Today's Topics: SHM

https://www.youtube.com/watch?v=6sas9N3OmuM&feature=youtu.be&t=16s

Simple Harmonic Motion (SHM)

1. There is a restoring force proportional to the distance displaced from the equilibrium — $F \alpha \Delta x$
2. The potential energy is proportional to the square of the displacement — $U \alpha (\Delta x)^2$
3. The period or frequency (1/T) is independent of the amplitude of the motion
4. The position, x, the velocity, v, and the acceleration are all sinusoidal in time — $x(t) = A\cos(\omega t)$

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

Interpreting the Result

- We' ll leave it to our friends in math to show that these results actually satisfy the N2 equations.
- What do the various terms mean?
  - A is the maximum displacement — the *amplitude* of the oscillation.
  - What is ω_0? If T is the *period* (how long it takes to go through a full oscillation) then

$$\omega_0 t : 0 \rightarrow 2\pi$$

$$t \quad : 0 \rightarrow T$$

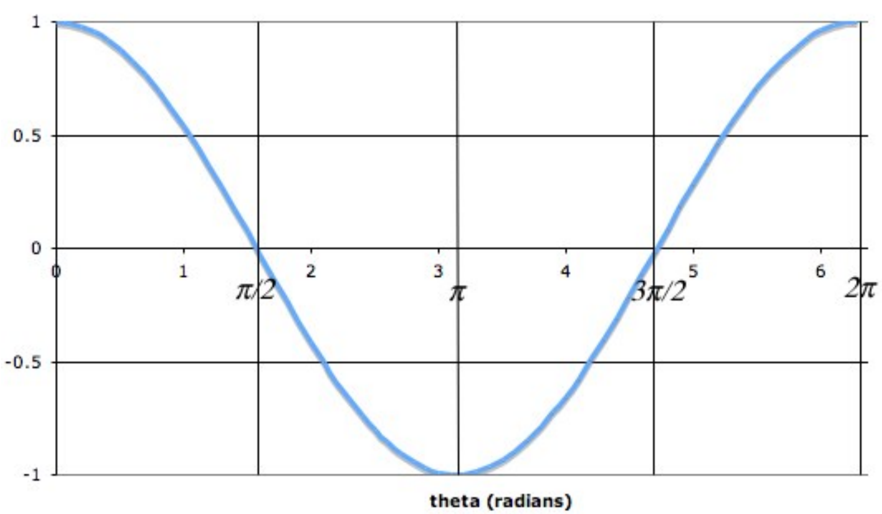
$$\omega_0 T = 2\pi \quad \Rightarrow \quad \omega_0 = \frac{2\pi}{T}$$

Graphs: $\sin(\theta)$ vs $\sin(\omega_0 t)$

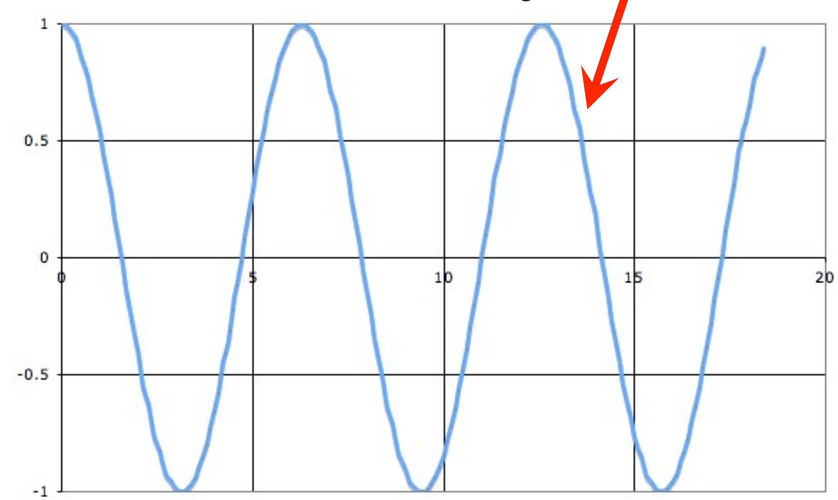
- For angles, $\theta = 0$ and $\theta = 2\pi$ are the same so you only get one cycle.
- For time, t can go on forever so the cycles repeat.

