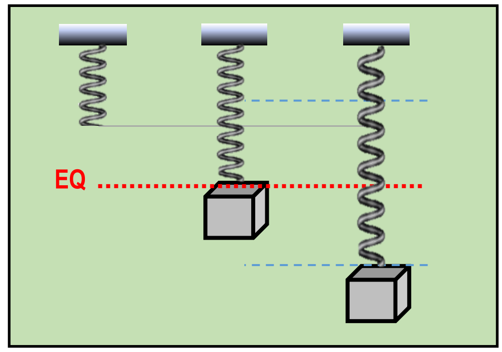
CONCEPT: Vertical Oscillations



● Vertical mass-spring systems are very similar to horizontal, <u>except</u>**:**

- Horizontal → Equilibrium at relaxed position (x = 0)
- Vertical → Equilibrium where forces ____________.

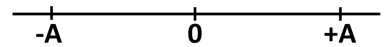
<u>EXAMPLE</u>**:** You hang a 0.5m spring from the ceiling. When you attach a 5kg mass to it, it stretches by 0.2m**.** You pull the mass-spring system down an additional 0.3m and release**.** Find (**a**) the springs's force constant**.** (**b**) At its maximum height, how far from the ceiling is the block?

● ΔL = __________________

● Equilibrium → ________ = ________

● A = additional push/pull, NOT ________

<u>PRACTICE</u>**:** A spring with spring constant 15 N/m hangs from the ceiling**.** A ball is attached to the spring and allowed to come to rest**.** It is then pulled down 6.0 cm and released**.** If the ball makes 30 oscillations in 20 s, what are its (**a**) mass and (**b**) maximum speed?



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

<u>EXAMPLE</u>**:** An elastic cord is 65 cm long when a weight of 75 N hangs from it but is 85 cm long when a weight of 180 N hangs from it**.** What is the “spring” constant *k* of this elastic cord?

PRACTICE**:** A chair of mass 30 kg on top of a spring oscillates with a period of 2s**.** (**a**) Find the spring's force constant. You place an object on top of the chair, and it now oscillates with a period of 3s**.** (**b**) Find the object's mass**.**