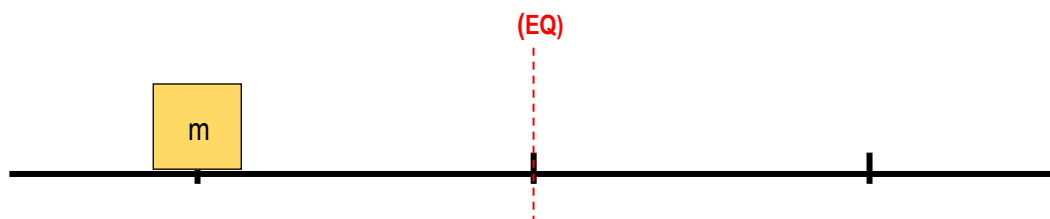


CONCEPT: Energy in Simple Harmonic Motion

- At any point of SHM, the mass-spring system may have 2 types of Energy: _____ + _____.

- $W_{nc} = \underline{\hspace{2cm}}$, so the Mechanical Energy (M.E.) is _____.



• Energy Conservation → always compare energies at 2 special points:		
<u>Amplitude:</u>	<u>Equilibrium:</u>	<u>Any other Point:</u>
$x = \underline{\hspace{2cm}}$	$x = \underline{\hspace{2cm}}$	$x = \underline{\hspace{2cm}}$
Elastic Energy (U_A) = $\frac{1}{2}kx^2 = \underline{\hspace{2cm}}$	Elastic Energy (U_0) = $\frac{1}{2}kx^2 = \underline{\hspace{2cm}}$	Elastic Energy (U_P) = $\frac{1}{2}kx^2 = \underline{\hspace{2cm}}$
Kinetic Energy (K_A) = $\frac{1}{2}mv^2 = \underline{\hspace{2cm}}$	Kinetic Energy (K_0) = $\frac{1}{2}mv^2 = \underline{\hspace{2cm}}$	Kinetic Energy (K_P) = $\frac{1}{2}mv^2 = \underline{\hspace{2cm}}$
Total M.E. = $\underline{\hspace{2cm}}$	Total M.E. = $\underline{\hspace{2cm}}$	Total M.E. = $\underline{\hspace{2cm}}$

- Comparing all these energies at different points:

$$U_A = K_0 = U_P + K_P$$

$\underline{\hspace{2cm}} = \underline{\hspace{2cm}} = \underline{\hspace{2cm}} + \underline{\hspace{2cm}}$

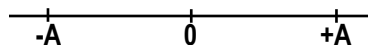
→

$v(x) = \underline{\hspace{2cm}}$

(Energy Conservation for Springs)

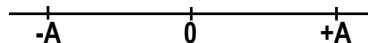
EXAMPLE 1: A 5 kg mass oscillates on a horizontal spring with $k = 30[\text{N/m}]$ and an amplitude of 0.4 m. Find its (a) max speed, (b) speed when it is at -0.2 m, and (c) the total mechanical energy of the system.

EXAMPLE: A 0.25-kg mass oscillates on a spring with a period of 3.2s. At $x=0.4\text{m}$, it is observed to have a speed of 5m/s. What is the system's (a) Amplitude and (b) total mechanical energy?



Mass-Spring SHM Equations	
$ F_s = F_A = kx$ $a = -\frac{k}{m}x$	$\rightarrow F_{\max} = \pm kA$ $\rightarrow a_{\max} = \pm \frac{k}{m}A$
$x(t) = + A \cos(\omega t)$ $v(t) = -A\omega \sin(\omega t)$ $a(t) = -A\omega^2 \cos(\omega t)$	$\rightarrow x_{\max} = \pm A$ $\rightarrow v_{\max} = \pm A\omega$ $\rightarrow a_{\max} = \pm A\omega^2$
$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$	
$N [\text{cycles}] = \frac{t [\text{time}]}{T [\text{Period}]} = t * f$	
$M.E. = \frac{1}{2}kA^2 = \frac{1}{2}mv_{\max}^2 = \frac{1}{2}kx_p^2 + \frac{1}{2}mv_p^2$ $v(x) = \omega\sqrt{A^2 - x^2}$	

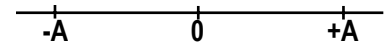
PRACTICE: A block of mass 0.300 kg is attached to a spring. At $x = 0.240 \text{ m}$, its acceleration is $a_x = -12.0 \text{ m/s}^2$ and its velocity is $v_x = 4.00 \text{ m/s}$. What are the system's (a) force constant k and (b) amplitude of motion?



Mass-Spring SHM Equations	
$ F_s = F_A = kx$ $a = -\frac{k}{m}x$	$\rightarrow F_{\max} = \pm kA$ $\rightarrow a_{\max} = \pm \frac{k}{m}A$
$x(t) = + A \cos(\omega t)$ $v(t) = -A\omega \sin(\omega t)$ $a(t) = -A\omega^2 \cos(\omega t)$	$\rightarrow x_{\max} = \pm A$ $\rightarrow v_{\max} = \pm A\omega$ $\rightarrow a_{\max} = \pm A\omega^2$
$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$	
$N [\text{cycles}] = \frac{t [\text{time}]}{T [\text{Period}]} = t * f$	
$M.E. = \frac{1}{2}kA^2 = \frac{1}{2}mv_{\max}^2 = \frac{1}{2}kx_p^2 + \frac{1}{2}mv_p^2$ $v(x) = \omega\sqrt{A^2 - x^2}$	

EXAMPLE: You increase the amplitude of oscillation of a mass vibrating on a spring. Which statements are correct?

- (a) Period of oscillation increases (b) Maximum acceleration increases (c) Maximum speed increases
- (c) Max Kinetic Energy increases (d) Max Potential Energy increases (e) Max Total Energy increases



Mass-Spring SHM Equations	
$ F_S = F_A = kx$ $a = -\frac{k}{m}x$	$\rightarrow F_{\max} = \pm kA$ $\rightarrow a_{\max} = \pm \frac{k}{m}A$
$x(t) = + A \cos(\omega t)$ $v(t) = -A\omega \sin(\omega t)$ $a(t) = -A\omega^2 \cos(\omega t)$	$\rightarrow x_{\max} = \pm A$ $\rightarrow v_{\max} = \pm A\omega$ $\rightarrow a_{\max} = \pm A\omega^2$
$\omega = 2\pi f = \frac{2\pi}{T} = \sqrt{\frac{k}{m}}$ $N [\text{cycles}] = \frac{t [\text{time}]}{T [\text{Period}]} = t * f$	
$M.E. = \frac{1}{2}kA^2 = \frac{1}{2}mv_{\max}^2 = \frac{1}{2}kx_p^2 + \frac{1}{2}mv_p^2$ $v(x) = \omega\sqrt{A^2 - x^2}$	