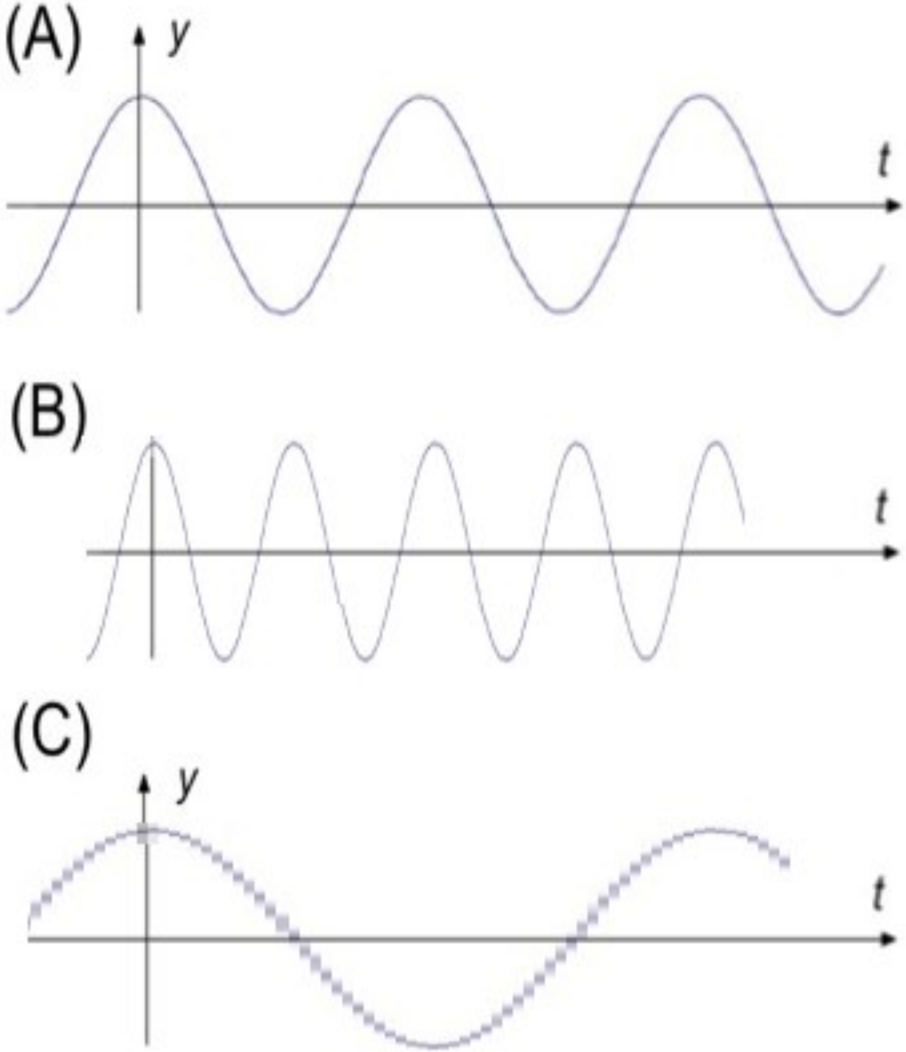
What does changing ω_0 do to this graph?

