Today's Topics: Atomic Energy & SHM

https://www.youtube.com/watch?v=HFh9DOWlZCs

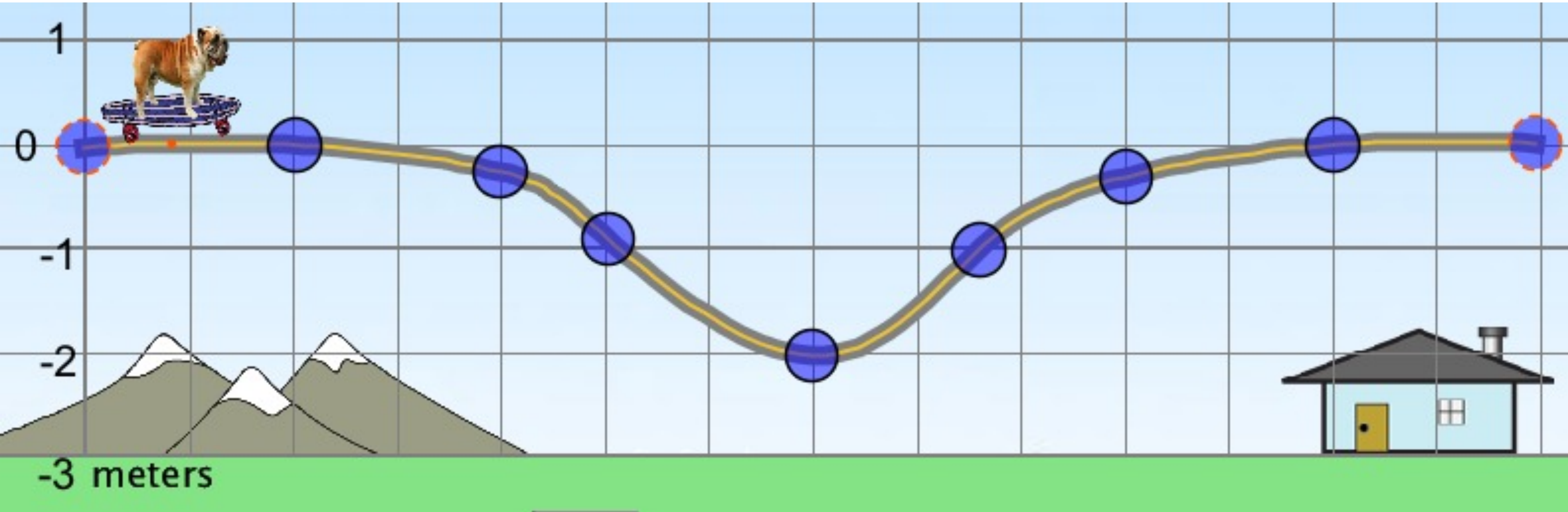
A bulldog on a skateboard is moving very slowly when he encounters a 2 m dip. How fast will be be going when he is at the bottom of the dip? The bulldog and skateboard combined have a mass of 20 kg.
Friction and air drag can be ignored.

A. Very slowly

B. About 2 m/s

C. About 6 m/s

D. You can’t tell from the information given.



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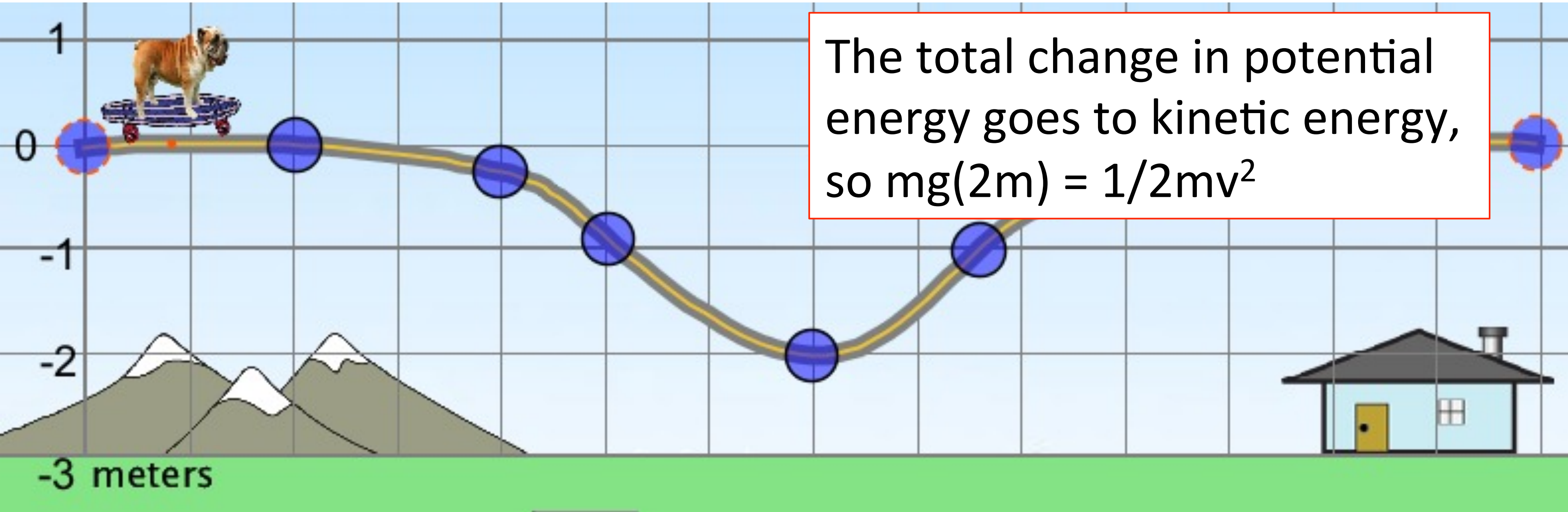


