Newton's 2nd Law (N2L) of Motion:

- Classically, N2L is written as

$$F = ma$$

Net force: $\frac{kgm}{s^2}$ — mass: kg — acceleration: $\frac{m}{s^2}$

- But we can rewrite N2L in its differential form if we think about how acceleration relates to displacement 'x':
  - We call the change in displacement 'x' over time 't' the velocity 'v.' If we want the instantaneous change of 'x' with 't', we turn to calculus:

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

  - And since acceleration is the change in velocity over time,

$$a = \frac{dv}{dt} = \frac{d}{dt}\left(\frac{dx}{dt}\right) = \frac{d^2x}{dt^2}$$

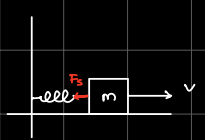
- So the acceleration is the change in the change of position over time. So N2L becomes:

$$F = ma \quad \downarrow \quad F = m\frac{d^2x}{dt^2}$$

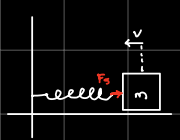
Springs

- 2 main things to know about springs:

1) Springs cause a restorative force



If the mass moves rightward, the restorative spring force F_s pulls leftward.



If the mass moves leftward, the restorative spring force F_s pushes rightward.

2) That force F_s is given by Hooke's Law:

$$F_s = -kx$$

'−' shows it's restorative; x = distance spring has been compressed or extended; k = spring constant (spring stiffness)

Putting it all together:

- For a spring mass system, the net force 'F' in N2L is just F_s

$$F = ma$$
$$F_s = m\frac{d^2x}{dt^2}$$
$$-kx = m\frac{d^2x}{dt^2}$$