$\cos(\theta)$



$\cos(\omega_0 t)$





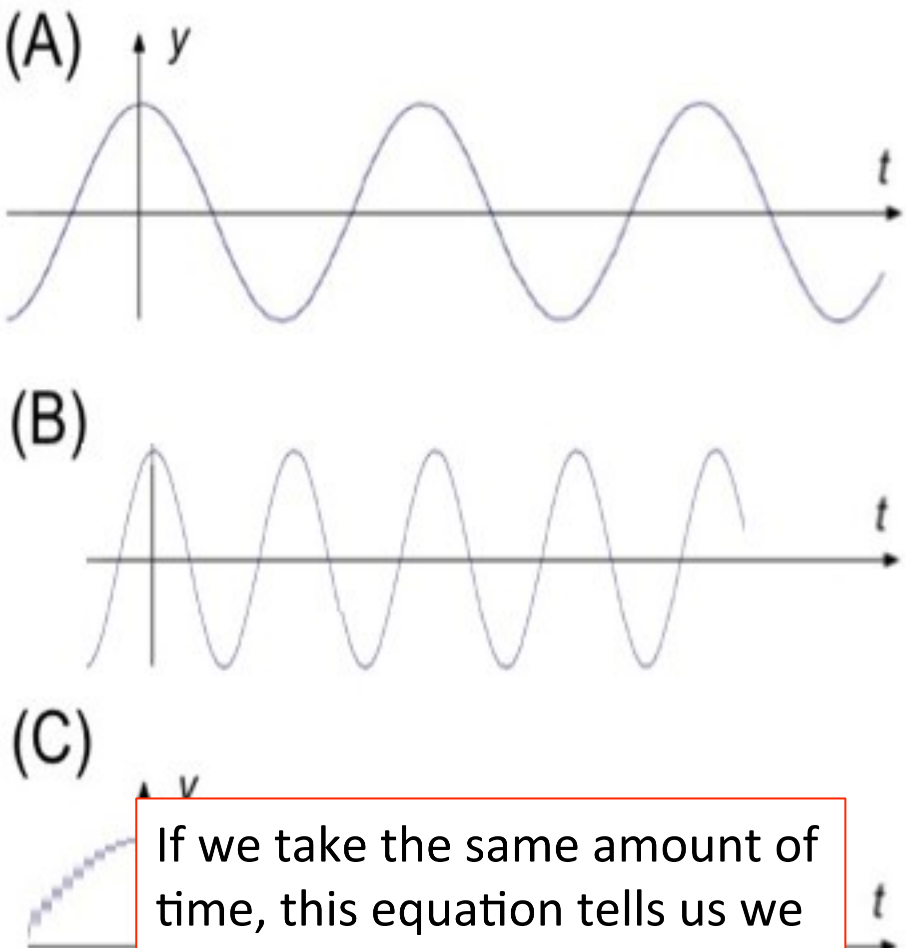
If curve (A) is

$$A\cos(\omega_0 t)$$

which curve is

$$A\cos(2\omega_0 t)?$$

A. (A)
B. (B)
C. (C)
D. None of the above.



If we take the same amount of time, this equation tells us we have to get 2x the number of oscillations – so the graph must be squished.