The total change in potential energy goes to kinetic energy, so $mg(2m) = 1/2mv^2$

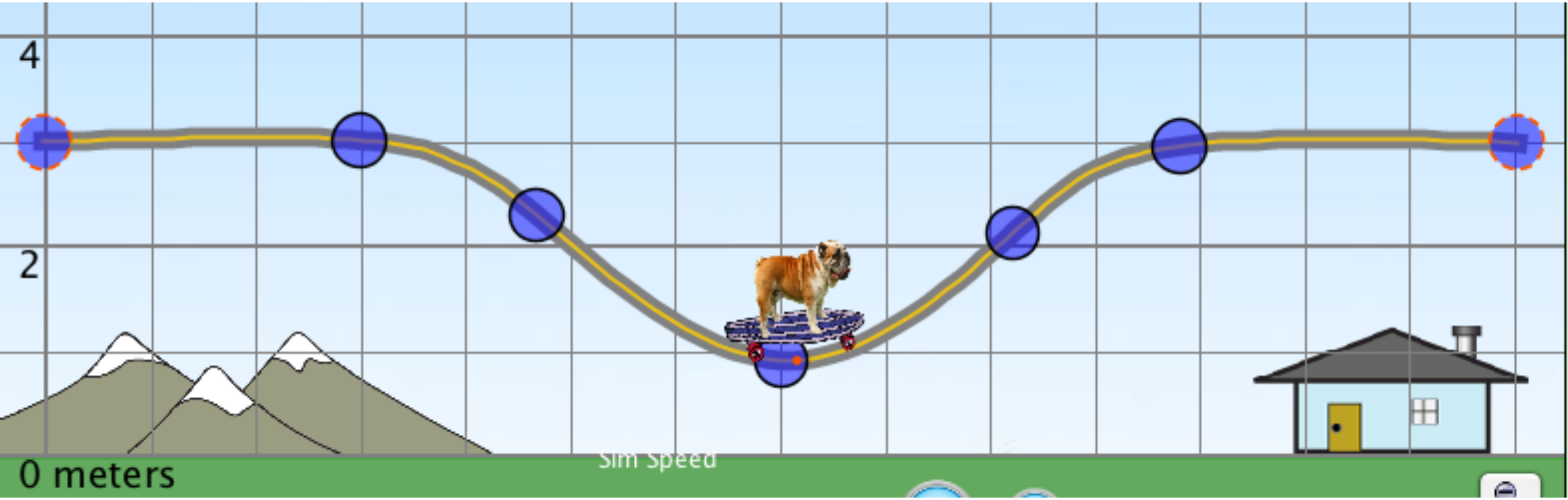
If the bulldog/skateboard (20kg) was in the bottom of the 2m well, how much kinetic energy would you have to give him to get out?

