**DERIVATIVE = Rate of Change**

= Slope of tangent line

**Long-term behavior**

Ex: \( Q(t) \to 12 \text{g} \) as \( t \to \infty \)

As \( t \to \infty \), salt concentration \( \to 3 \text{g/L} \)

\[ Q(t) \to \left( \frac{3 \text{g}}{4} \right) (4 \text{L}) = 12 \text{g} \]

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**Let** \( Q(t) = \) amount of salt in tank after \( t \) minutes

\( Q(0) = 5 \text{g} \)

\[ \frac{\text{g}}{4 \text{L}} \text{ concentration entering} \]

\[ \downarrow \quad 2 \text{L/min} \quad \frac{\text{g}}{4 \text{L}} \text{ concentration leaving} \]

\[ \frac{Q}{4} \text{L} \quad \text{constant} \]

\[ \frac{\text{g}}{\text{L}} \]

\[ \text{rate in} = \text{rate out} \]

\[ \frac{dQ}{dt} = \frac{3 \text{g}}{2 \text{min}} \cdot \frac{2 \text{L}}{\text{min}} - \frac{Q \text{g}}{4 \text{L}} \cdot \frac{2 \text{L}}{\text{min}} \]

**Initial Value Problem** \( \frac{dQ}{dt} = 6 - \frac{Q}{2} \), \( Q(0) = 5 \text{g} \)
A Slope field = Direction field = Plot of slopes in $(t, Q)$ plane

$\frac{dQ}{dt} = 6 - \frac{Q}{2}$

$Q = 6 \cdot \frac{Q}{2} \Rightarrow Q = 12$

Slope 0 $\Rightarrow 0 = 6 - \frac{Q}{2} \Rightarrow Q = 12$

Equilibrium soln = Constant soln

$Q = C$

$\Rightarrow \frac{dQ}{dt} = 0$

Thus to find equil soln (when it exists)

Set $\frac{dQ}{dt} = 0 \Rightarrow \text{solve for } Q$

Ex: $\frac{dQ}{dt} = 6 - \frac{Q}{2} \Rightarrow 0 = 6 - \frac{Q}{2} \Rightarrow Q = 12$