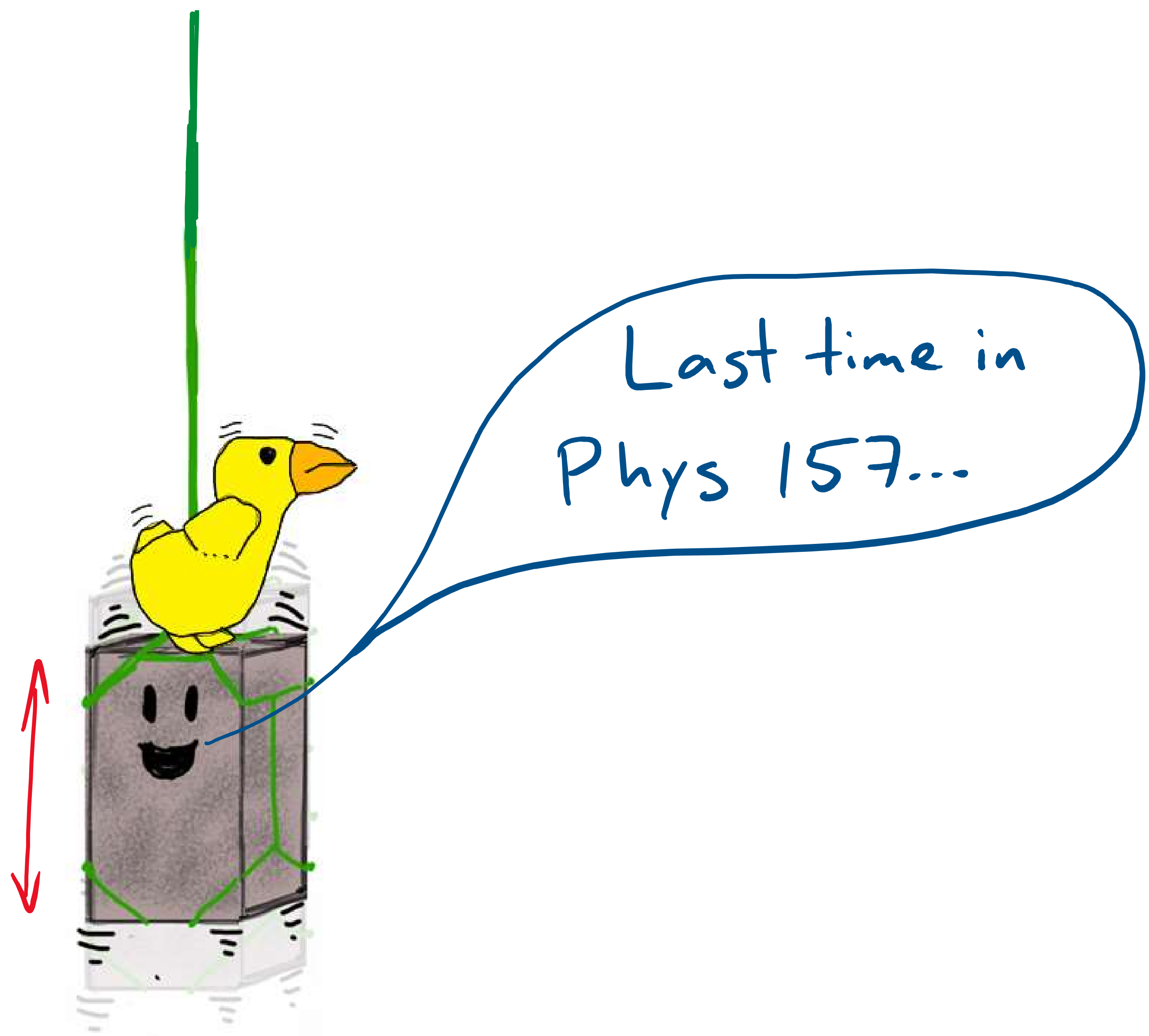
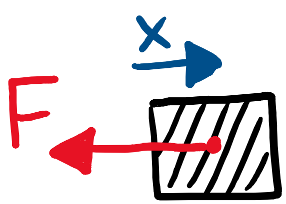

Last time in
Phys 157...