A. Almost zero

B. About 200 Joules

C. About 400 Joules

D. You can't tell from the information given.



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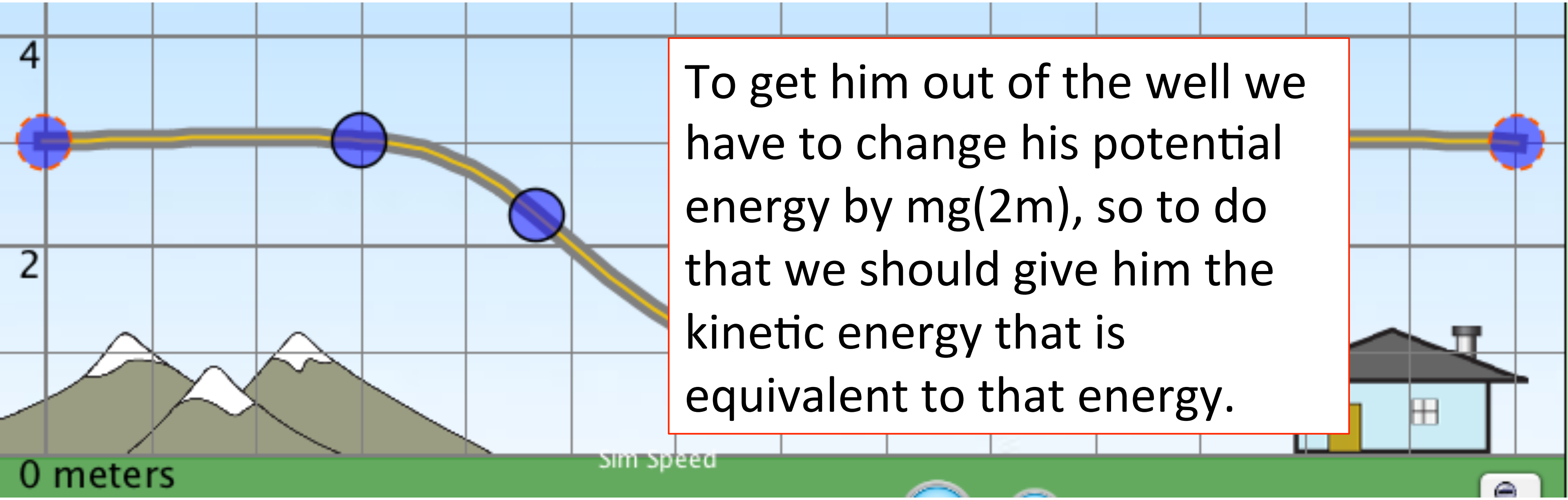
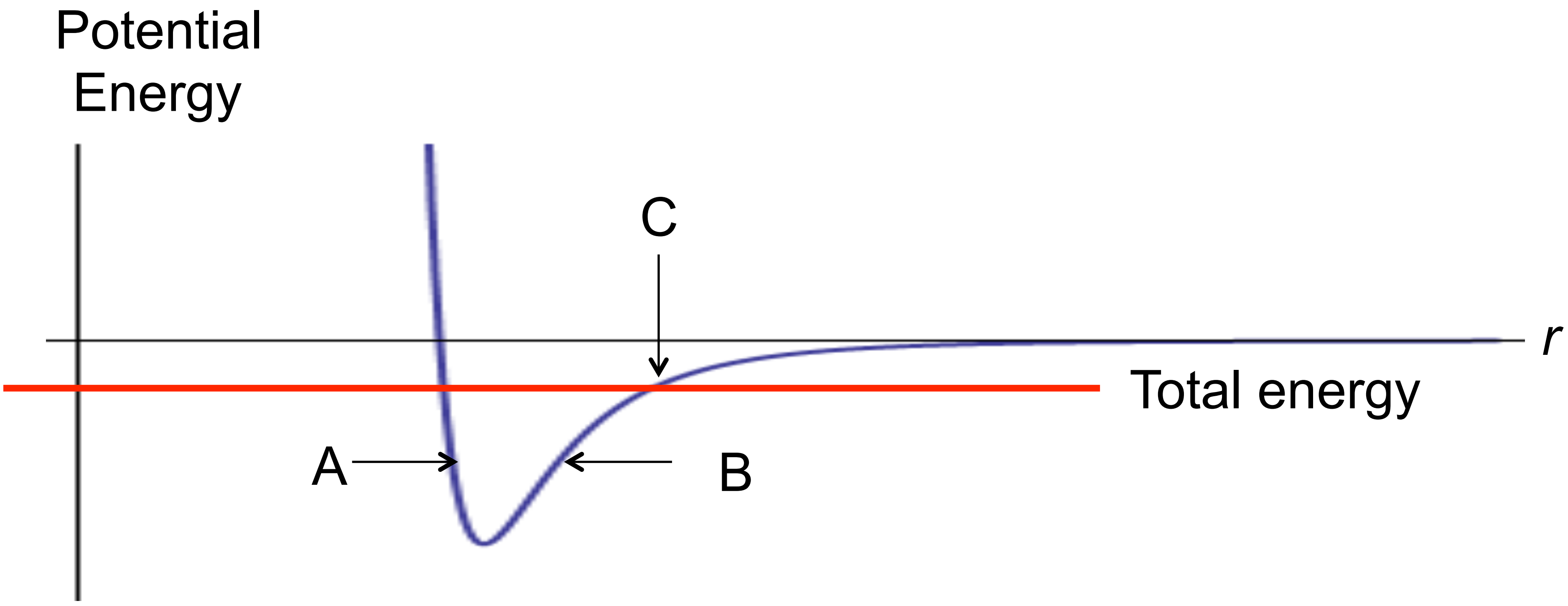
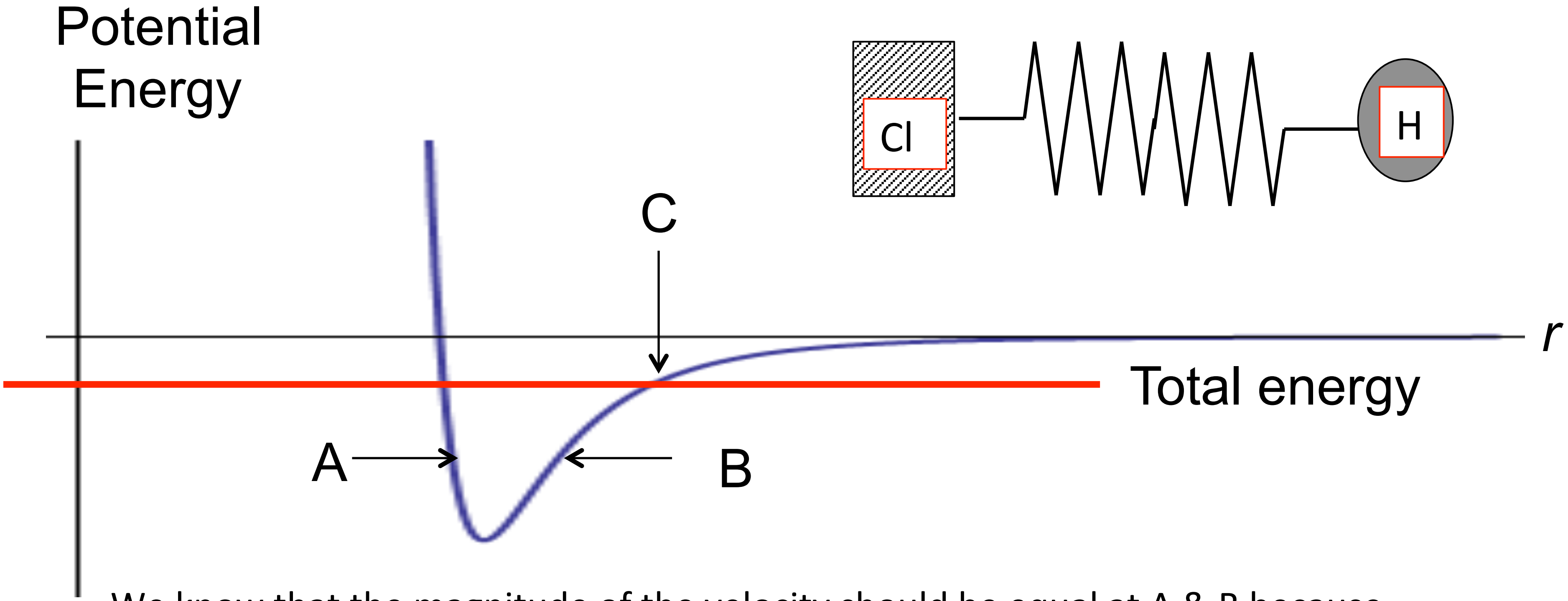