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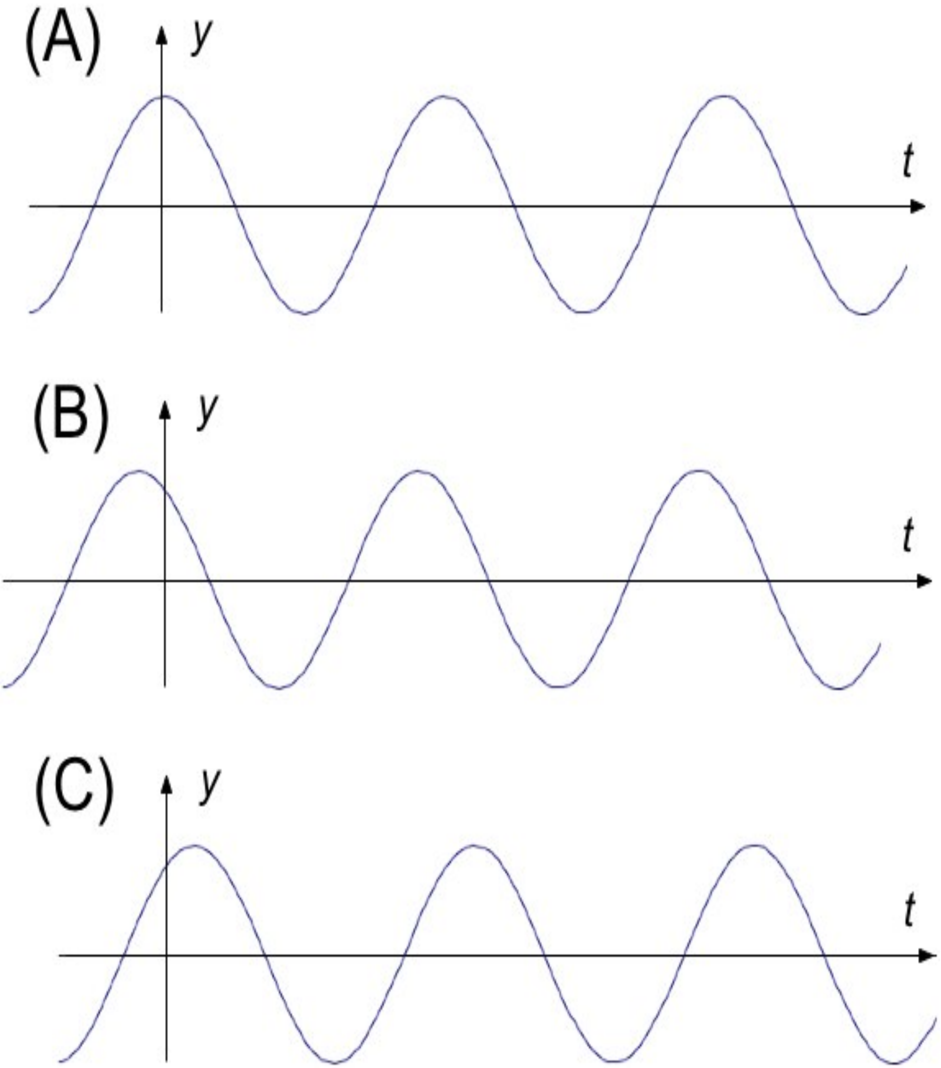
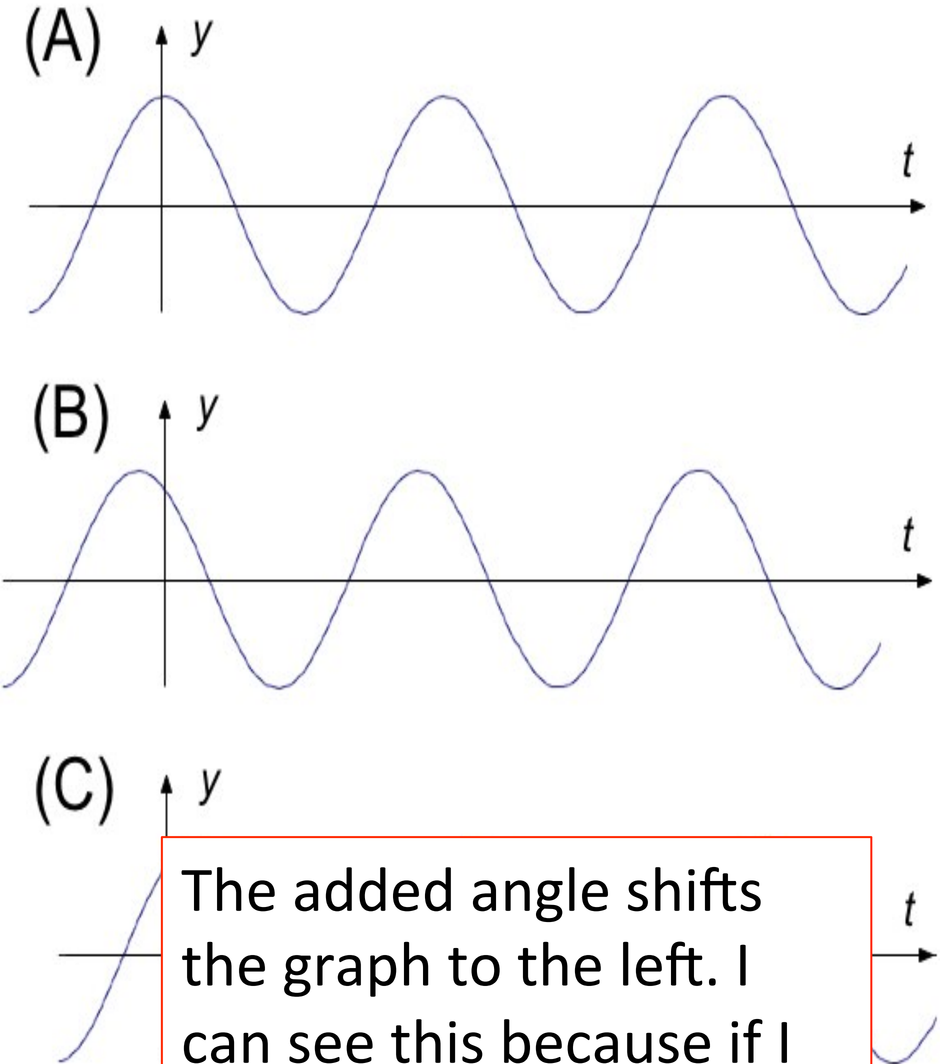


Which of these curves is described by

$$A\cos(\omega_0 t + \phi)$$

with $\phi > 0$ (and $\phi << 2\pi$)?

A. (A)
B. (B)
C. (C)
D. None of the above.



The added angle shifts the graph to the left. I can see this because if I put in t=0 then I cos(#) and not cos(0).