$F = -kx$

Linear restoring force: $F_{NET} = -kx$

$\Big\downarrow$ Newton's 2nd Law

$$a = -\frac{k}{m}x$$

$\Big\downarrow$

Simple harmonic motion

Simple Harmonic Motion

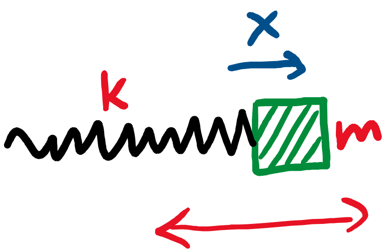
$$x(t) = A\cos(\omega t + \phi)$$

satisfies $\frac{d^2x}{dt^2} = -\omega^2 x$, $\omega^2 = \frac{k}{m}$

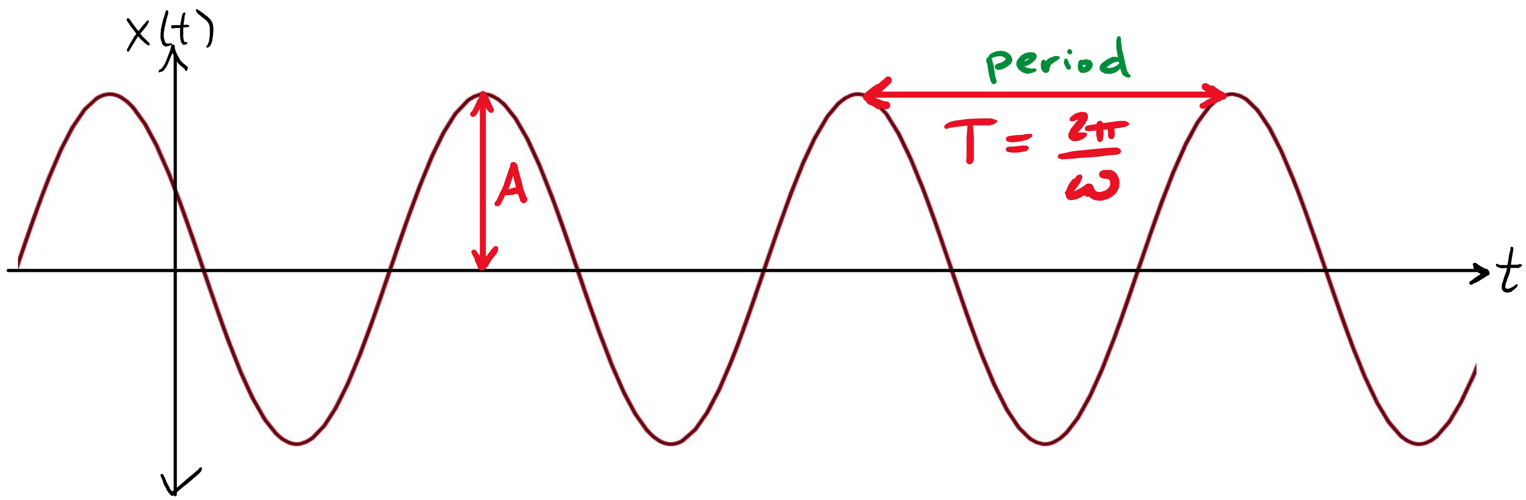
Amplitude (A)

angular frequency (ω)

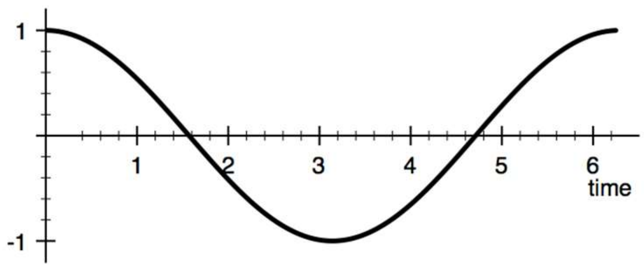
phase (ϕ)



$$\omega = \sqrt{\frac{k}{m}}$$

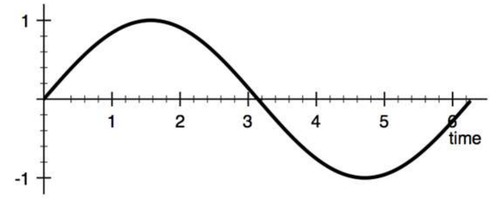


Velocity vs displacement

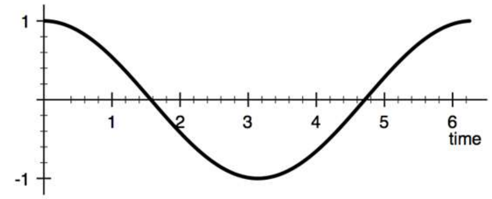


A plot of displacement as a function of time for an oscillator is shown above. Which of the diagrams to the right describes the ***velocity*** as a function of time for the same motion?

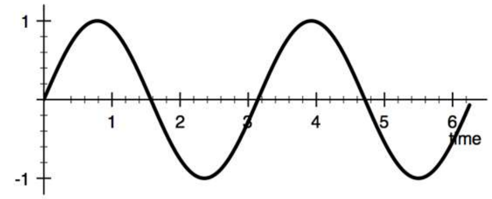
A.



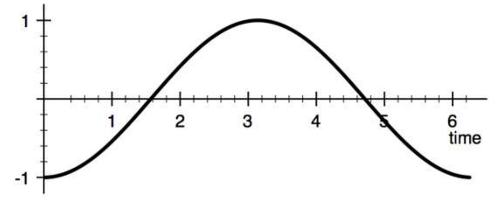
B.



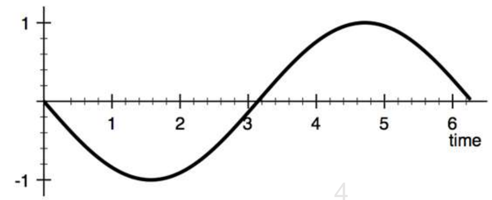
C.



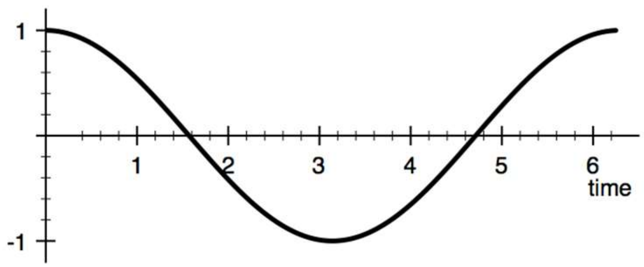
D.



E.



Velocity vs displacement



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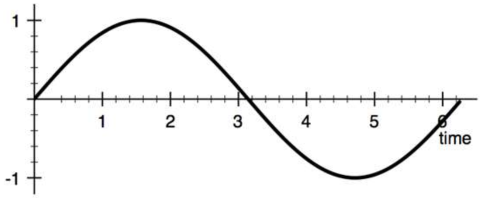
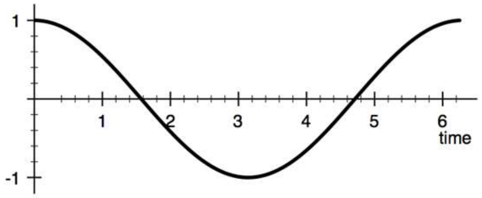
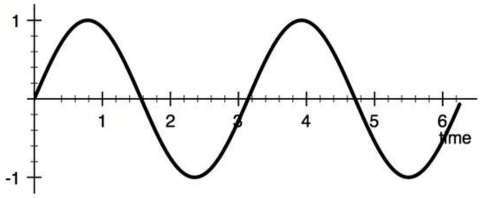


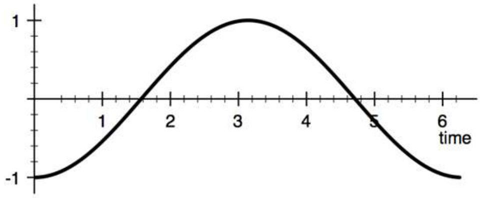
B.