To get him out of the well we have to change his potential energy by mg(2m), so to do that we should give him the kinetic energy that is equivalent to that energy.



What is the **velocity** and **force** at point A,B,C Consider both magnitude and direction!

Draw the vectors on the whiteboard

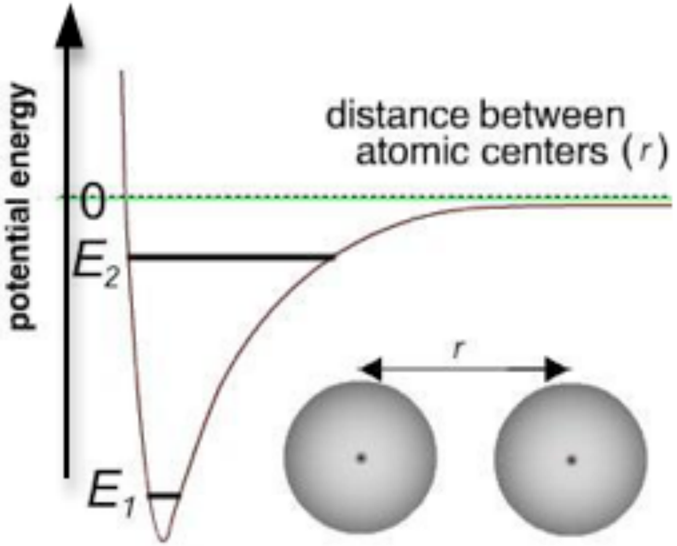


We know that the magnitude of the velocity should be equal at A & B because they have the same amount of potential energy and the rest must be kinetic, and at C v=0 because all the energy is potential so therefore none is kinetic and the speed must be 0. The direction of these vectors not determinable because they could be moving away from equilibrium or toward equilibrium, but it must always be left or right.

The force we can determine. At A & B the force must be pulling the particle back to equilibrium (which is the point at the bottom of the well) so at A the force must be to right, at B the force must be to the left. And also at C is must be to the left. We can also see this by using the slope of the line F = - dU/dx

While wandering around their environment, the molecule collides with another (fast moving) molecule and winds up being shifted to the state with a total energy E_2 as shown on the figure. Which of the following statements are now true about these atoms?

A. They are no longer in a bound state.
B. They are more tightly bound than they were before.
C. There are less tightly bound than they were before.
D. Their binding energy has not changed.
E. More than one is true.



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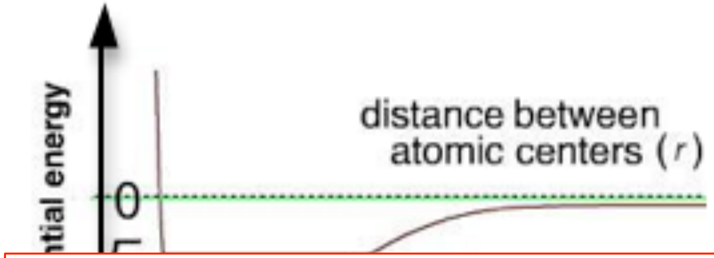


A is not true because E_2 still is inside the well.
B is not true because the maximum distance the atoms can stretch with E_2 is greater than with E_1.
D is not true because the amount of energy you need to put in the well is less at E_2 than at E_1 so the binding energy must have changed.

