Instituto Tecnológico y de Estudios Superiores de Monterrey

# Fase 1 Actividad 3

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#### Ecuaciones de órbita del sistema

Considerando las ecuaciones de Lotka-Volterra, donde p(t) representa las presas y d(t) los depredadores:

$$\begin{cases} p'(t) = \alpha_1 p(t) - \alpha_2 p(t) d(t) \\ d'(t) = -\beta_1 d(t) + \beta_2 p(t) d(t) \end{cases}$$

Las órbitas son las curvas que representan la solución de la ecuación diferencial:

$$\frac{dy}{dx} = \frac{-\beta_1 y + \beta_2 xy}{\alpha_1 x - \alpha_2 xy}$$

La ecuación es separable. Encontrar las soluciones de manera que se pueda expresar la ecuación de las órbitas como:

$$F(x) = G(y)$$

Estudiar la forma de F(x) y G(y) (por ejemplo, en Desmos) usando:

$$\alpha_1 = 0.4, \alpha_2 = 0.01, \beta_1 = 0.8, \beta_2 = 0.02$$

Calcular máximos y mínimos de F(x) y G(x).



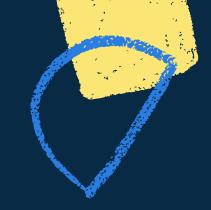












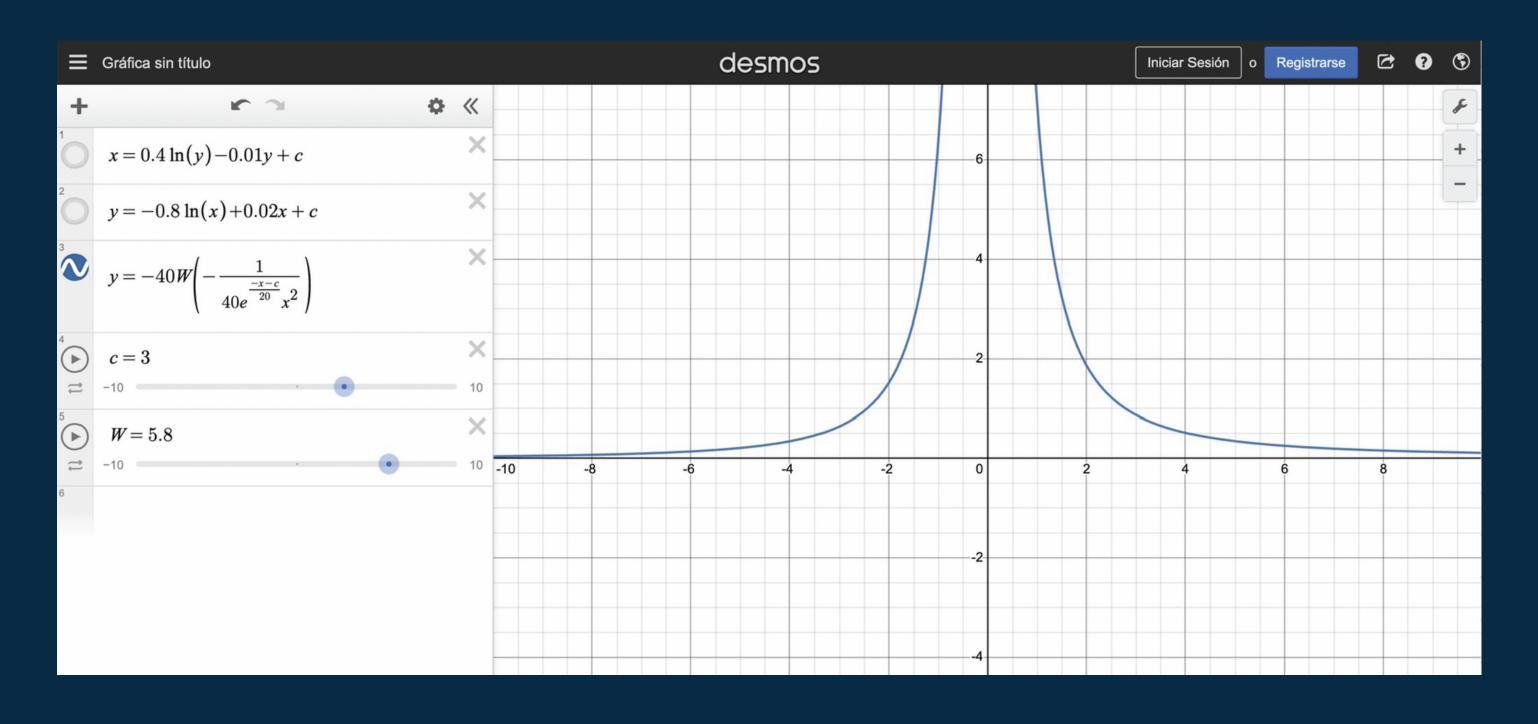
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\alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{1}}{x} \frac{\beta_{1}}{x} \frac{dx}{dx} + \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{1}}{x} \frac{\beta_{1}}{x} \frac{dx}{dx} + \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{1}}{x} \frac{\beta_{1}}{x} \frac{dx}{dx} + \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{1}}{x} \frac{\beta_{1}}{x} \frac{dx}{dx} + \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{1}}{x} \frac{\beta_{1}}{x} \frac{dx}{dx} + \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{1}}{x} \frac{\beta_{2}}{x} \frac{dx}{dx} + \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{2}}{x} \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{2}}{x} \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{2}}{x} \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{2}}{x} \frac{\beta_{2}}{x} \frac{\beta_{2}}{x} \frac{dx}{dx}$ $\frac{(\alpha_{1} - \alpha_{2y})}{x(\alpha_{1} - \alpha_{2y})} = \frac{\beta_{2}}{x} \frac{\beta_{2}}{x} \frac{\beta_{2}$ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} - \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dx} = \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} $ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2x})}{x(\alpha_{1} - \alpha_{2y})} - y + \frac{(\alpha_{1} - \alpha_{2y})}{y} \frac{dy}{dy} = \frac{(-\beta_{1} - \beta_{1})}{x(\alpha_{1} - \alpha_{2y})}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2} \frac{dy}{dy} = \int \frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dx} - \int \alpha_{2} \frac{dy}{dx} + \int \beta_{2} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dx} - \int \alpha_{2} \frac{dy}{dx} + \int \beta_{2} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{dx}$ $\int \frac{\alpha_{1}}{y} \frac{dy}{dx} - \int \alpha_{2} \frac{dy}{dx} + \int \beta_{2} \frac{dx}{dx} + \int \beta_{2} \frac{dx}{d$ | $\frac{dy}{dx} : \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \rightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $  \ln  y  - \alpha_{2}y = -\beta_{1} \ln  x  + \beta_{2}x + C$ $  = 0.4 \qquad 0.4 \ln  y  - 0.01y = -0.8 \ln  x  + 0.02x$ $  = 0.8 \qquad 0.8$ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \rightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $  \ln  y  - \alpha_{2}y = -\beta_{1} \ln  x  + \beta_{2}x + C$ $  = 0.4 \qquad 0.4 \ln  y  - 0.01y = -0.8 \ln  x  + 0.02x + C$ $  = 0.9 \qquad 0.8 \qquad 0.4 \qquad 0.4 \qquad 0.4 \qquad 0.4 \qquad 0.02x + C$ | $\frac{dy}{dx} : \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ | $\frac{d_{y}}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ | $\frac{dy}{dx} : \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{x} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{(-\beta_{1} + \beta_{2}x)}{x} \longrightarrow \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow$ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{\alpha_{1}}{y}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $  \ln  y  - \alpha_{2}y = -\beta_{1} \ln  x  + \beta_{2}x + C$ $  = 0.4 \qquad 0.4 \ln  y  - 0.01y = -0.8 \ln  x  + 0.02x + C$ $  = 0.8 \qquad 0.8$ | $\frac{dy}{dx} : \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{\alpha_{1} - \beta_{2}x}{y}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $  \ln  y  - \alpha_{2}y = -\beta_{1} \ln  x  + \beta_{2}x + C$ $  = 0.4 \qquad 0.4 \ln  y  - 0.01y = -0.8 \ln  x  + 0.02x + C$ $  = 0.8 \qquad 0.9 \qquad 0$ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} - y = \frac{(-\beta_{1} + \beta_{2}x)}{x} dx - y = \frac{\alpha_{1} - \alpha_{2}y}{y}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{1} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $  \ln  y  - \alpha_{2}y = -\beta_{1} \ln  x  + \beta_{2}x + C$ $  -0.4  = 0.4 $ $  -0.01  = 0.8$ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{\alpha_{1}}{x} - \alpha_{2} \frac{dy}{y}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{x} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ | $\frac{dy}{dx} : \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{0} - \alpha_{2}y)} \rightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dx} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{x} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} - \alpha_{2} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \rightarrow \frac{\alpha_{1}}{y} \frac{dx}{dx} \rightarrow \frac{\alpha_{2}}{y} \frac{dy}{dx} \rightarrow \frac{\alpha_{1}}{y} \frac{dx}{dx} \rightarrow \frac{\alpha_{2}}{y} \frac{dy}{dx} \rightarrow \frac{\alpha_{1}}{y} \frac{dy}{dx} \rightarrow \frac{\alpha_{2}}{y} $ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{\alpha_{1} - \alpha_{2}}{y} = -\frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} dx$ $\frac{\alpha_{1}}{y} \frac{dy}{dy} - \int \alpha_{2}y = -\frac{\beta_{1}}{x} \frac{dx}{dx} + \int \beta_{2} dx$ $\frac{ \alpha_{1} }{ \alpha_{2} } \frac{dy}{dy} - \frac{ \alpha_{2} }{ \alpha_{2} } = -\frac{\beta_{1}}{ \alpha_{1} } \frac{ \alpha_{1} }{ \alpha_{2} } + \frac{\beta_{2}}{ \alpha_{2} } + C$ $\frac{ \alpha_{1} }{ \alpha_{2} } \frac{ \alpha_{1} }{ \alpha_{2} } = -\frac{\beta_{1}}{ \alpha_{1} } \frac{ \alpha_{1} }{ \alpha_{1} } + \frac{\beta_{2}}{ \alpha_{2} } + C$ $\frac{ \alpha_{1} }{ \alpha_{2} } \frac{ \alpha_{1} }{ \alpha_{1} } = -\frac{\beta_{1}}{ \alpha_{1} } \frac{ \alpha_{1} }{ \alpha_{1} } + \frac{\beta_{2}}{ \alpha_{2} } + C$ $\frac{ \alpha_{1} }{ \alpha_{1} } \frac{ \alpha_{1} }{ \alpha_{1} } = -\frac{\beta_{1}}{ \alpha_{1} } \frac{ \alpha_{1} }{ \alpha_{1} } + \frac{\beta_{2}}{ \alpha_{2} } + C$ | $\frac{dy}{dx} = \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{\alpha_{1}}{y} - \alpha_{2}y = -\frac{\beta_{1}}{x} \frac{dx}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ | $\frac{d_{y}}{dx} = \frac{y(-\beta_{1} + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{dx} \longrightarrow \frac{\alpha_{1}}{x} - \alpha_{2} \frac{dy}{dy} = -\frac{\beta_{1}}{x} + \beta_{2}x}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2} dx$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2} dy = -\beta_{1} \ln x  + \beta_{2}x + C$ | $\frac{d_{y}}{dx} : \frac{y(-\beta_{1} + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \longrightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} \frac{dy}{dy} = \frac{(-\beta_{1} + \beta_{2}x)}{x} \frac{dx}{x} \longrightarrow \frac{\alpha_{1}}{y} - \alpha_{2}dy = -\frac{\beta_{1}}{y} + \frac{\beta_{2}}{y} \frac{dx}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2}dx$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} \ln x  + C$ | $\frac{d_{y}}{dx} = \frac{y(-\beta_{1} + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} - y + \frac{(\alpha_{1} - \alpha_{2}y)}{y} dy = \frac{(-\beta_{1} + \beta_{2}x)}{x} dx - y - \frac{\alpha_{1}}{x} - \alpha_{2}dy = -\frac{\beta_{1}}{y} + \frac{\beta_{2}}{z}dx}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2}dx$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}}{y} dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}y}{y} dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}y}{y} dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}y}{y} dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}}{y} dy - \frac{\beta_{2}y}{y} dy - \frac{\beta_{2}y}{y} dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}y}{y} dy - \frac{\beta_{2}y}{y} dy - \frac{\beta_{2}y}{y} dy = -\frac{\beta_{1}}{y} \ln x  + \frac{\beta_{2}x}{y} + C$ $\int \frac{\alpha_{1}y}{y} dy - \frac{\beta_{2}y}{y} dy - \frac{\beta_{2}y}{y} dy + \frac{\beta_{2}y}{$ | $\frac{d_{3}}{dx} : \frac{y(-\beta + \beta_{2}x)}{x(\alpha_{1} - \alpha_{2}y)} \rightarrow \frac{(\alpha_{1} - \alpha_{2}y)}{y} dy = \frac{(-\beta_{1} + \beta_{2}x)}{x} dx \rightarrow \frac{\alpha_{1}}{x} - \alpha_{2}dy = -\beta_{1} + \beta_{2}dx}{x}$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{1} dy = \int \frac{\beta_{1}}{x} dx + \int \beta_{2}dx$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ $\int \frac{\alpha_{1}}{y} dy - \int \alpha_{2}y = -\beta_{1} \ln x  + \beta_{2}x + C$ |