C.



D.



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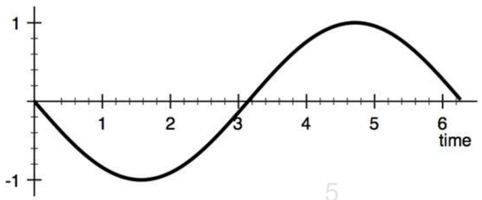
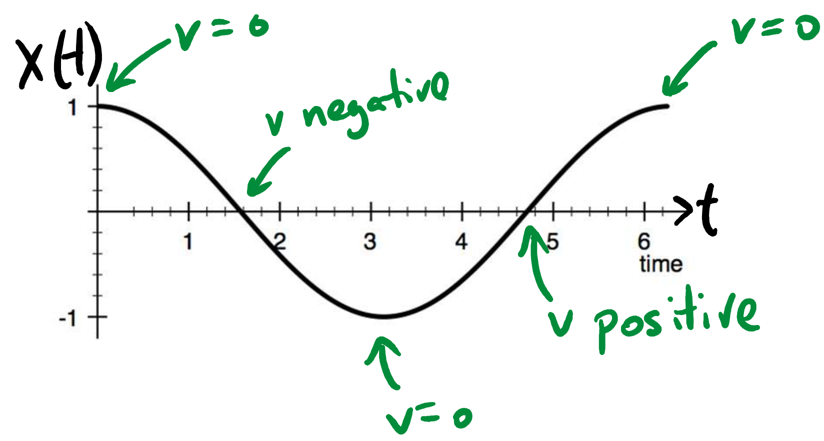
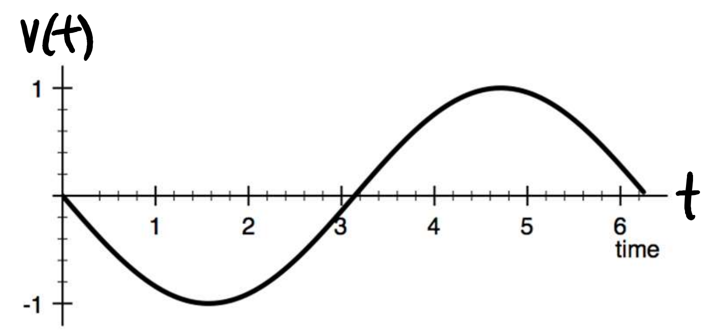


Velocity from displacement:

$$v = \frac{dx}{dt}$$

$v(t)$ = slope of $x(t)$
at time t



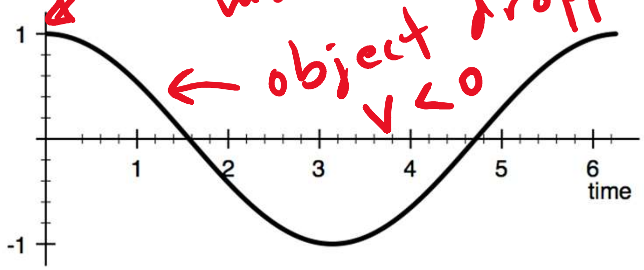


Velocity vs displacement

because switching from v>0 to v<0

object at top of motion here, so v=0

object dropping, so v<0



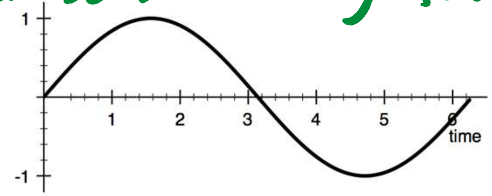
A plot of displacement as a function of time is shown above. Which of the diagrams to the right describes the ***velocity*** as a function of time for the same motion?

other method:

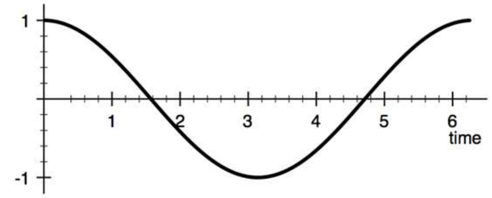
$$v = \frac{dx}{dt}$$

= slope of graph

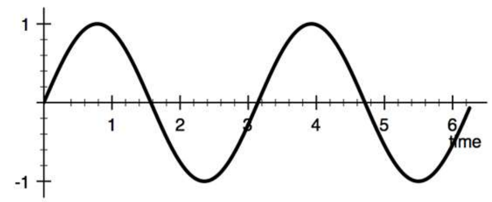
A.



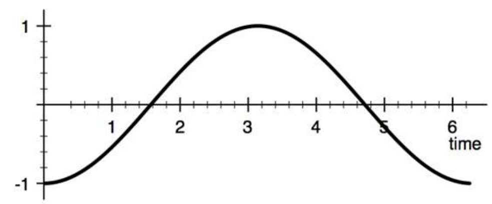
B.



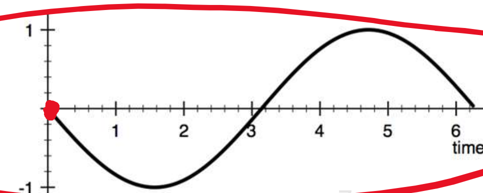
C.