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

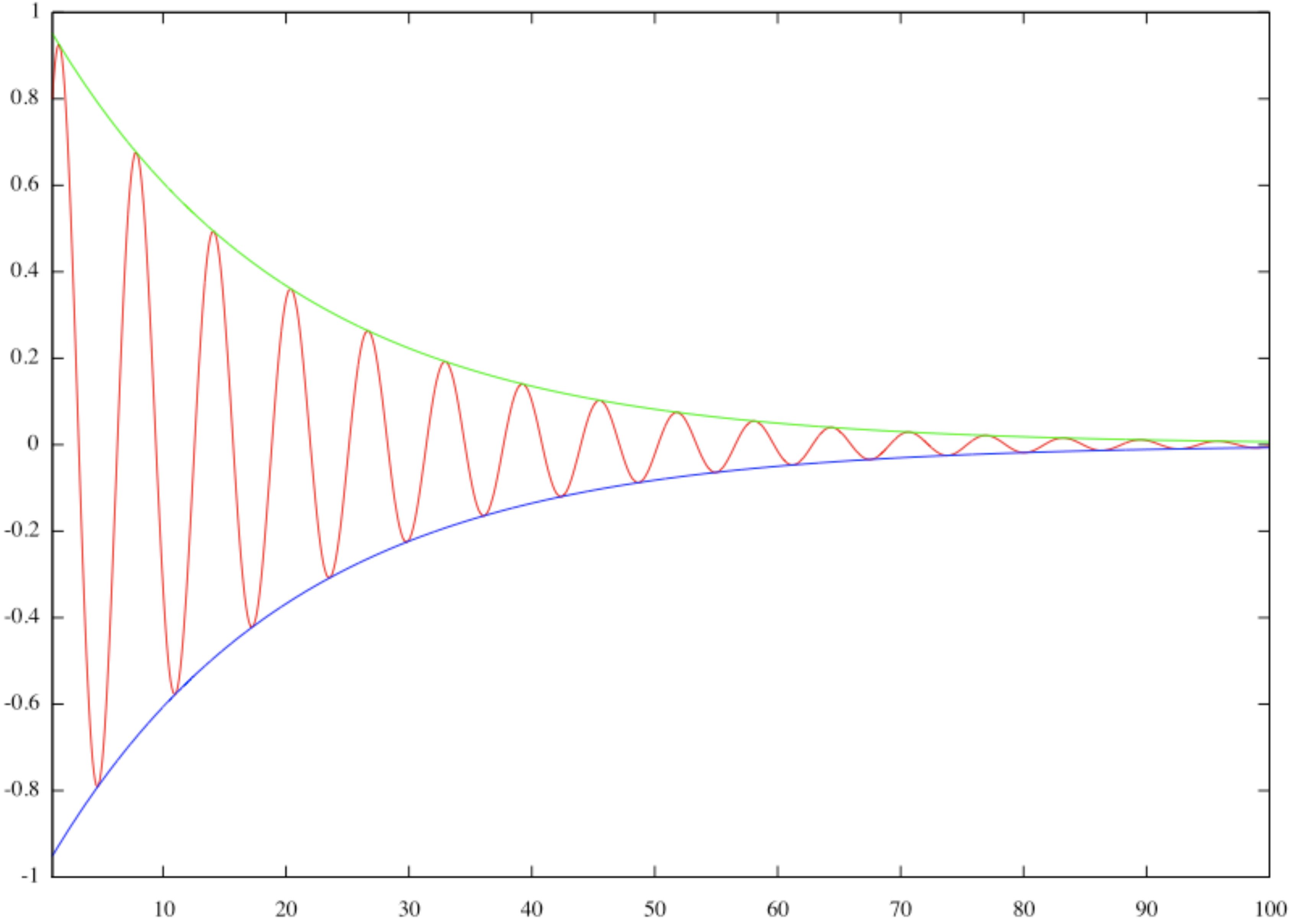
$U \alpha (\Delta x)^2$

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

Damped Harmonic Oscillator



Foothold ideas: Damped oscillator 1

- Amplitude of an oscillator tends to decrease. Simplest model is viscous drag.

$$ma = -kx - bv$$

$$\frac{d^2x}{dt^2} + \gamma\frac{dx}{dt} + \omega_0^2 x = 0 \qquad \gamma = \frac{b}{m} \quad \omega_0 = \sqrt{\frac{k}{m}}$$

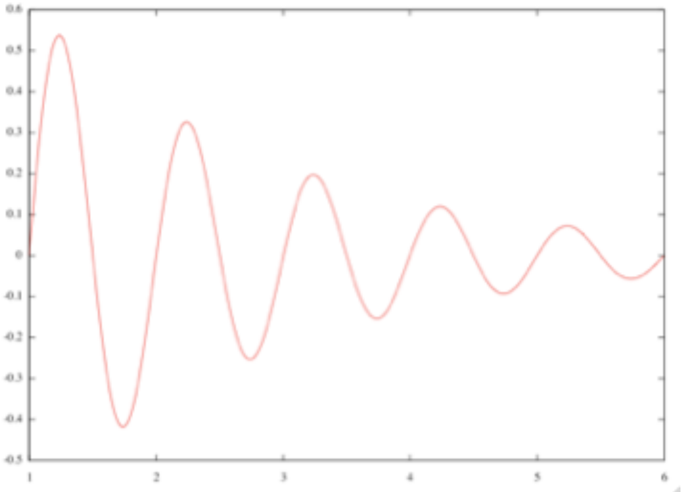
- Solution:

$$x(t) = A_0 e^{-\gamma t/2}\cos\left(\omega_1 t + \phi\right)$$

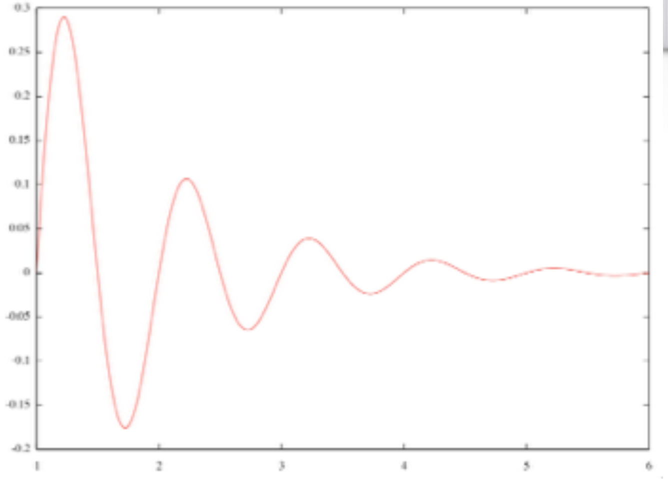
$$\omega_1 = \sqrt{\omega_0^2 - \frac{\gamma^2}{4}}$$

Which of these damped harmonic oscillators has the largest value of γ?

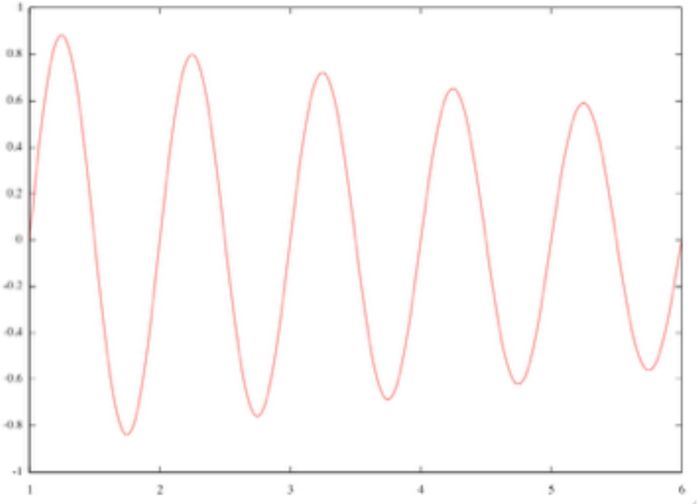
A



B



C



D) All are identical

E) Can’t tell from the information given

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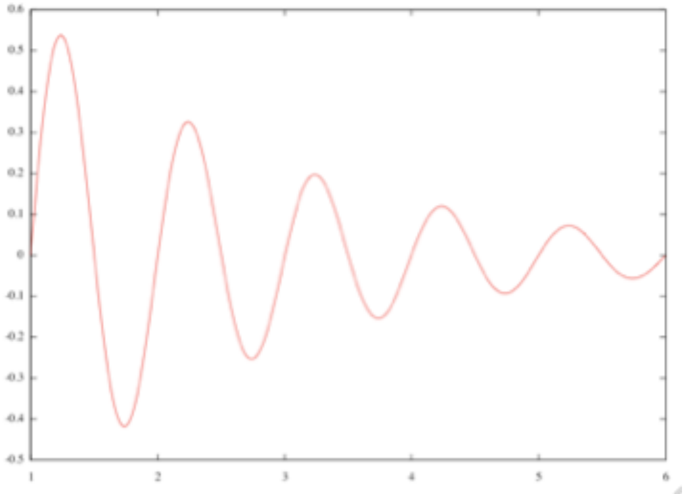
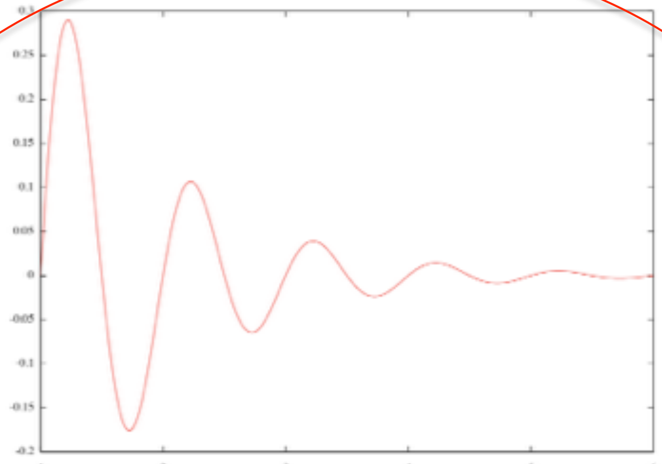
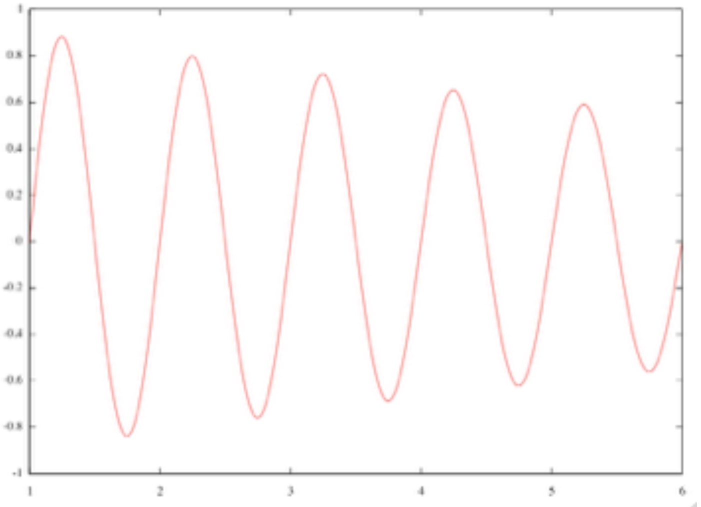