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### Forma F(x) y G(x) en Desmos

















## MMM

## Máximos y Mínimos

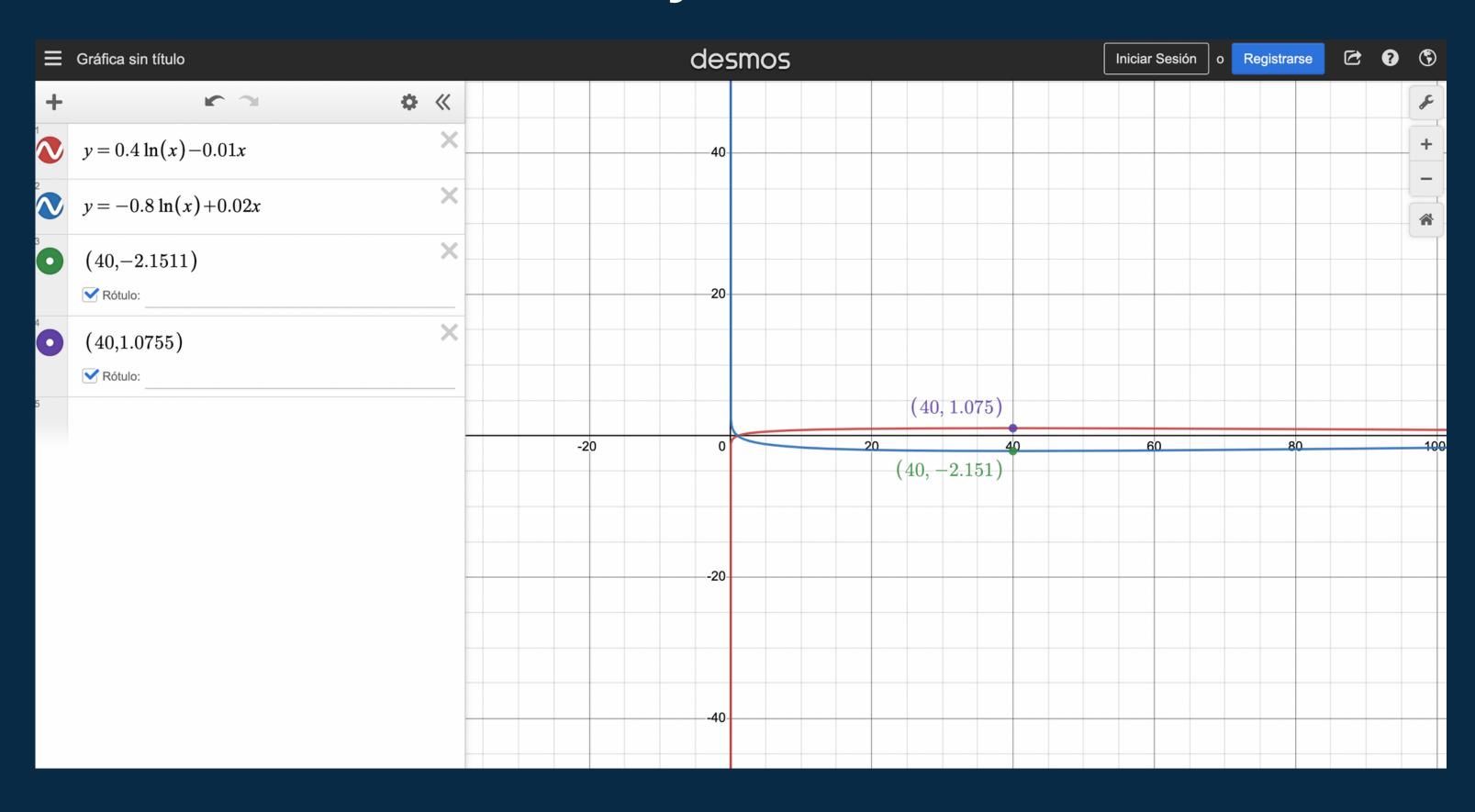


Δ Calcular máximos y mínimos de F(x) y G(x	
$F(x) = a_1 l_n  _{x}  _{x} = 0$ $F'(x) = a_1 - a_2 = 0$	$G(x) = -\beta,   x   + \beta_2 \times = 0$ $G'(x) = -\frac{\beta_1}{x} + \beta_2 = 0$
Sustituyendo a. y az	Sustituye Pr + P2
0.4 - 0.01 = 0 x	- 0.8 + 0.02 = 0
O.4 = 0.01 O.4 = 0.01 x	- 0.8 = -0.02 x
0.4 = x 0.01 40 = x	-0.8 = -0.02 x $-0.8 = x$ $-0.02$
40 = x	40 = ×
Sustituimos en F(x)	Sustituímas en G(x)
0.4 ln(40) - 0.01(40) 1.0755	$-0.8 l_{n}(40) + 0.02(40) = 0$ $-2.1511$
(40, 1.0 755) Máximo	(40, -2.1511) Minimo





#### Puntos Máximos y Mínimos en Desmos



#### Orbitas del sistema

