[dc circuits + capacitance] .quiz

1) ammeters and voltmeters

Consider an ideal voltmeter and an ideal ammeter, connected to a circuit like Fig. 1. The numerical values are $E = 4.00$ V, $R_1 = 100\ \Omega$, $R_2 = 200\ \Omega$, and $R_3 = 300\ \Omega$.

a) Draw this circuit again, putting short circuits, i.e. simply wires, and/or open circuits instead of the meters.
b) Find the current passing through R_2.
c) Find the current passing through the ammeter and the voltage reading of the voltmeter.

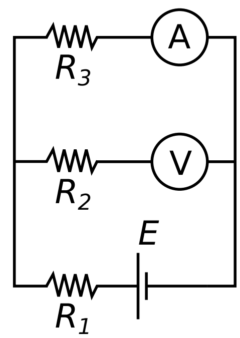
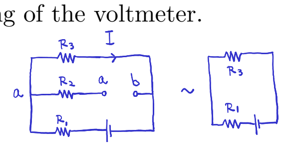


Figure 1: The circuit for the problem 2.

a)



b) Zero.

c) $I = \frac{\mathcal{E}}{R_1+R_3}$, $V_a - V_b = R_3 I = \frac{R_3}{R_1+R_3}\mathcal{E}$.

2) RC Circuits

Consider the RC circuit shown in fig. 1, where $R_1 = 5.0$ kΩ, $R_2 = 20$ kΩ, $C_1 = C_2 = 4.7$ mF, and $\mathcal{E} = 12$ V. The left switch is connected when $0 < t < T$, and the right switch is connected after that, i.e. $t > T$. Initially capacitors has no charge. For numerical values you can use $T = 60$ s.

a) Draw two circuits, one for $0 < t < T$, and the other one for $t > T$.
b) Find $V_{c_1}(t)$ when $0 < t < T$. What is the time constant?
c) What happens right after the moment $t = T$ when capacitors are connected in parallel?
d) Find $V_{c_1}(t)$ when $t > T$.
e) Qualitatively plot $V_{c_1}(t)$ versus time.

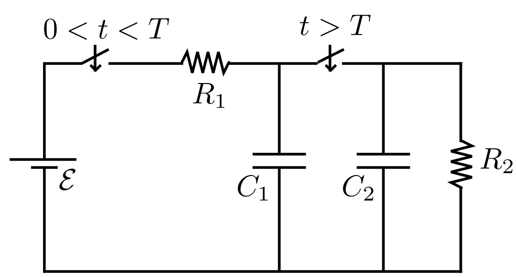
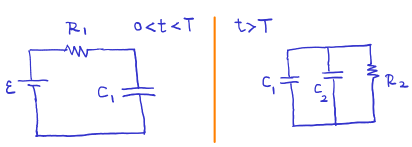
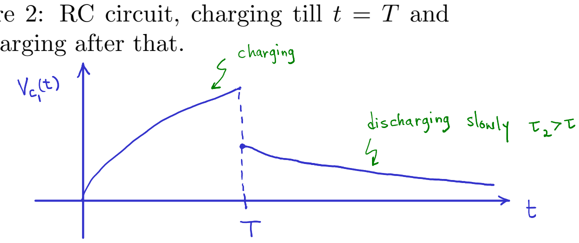


Figure 2: RC circuit, charging till $t = T$ and discharging after that.

a)



e)



b) $0<t<T$: $V_{c_1}(t) = \mathcal{E}\left[1 - e^{-t/\tau_1}\right]$, $\tau = R_1 C_1$.

c) $V_{c_1} = V_{c_2}$ → so they share total charge on C_1 right before T between them so that $\frac{q_1}{C_1} = \frac{q_2}{C_2}$, $q_1 + q_2 = Q_{c_1}(T^-)$.
Here $C_1 = C_2$ so each get half and $V_{c_1}(T^+) = V_{c_2}(T^+) = \frac{1}{2} V_{c_1}(T^-) = \frac{1}{2}\mathcal{E}\left[1 - e^{T/\tau_1}\right]$.

d) $t > T$: $V_{c_1}(t) = V_{c_1}(T^+)\ e^{-(t-T)/\tau_2}$, It discharges through R_2 with $\tau_2 = R_2(C_1 + C_2)$.