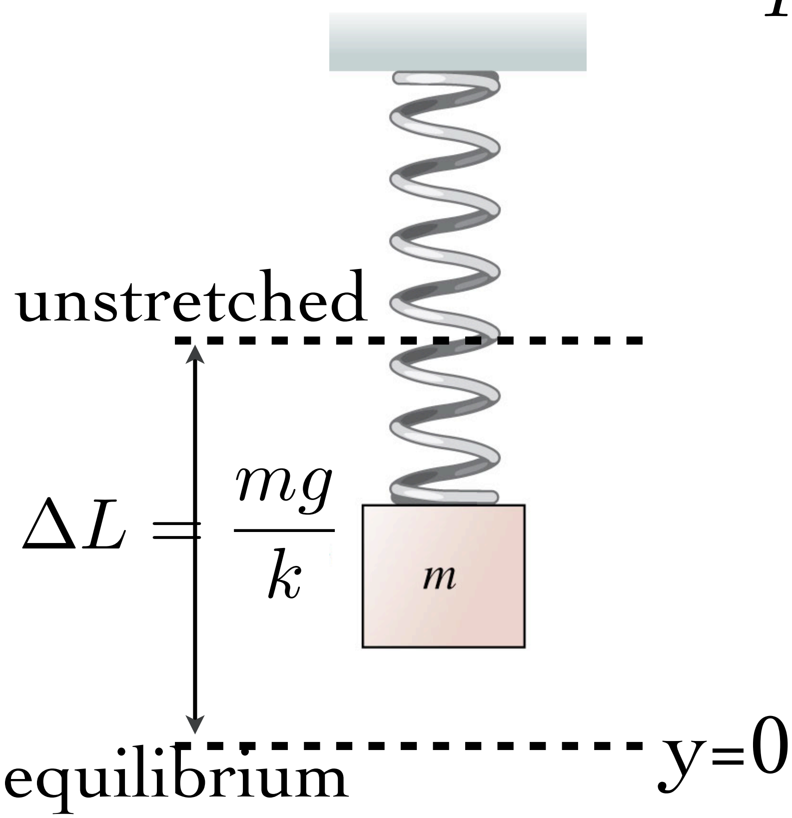
$$F_{\text{net}} = -kx$$

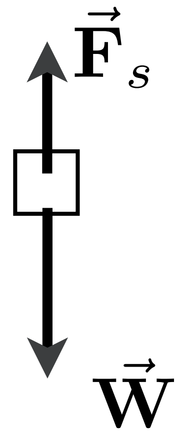
equilibrium

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

Simple Harmonic Motion

$$F_{\text{net}} = -m\omega^2 x$$





$$F_{\text{net}} = -mg + k(\Delta L - y)$$

$$F_{\text{net}} = -ky + (k\Delta L - mg)$$

$$F_{\text{net}} = -ky$$

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

For Friday:

1. ted.ucsd.edu or cass.ucsd.edu/~rskibba/
2. self-enroll on www.webassign.net using our class key (ucsd 2397 3544)
3. work on the homework problems (Obj.Q. #1, Conc.Q. #1 & #4, Problems #1, 3, 17, 33) and reading quiz
4. read through the second half of chapter 12