D.

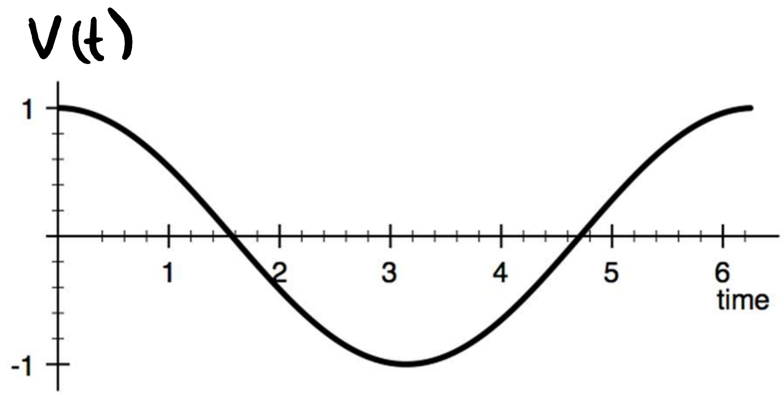


E.

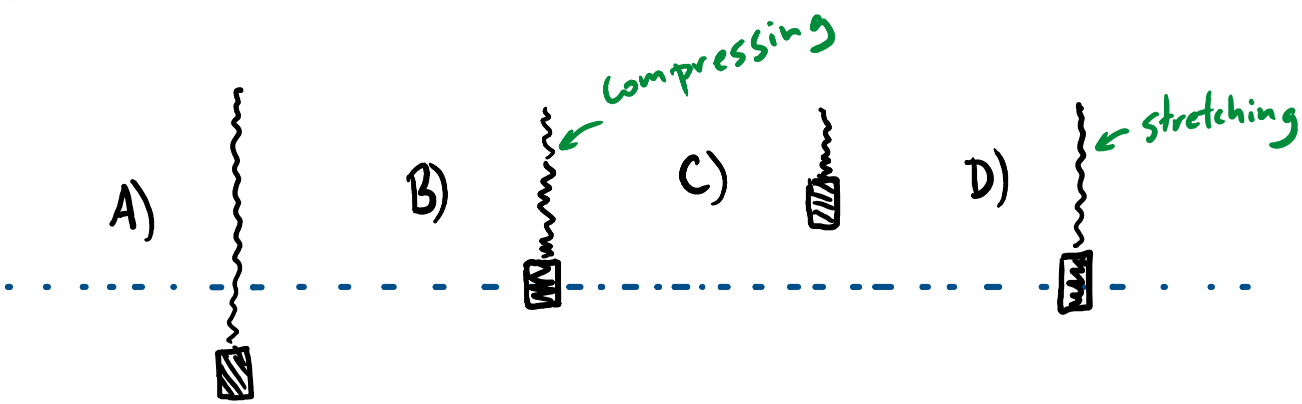


v starts at 0 and goes negative

Simple Harmonic Motion:



A plot of upward ***velocity*** (in cm/s) as a function of time (in s) is shown above for a mass hanging from a spring. Which of the pictures best represents the situation at t=1.6s?



EXTRA: what does x(t) look like?

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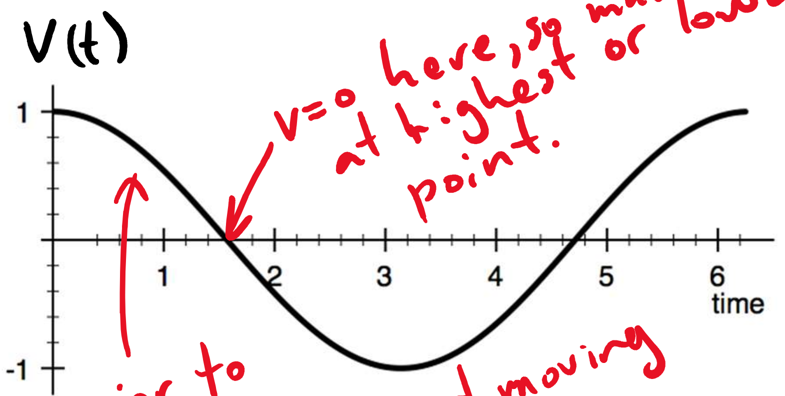

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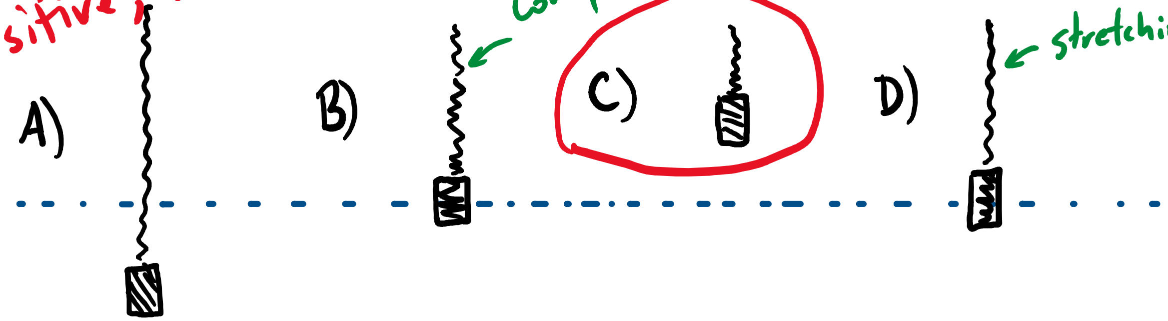