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$F \propto \Delta x$

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

Energy?

$$U = -\int F\,dx$$

$$U = -\int (-kx)\,dx$$

$$\boxed{U = \tfrac{1}{2}kx^2}$$

Potential energy stored by a spring

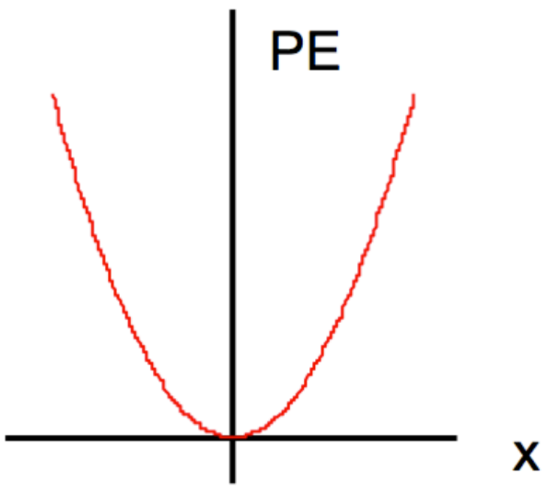
But we just established that this thing is also always moving, so it must have kinetic energy

E_{TOT} = ½ kx^2 + ½ mv^2

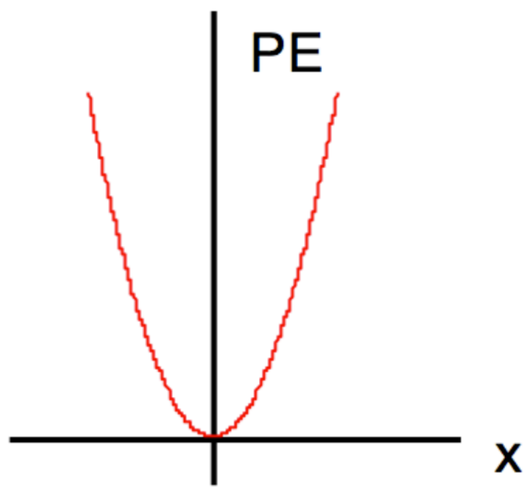
At the turn around point, v = 0 and x is at it's maximum (A) so

E_{TOT} = ½ kA^2

A stiff spring and a floppy spring have potential energy diagrams shown below. Which is the stiff spring?



Pink



Yellow

A. Pink
B. Yellow

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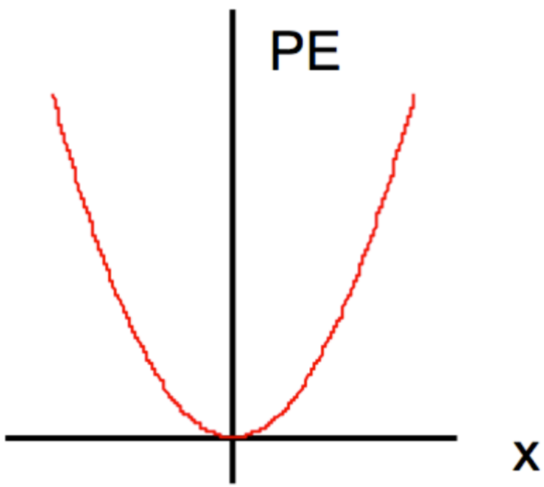

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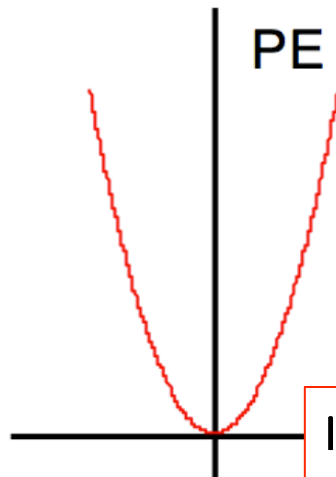


