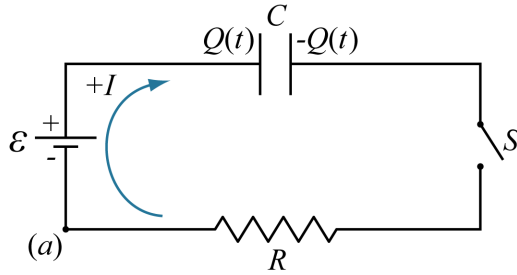


# Capacitor charge vs. time in an RC series circuit



$$\Delta V_{\text{LOOP}} = 0$$

$$+\varepsilon - \frac{Q}{C} - IR = 0$$

Early times (just after closing "S")	Intermediate time $t$	Late times (long after closing "S")									
$+\varepsilon - \frac{0}{C} - IR = 0$ <p>Capacitor: <math>Q_0 = 0, V_0 = 0</math></p> <p>Resistor: <math>I_0 = \frac{\varepsilon}{R}, V_0 = \varepsilon</math></p>	$+\varepsilon - \frac{Q}{C} - I R = 0$ $R \frac{dQ}{dt} + \frac{1}{C} Q - \varepsilon = 0$ $\underbrace{RC}_{\tau} \frac{dQ}{dt} + Q - C\varepsilon = 0$ $\tau \int_{Q=Q_i}^{Q=Q_f} \frac{1}{C\varepsilon - Q} dQ = \int_{t=t_i}^{t=t_f} dt$ $-\tau [\ln C\varepsilon - Q ]_{Q=Q_i}^{Q=Q_f} = t_f - t_i$ <p>Note: <math>C\varepsilon - Q \geq 0</math></p> $-\tau \ln\left(\frac{C\varepsilon - Q_f}{C\varepsilon - Q_i}\right) = t_f - t_i$ <table border="1" data-bbox="570 1255 1036 1367"> <thead> <tr> <th></th> <th>Time</th> <th>Charge</th> </tr> </thead> <tbody> <tr> <td>Initial</td> <td><math>t_i = 0</math></td> <td><math>Q_i = 0</math></td> </tr> <tr> <td>Final</td> <td><math>t_f = t</math></td> <td><math>Q_f = Q</math></td> </tr> </tbody> </table> $Q = \underbrace{C\varepsilon}_{Q_\infty} \left[1 - e^{-\frac{t}{\tau}}\right]$		Time	Charge	Initial	$t_i = 0$	$Q_i = 0$	Final	$t_f = t$	$Q_f = Q$	$+\varepsilon - \frac{Q}{C} - \underbrace{I}_0 R = 0$ <p>Capacitor: <math>Q_\infty = C\varepsilon, V_\infty = \varepsilon</math></p> <p>Resistor: <math>I_\infty = 0, V_\infty = 0</math></p>
	Time	Charge									
Initial	$t_i = 0$	$Q_i = 0$									
Final	$t_f = t$	$Q_f = Q$									