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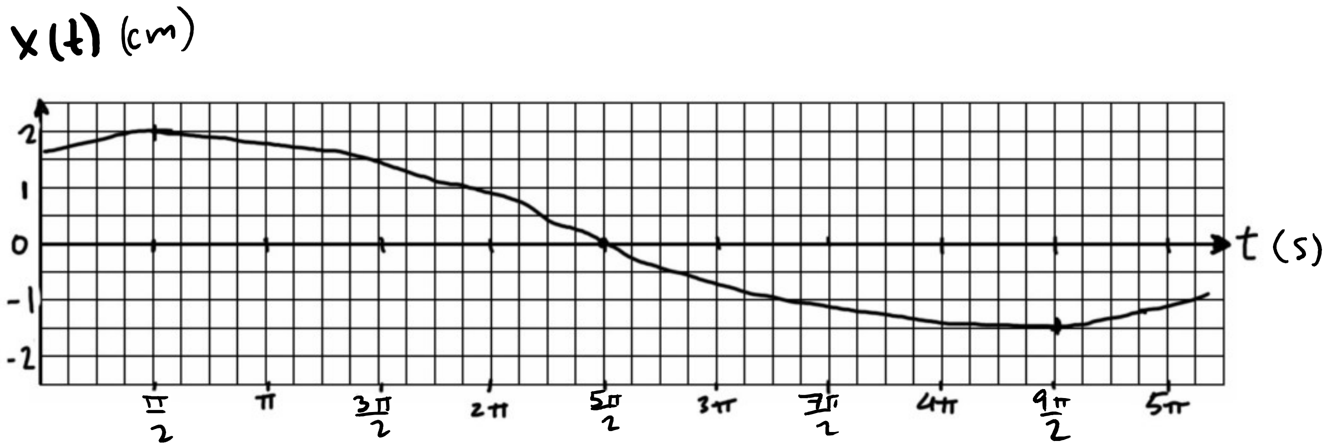
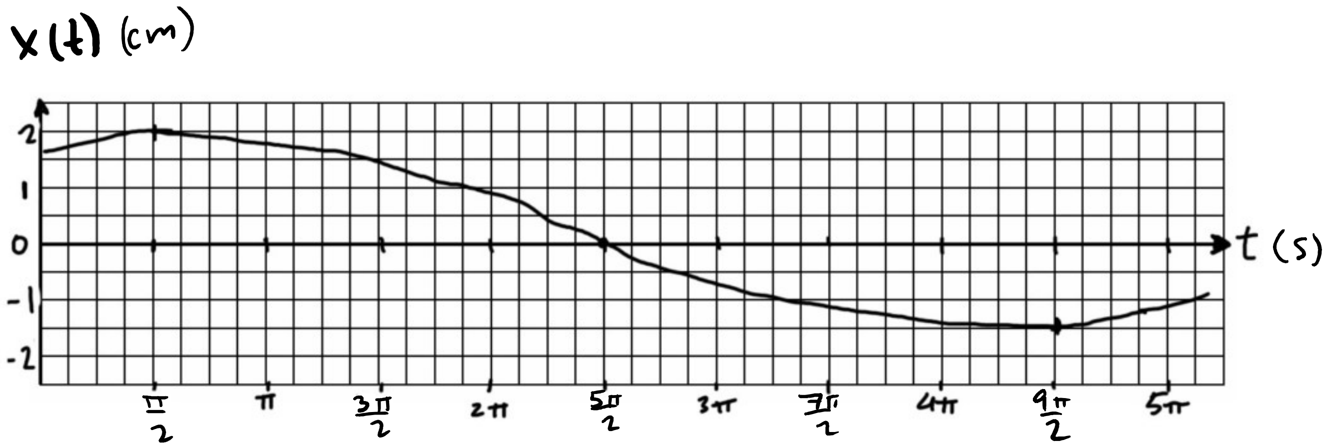


$\omega = \frac{2\pi}{T}$

$x(t) = A\cos(\omega t + \phi)$

For the displacement graph shown, what is the maximum magnitude of velocity, in cm/s?

A) 4 B) 2 C) 1 D) 1/2 E) 1/4



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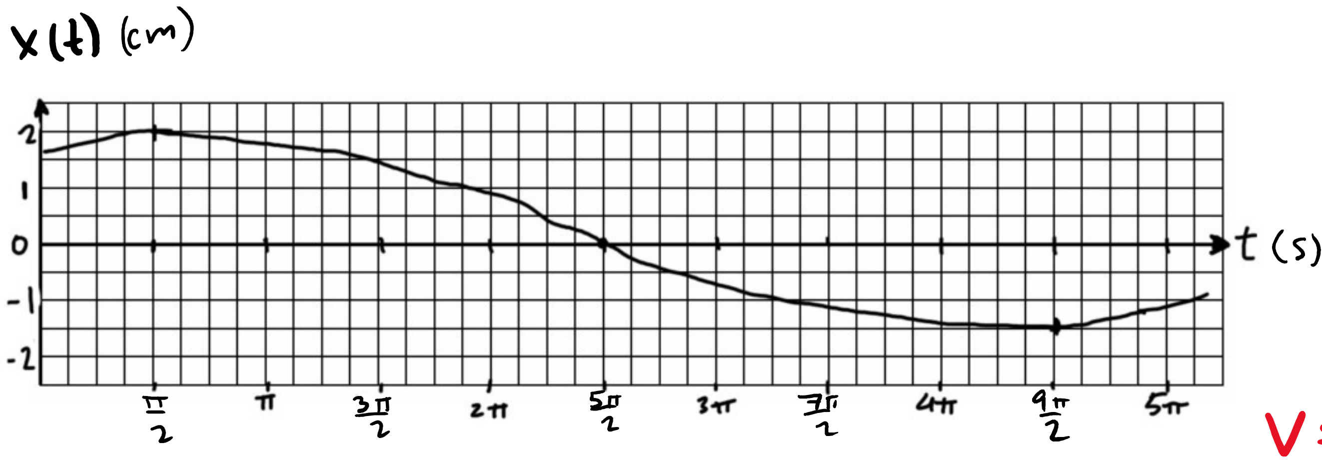