Yellow

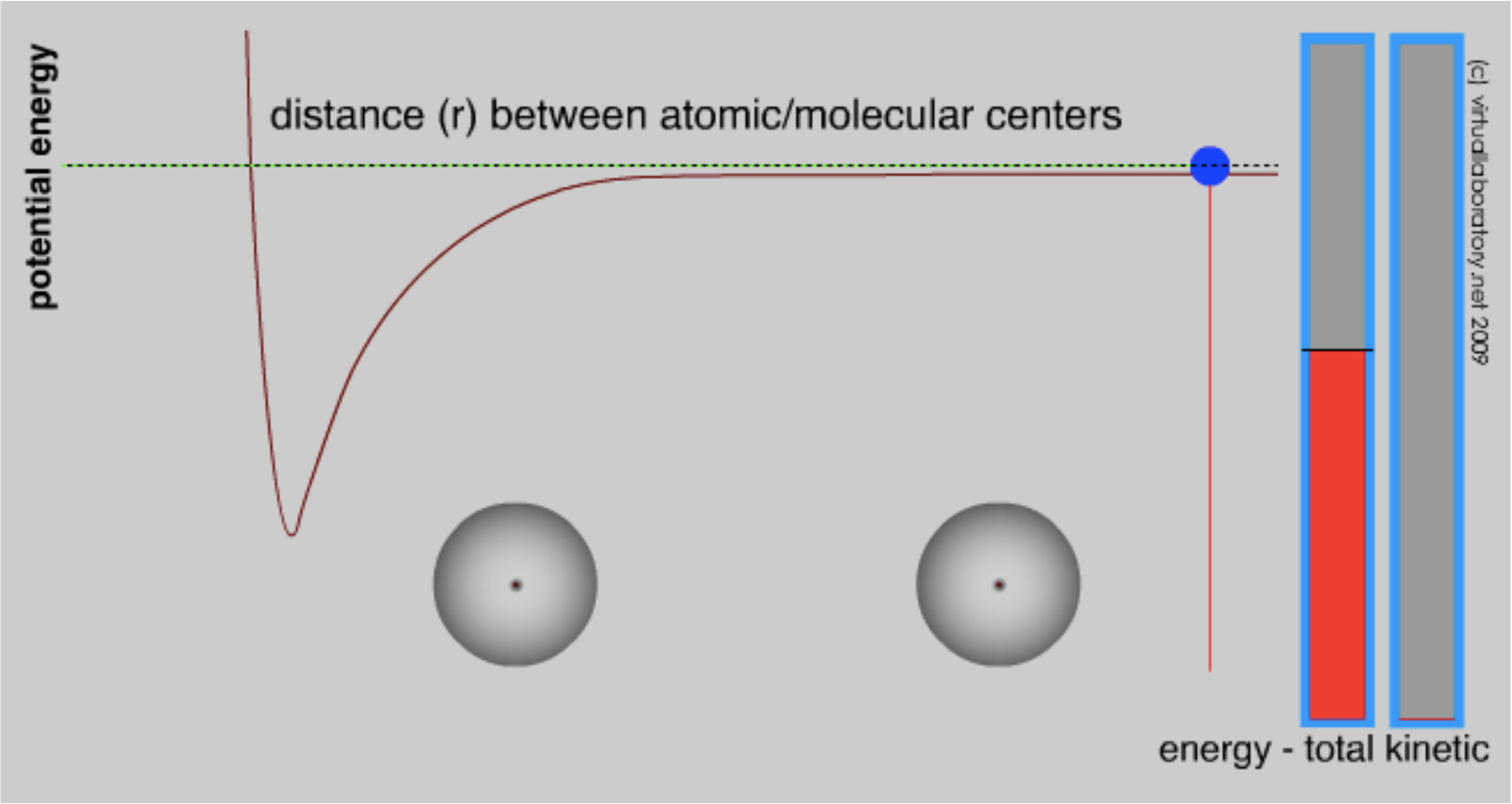
A. Pink

B. Yellow

If k gets bigger, then for every x you get a higher PE so a more narrow PE well.

Stiff spring = higher k, so Yellow

Molecular Level



http://besocratic.colorado.edu/CLUE-Chemistry/activities/LondonDispersionForce/1.2-interactions-0.html

You know that two atoms
that are far apart are barely interacting.

How is this represented visually in the PE diagram?

