$$Ma = -CV^2$$

$$m\frac{dv}{dt} = -Cv^2$$

$$m\,dv = -Cv^2\,dt$$

$$dv = \frac{-Cv^2\,dt}{m}$$

$$\frac{dv}{V^2} = \frac{-C\,\cancel{dt}}{m}$$

$$\int \frac{dv}{V^2} = \frac{-C}{m}\int dt$$

$$= -\frac{1}{V} = \frac{-C}{m}t + C$$

If $V = V_0$
and
$t = 0$

$$-\frac{1}{V_0} = \cancel{\frac{-C}{m}0} + C$$

$$-\frac{1}{V_0} = C$$

$$-\frac{1}{V_0} = \frac{-C}{m}t + \left(-\frac{1}{V_0}\right)$$

$$-\frac{1}{V} = -\frac{1}{V_0}\left(\frac{CV_0t}{m} + 1\right)$$

$$\frac{1}{V} = \frac{1}{V_0}\left(\frac{CV_0t}{m} + 1\right)$$

$$\tau = \frac{m}{CV_0}$$

$$V = \frac{V_0}{\left(\frac{CV_0t}{m} + 1\right)} \rightarrow \boxed{V = \frac{V_0}{\left(\frac{t}{\tau} + 1\right)}}$$

$$P(t) = \int \frac{V_0}{\frac{t}{\tau} + 1}\,dt$$

$$\cancel{u} = \frac{t}{\tau} + 1$$

$$P(t) = V_0\tau\int \frac{1}{u}\,du$$

$$P(t) = V_0\tau\ln(u)$$

$$P(t) = V_0\tau\ln\left(\frac{t}{\tau} + 1\right) + C$$

$$du = \frac{d}{dt}\left[\frac{t}{\tau} + 1\right]$$

$$du = \frac{1}{\tau}\cdot\frac{d}{dt}(t) + \frac{d}{dt}1$$

$$du = \frac{1}{\tau}dt$$

$$dt = du\,\tau$$