- **First-Order Ordinary Differential Equations** take the from $\frac{dy}{dx} = f(x, y)$
- **Slope fields** – plots the behavior (slope) at certain points using a differential equation
    - **Isoclines** – curves along which the slope is constant. Common method for drawing slope fields
- **Integral curve**
    - Curve that represents a specific solution of an ordinary differential equation.
    - Tangent to slope field lines.
    - Cannot cross each other as long as $\frac{dy}{dx} = f(x, y)$ and $\frac{\partial f}{\partial y}$ are continuous
- **Steady State** – an asymptote that all solutions of the differential equation tend to regardless of initial condition. In solutions to most differential equations, they do not exist.
- **Existence Theorem**: If $\frac{dy}{dx} = f(x, y)$ is continuous on an open disk containing (x_o, y_o), then there exists a solution to $\frac{dy}{dx} = f(x, y)$ at (x_o, y_o).
    - Corollary (by contraposition): If there is not a solution to $\frac{dy}{dx} = f(x, y)$ at (x_o, y_o), then $\frac{dy}{dx} = f(x, y)$ is discontinuous on an open disk containing (x_o, y_o).
    - Be careful! – Inverse and converse are not true!
- **Uniqueness Theorem**: If $\frac{dy}{dx} = f(x, y)$ and $\frac{\partial f}{\partial y}$ are continuous on an open disk containing (x_o, y_o), then there exists one and only one solution to $\frac{dy}{dx} = f(x, y)$ at (x_o, y_o).
    - Corollary (by contraposition): If there is not exactly one solution to $\frac{dy}{dx} = f(x, y)$ at (x_o, y_o), then either $\frac{dy}{dx} = f(x, y)$ or $\frac{\partial f}{\partial y}$ (or both $\frac{dy}{dx} = f(x, y)$ and $\frac{\partial f}{\partial y}$) is discontinuous on an open disk containing (x_o, y_o).
    - Be careful! – Inverse and converse are not true!
- Applications:
    - Exponential growth and decay models
    - Projectile motion with drag
    - RC circuits and RL circuits
    - Mixing and diffusion