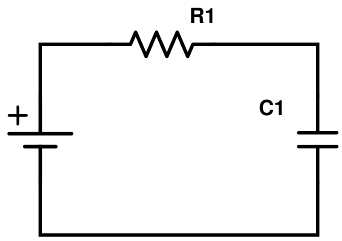
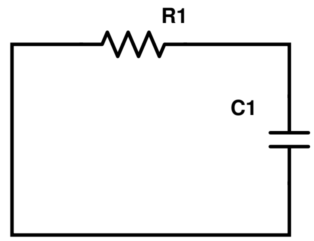
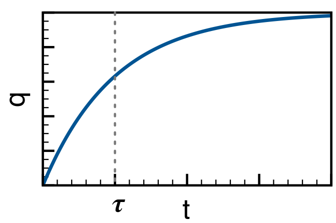
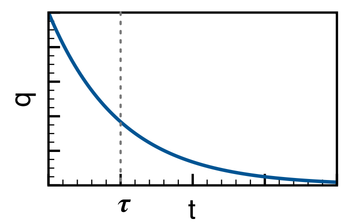
RC TRANSIENTS IN-BRIEF

RC circuits exhibit transient time-dependent behaviour. Below two cases are shown in brief: charging when first connected to a voltage source (e.g. battery), and discharging when first shorted across a resistor. The Kirchoff's law equation is used to establish a differential equation describing the charging behaviour and from there $q(t)$, $I(t)$ and $V_C(t)$ can be determined.

	charging	**discharging**
		
Kirchoff's law:	$V_B - IR_1 - V_C = 0; I = \frac{dq}{dt}$	$V_C - IR_1 = 0; I = -\frac{dq}{dt}$
Rearranging:	$V_B - \frac{dq}{dt}R_1 - \frac{q}{C_1}$	$\frac{q}{C_1} + \frac{dq}{dt}R_1 = 0$
1st order DE:	$\frac{dq}{dt} = \frac{1}{R_1}(V_B - \frac{q}{C_1})$	$\frac{dq}{dt} = -\frac{q}{R_1 C_1}$
solving for $q(t)$:	$q(t) = C_1 V_B(1 - e^{-t/R_1C_1})$	$q(t) = Q_0 e^{-t/R_1C_1}$
	$C_1 V_B = Q_{max}$	$Q_0 =$ initial charge
		
solving for $V_C(t) = q/C_1$:	$V_C(t) = V_B(1 - e^{-t/R_1C_1})$	$V_C(t) = V_0 e^{-t/R_1C_1}$
solving for $I(t) = \frac{dq}{dt}$:	$I(t) = I_0 e^{-t/R_1C_1}$	$I(t) = I_0 e^{-t/R_1C_1}$

Typically we define a "time constant" $\tau = RC$ which is a characteristic decay time of the exponential (like in other decaying systems), such that the exponentials become $e^{-t/\tau}$. τ is the time it takes for a decaying exponential to reach $1/e$ of its initial value, and can be read directly off a graph.