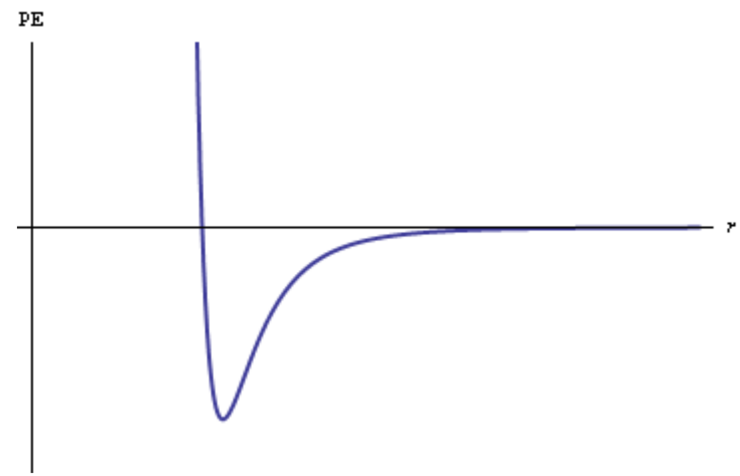
A. The potential energy approaches zero as *r* gets large.

B. The PE curve is close to vertical as *r* gets small.

C. The potential energy has a well-shape.

D. More than one of these

E. The PE diagram doesn't demonstrate this information



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If the atoms are barely interacting, then it's as if the spring is really stretched far. This corresponds to r getting very big and the U=0 at that point.

These two atoms can end up bound together.

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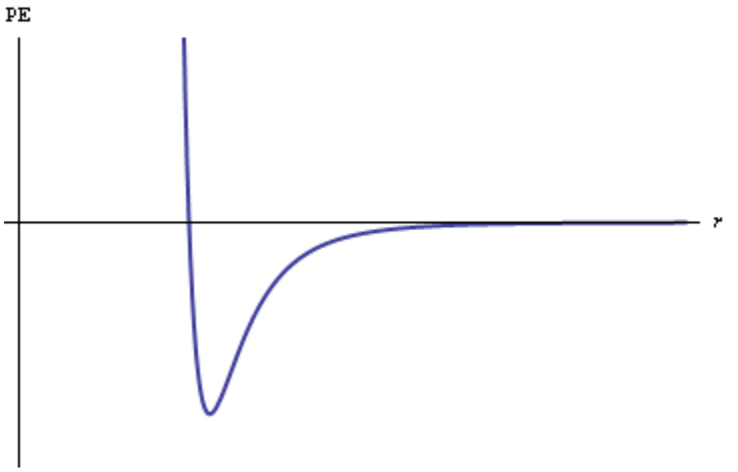

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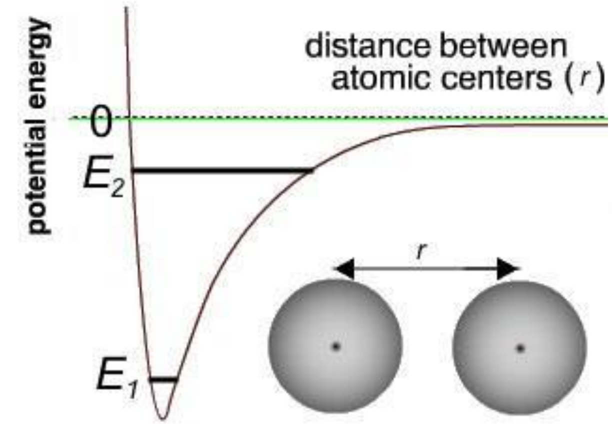
Because the potential energy has a well-shape, we can model two atoms bound as like to objects attached by a spring.

Two atoms interact with a potential energy between them that varies as a function of their separation as shown in the graph at the right. We take the zero of energy to be when they are very far apart and at rest. They have a total energy E_1 as shown on the figure. Which of the following statements are true about them?



A. They are in a bound state.

B. The total energy of the molecule is positive.

C. The total energy of the molecule is negative.

D. The total energy of the molecule is zero.

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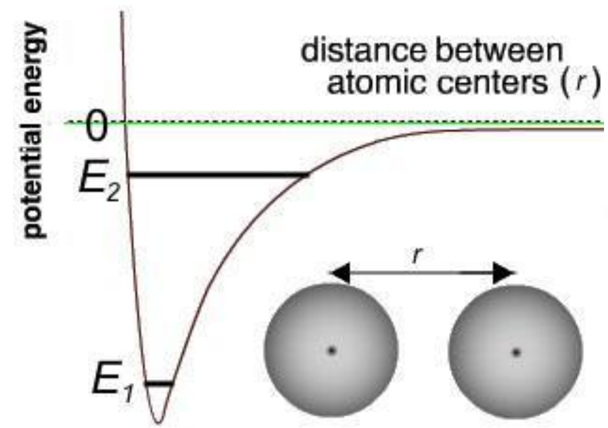

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See notes from 11/14 for explanation.