Linear Restoring forces + SHM

Hooke's Law $(F_{sp})_x = -k(\Delta x)$

displacement from equilibrium $= x$

spring constant (stiffer spring = larger k value)

$$(F_{sp})_x = -kx$$

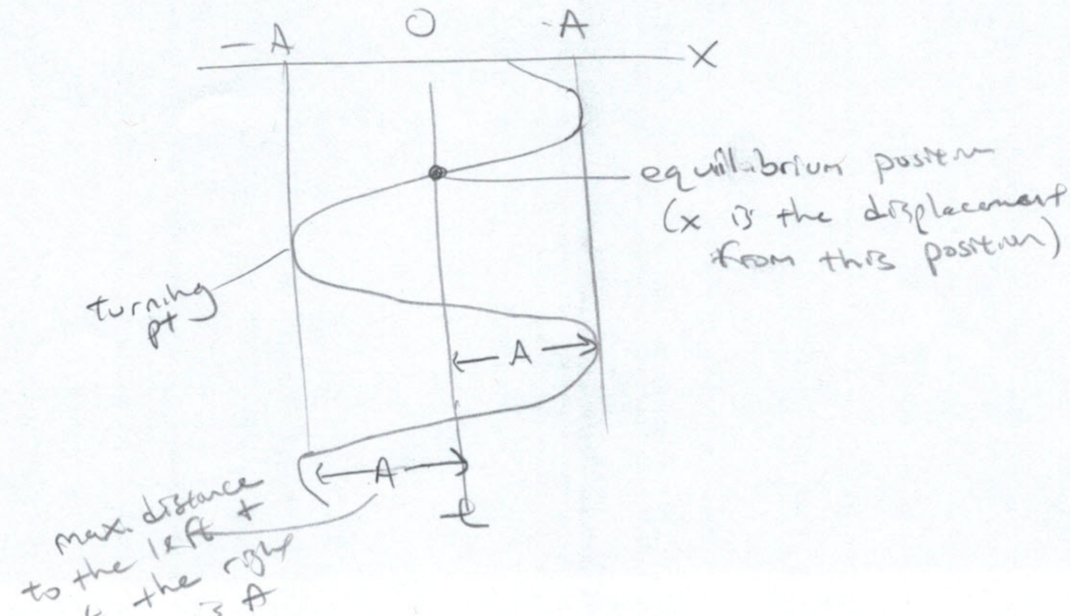
linear restoring force - the net force is toward the equilibrium position + is proportional to the distance from equilibrium

amplitude (A) - the object's max. displacement from equilibrium

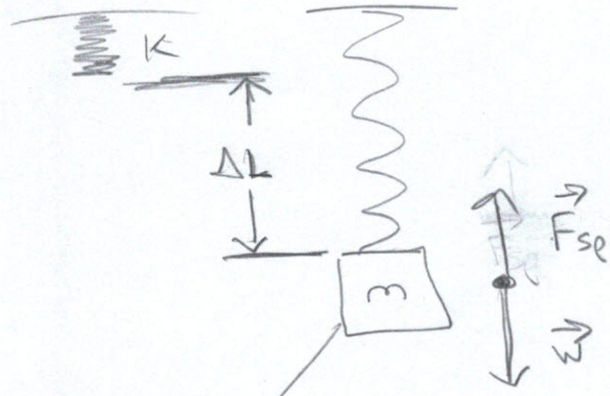
$(x = -A \text{ and } x = +A)$

☆☆ **NOT** the distance from the min. to the max. ☆☆

Oscillation about an equilibrium position w/a linear restoring force is always (SHM).



Vertical mass on a Spring



equilibrium (no net force)
hangs motionless

(Static-equilibrium problem)
- upward spring force balances the downward weight force of the block

$$(F_{sp})_y = k\,\Delta L$$

Newton's 1st law for the block in equilibrium

$$(F_{net})_y = (F_{sp})_y + w_y = k\,\Delta L - mg = 0$$

$$\Delta L = \frac{mg}{k}$$

the distance the spring stretches when the block is attached

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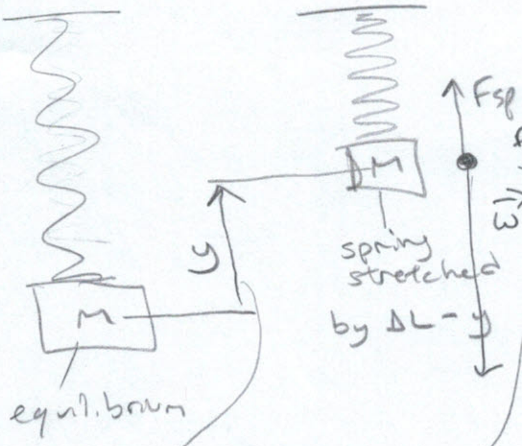
block at position y the spring is stretched $\Delta L - y$

and an upwards spring force applies $F_{sp} = k(\Delta L - y)$



net-force

$$(F_{net})_y = (F_{sp})_y + w_y = k(\Delta L - y) - mg = \underbrace{(k\Delta L - mg)}_{=0} - ky$$

block moving upward

net force downward

$$(F_{net})_y = -ky$$

Gravity doesn't affect the restoring force for displacement from the equilibrium position

The Pendulum

$(F_{net})_t = \sum F_t = w_t = -mg \sin\theta$

"restoring force" pulling the mass back to equilibrium position

$\sin\theta \approx \theta$ pendulum's oscillations

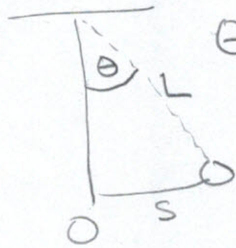
- at $10°$ (0.17 rad) or less
- in radians
- small angle approximation
- undergoes SHM

arc length $\theta = \frac{s}{L}$

restoring force

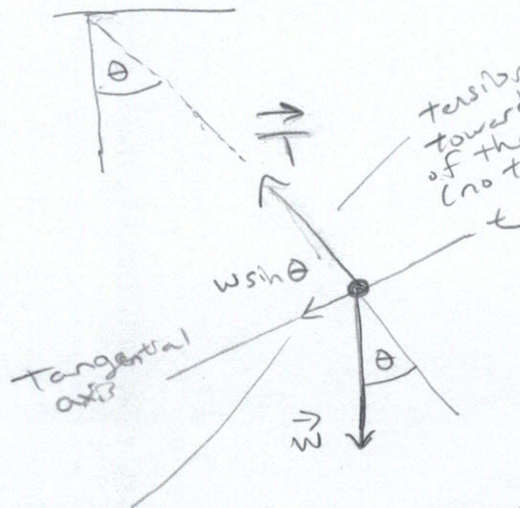
$(F_{net})_t = -mg \sin\theta \approx -mg\,\theta =$

$-mg\frac{s}{L} = -\left(\frac{mg}{L}\right)s$



θ and s are positive on the right (counter clockwise)

(− negative on the left sides) (clockwise)



tension directed towards the center of the circle (no tan component)

the w has a tan component

$w_t = -w \sin\theta$