$\omega = \frac{2\pi}{T}$

$V = \frac{dx}{dt}$

$x(t) = A\cos(\omega t + \phi)$

$= -A\omega \sin(\omega t + \phi)$

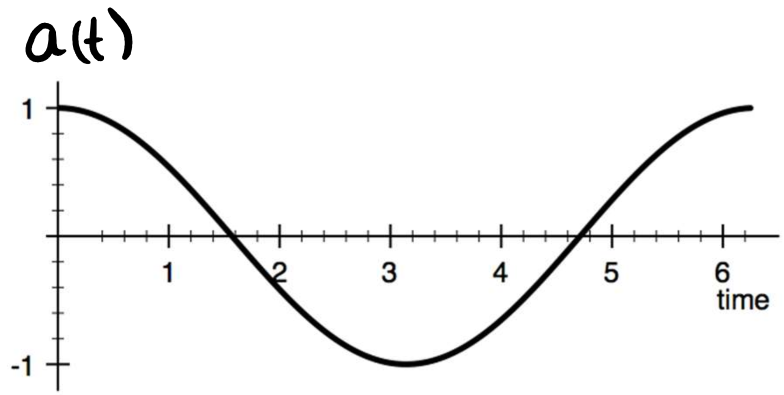
For the displacement graph shown, what is the maximum magnitude of velocity, in cm/s?

sin goes from -1 to 1, so max value of v is $A\omega$

A) 4 B) 2 C) 1 D) 1/2 E) 1/4

$A = 2\text{cm}, \quad \omega = \frac{2\pi}{T} = \frac{2\pi}{8\pi} = \frac{1}{4} \qquad A\omega = \frac{1}{2}$

Acceleration vs displacement:



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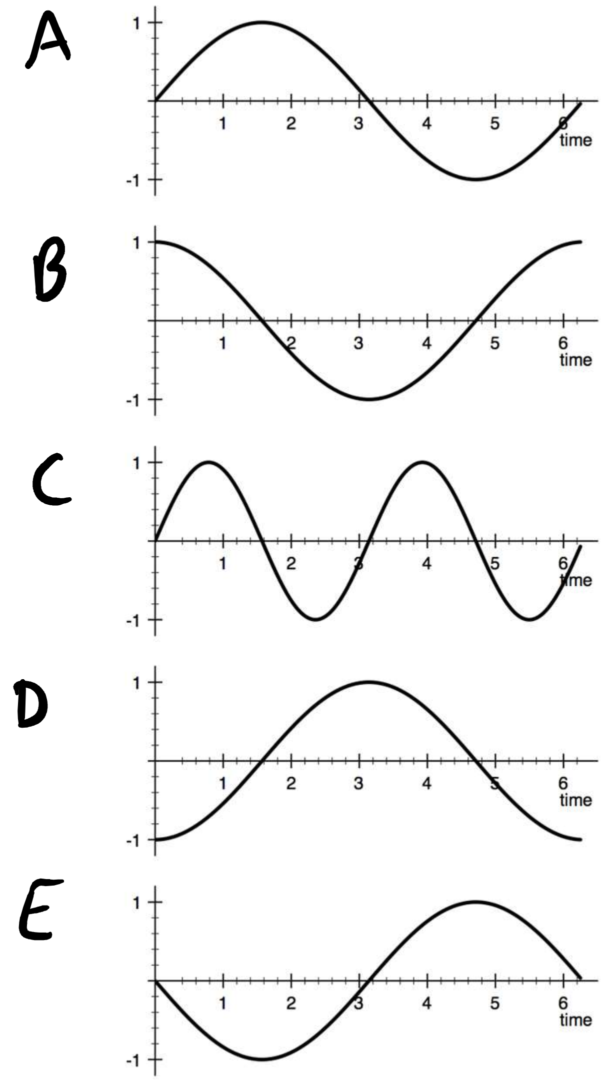
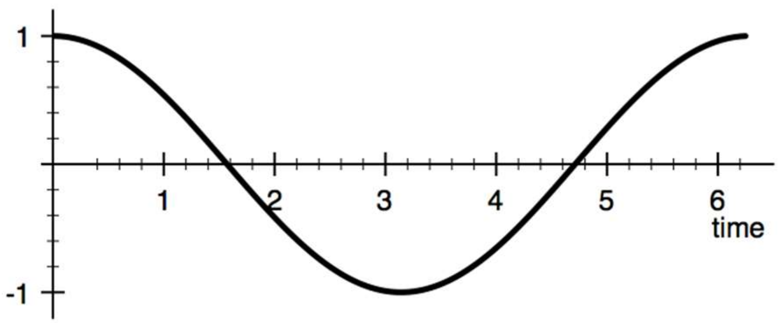


Acceleration vs displacement:

a(t)



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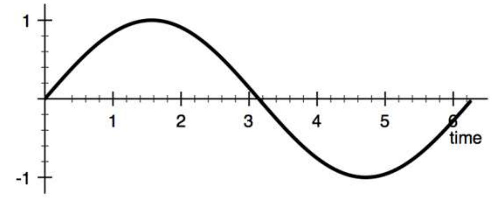
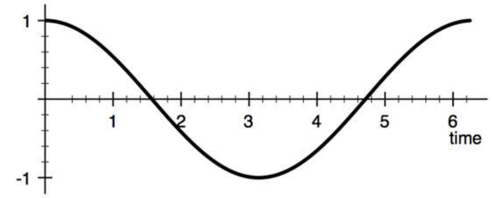
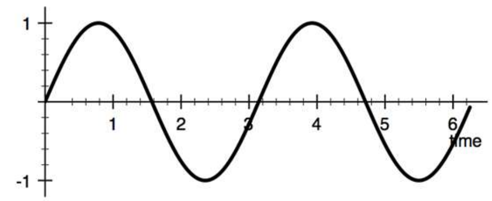