B



C



D) All are identical

E

i

The largest damping coefficient will correspond to stopping oscillating the fastest.

Foothold ideas:
Damped oscillator 2

- Competing time constants:

$$\frac{\gamma}{2} = \frac{1}{\tau} \qquad \frac{\omega_0}{2\pi} = \frac{1}{T} \qquad Q = \frac{\omega_0}{\gamma} = \pi\frac{\tau}{T}$$

Decay time

Period

Tells which force dominates: restoring or damping.

- If:

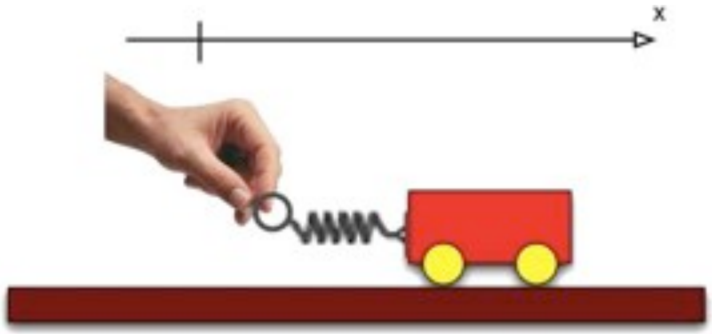
$\omega_0 > \gamma/2$ underdamped: oscillates

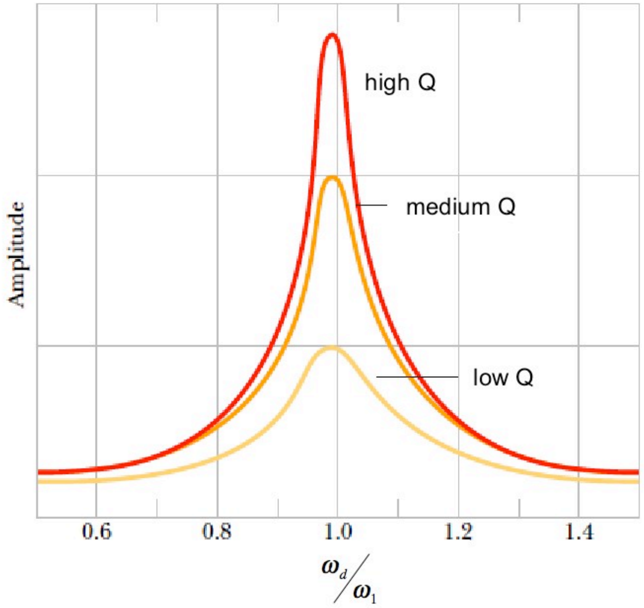
$\omega_0 = \gamma/2$ critically damped: no oscillation, fastest decay

$\omega_0 < \gamma/2$ over damped: no oscillation, slower decay

Foothold ideas:
Driven oscillator

- Adding an oscillating force.
- When the extra oscillating force (driver) matches the natural frequency of the oscillator you get a big displacement (**resonance**). Otherwise, not much.





Announcements

- Moving Ch14 Reading Questions due Tuesday, Nov 18th
- Homework Ch 11 &12 due tonight at midnight
- Exam 3 – Monday Nov 24 (Monday before Thanksgiving)

How familiar are you with Gibbs Free Energy ($\Delta G = \Delta H - T\Delta S$)?

A. Very familiar, we use that all the time!

B. Familiar enough to get by with it.

C. I recognize it, but I’m not comfortable using it.

D. I know I should remember this, but I don’t.

E. What is that?