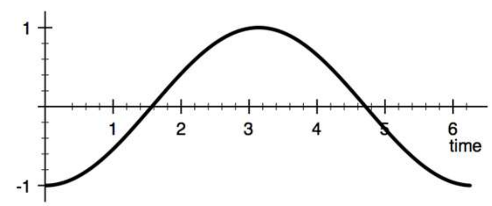
B



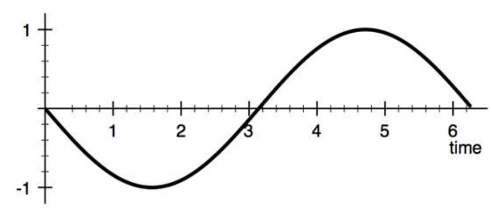
C



D

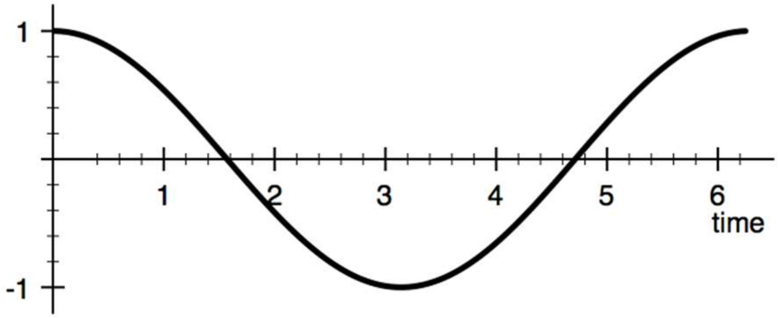


E



Acceleration vs displacement:

a(t)



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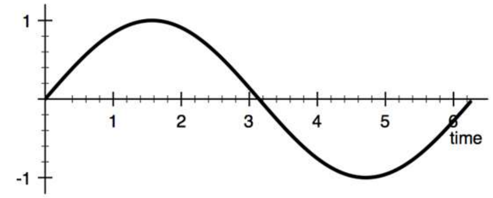
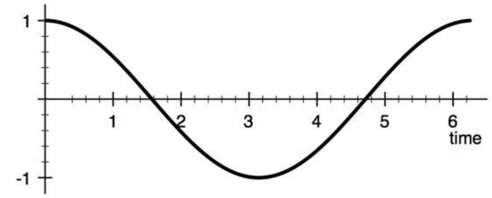
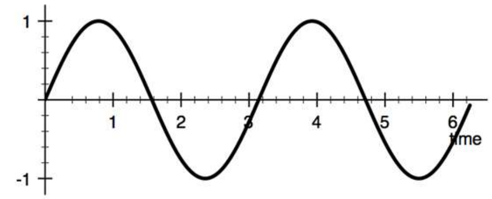


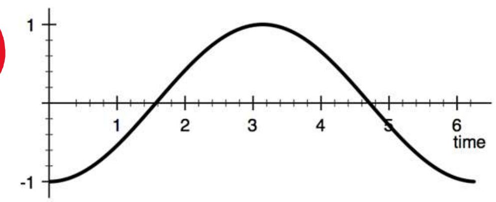
B



C



D



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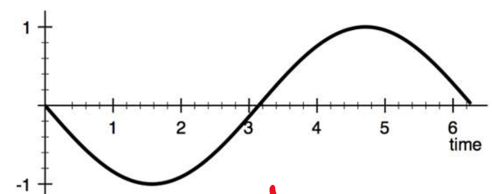
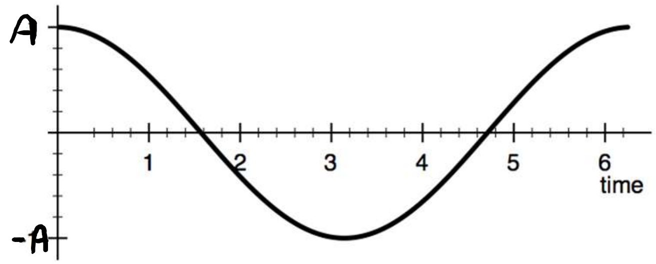


Have $a = -\omega^2 x$ for SHM, so x is maximum when a is minimum

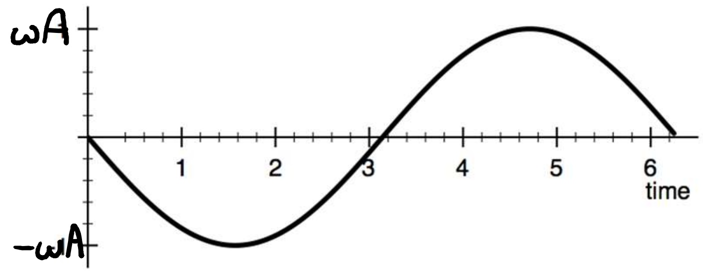
Position:



$$x(t) = A\cos(\omega t + \phi)$$

$\downarrow \frac{d}{dt}$ (slope)

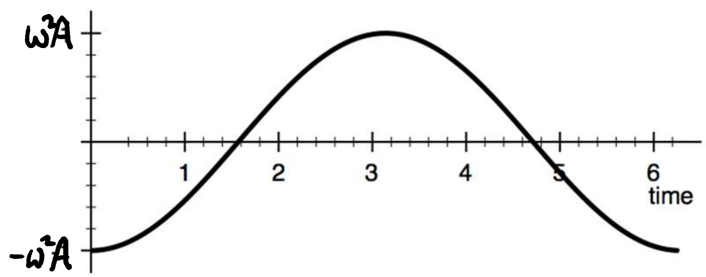
Velocity:



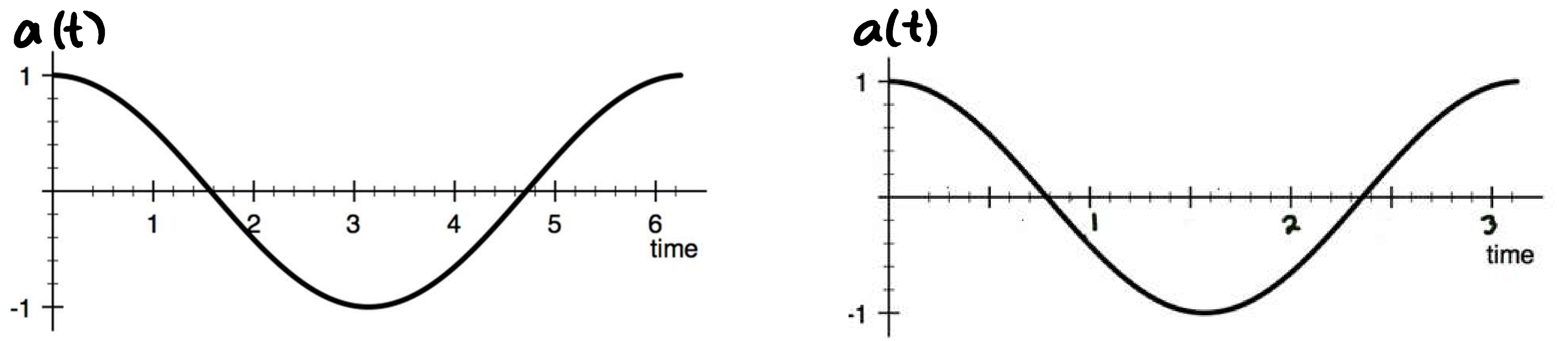
$$v(t) = -A\omega \sin(\omega t + \phi)$$

$\downarrow \frac{d}{dt}$ (slope)

Acceleration:

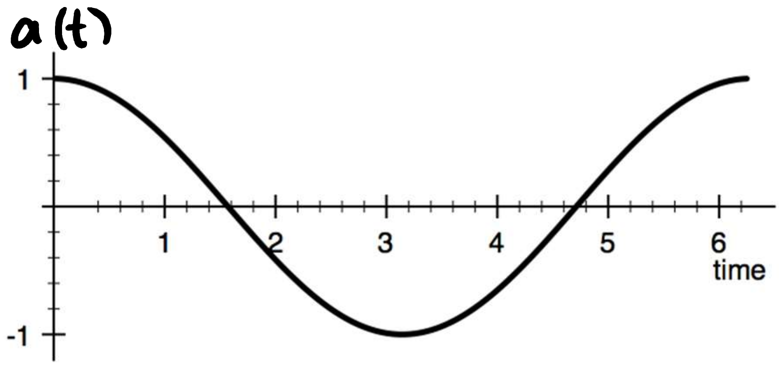


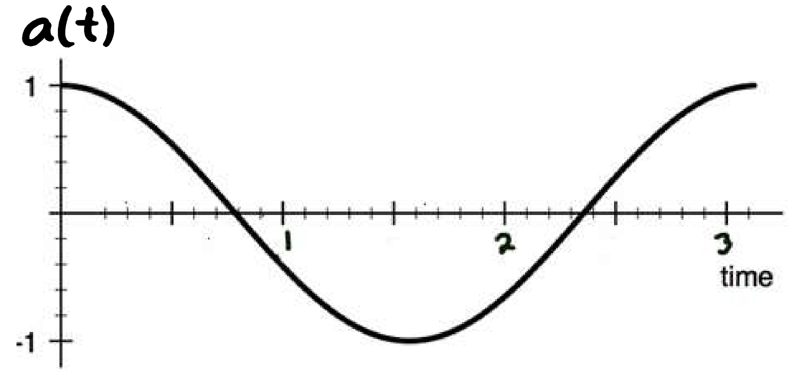
$$a(t) = -A\omega^2 \cos(\omega t + \phi) = -\omega^2 x(t)$$



The graphs show **acceleration** as a function of time for two different harmonic oscillators. The amplitude of the **displacement** in the first case is 1cm. For the second oscillator, the amplitude of the **displacement** is

A) 4cm B) 2cm C) 1cm D) 0.5 cm E) 0.25 cm





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A) 4cm B) 2cm C) 1cm D) 0.5 cm E) 0.25 cm

Have $a = -\omega^2 x$, so $x = -\frac{a}{\omega^2}$. T is half in 2nd case so ω is double, so amplitude of x is $\frac{1}{4}$

$\phi = \pm 2\pi \frac{t_{max}}{T}$ $\omega = \sqrt{\frac{k}{m}}$ $x(t) = A\cos(\omega t + \phi)$ $\omega = \frac{2\pi}{T}$

Approximately what is the spring constant of the spring in the simulation?

A) 1 N/m B) 2 N/m C) 4 N/m

D) 8N/m E)16N/m

$\phi = \pm 2\pi \frac{t_{max}}{T}$ $\omega = \sqrt{\frac{k}{m}}$ $x(t) = A\cos(\omega t + \phi)$ $\omega = \frac{2\pi}{T}$

* in our actual example it was 1,3 s.

Approximately what is the spring constant of the spring in the simulation?

A) 1 N/m B) 2 N/m C) 4 N/m

D) 8N/m E)16N/m

have: $T = 1s$ so $\omega = \frac{2\pi}{T} \approx 6.28\ s^{-1}$

Using $\omega = \sqrt{\frac{k}{m}}$ have: $k = m\omega^2 = 0.1 \times (6.28)^2\ N/m \approx 4\ N/m$