Voltmeter - high resistance hooked in parallel
Ammeter - low resistance hooked in series

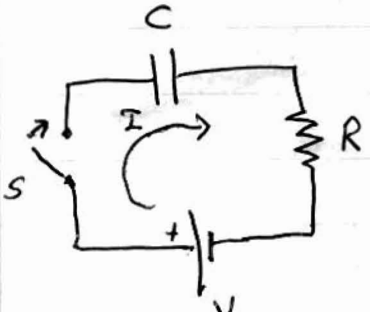
2/22/07

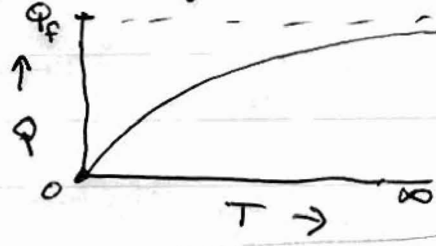
RC (Resistor - Capacitor) Timing Circuits

Time constant (seconds) $\underset{s}{\tau} = \underset{\Omega}{R}\,\underset{F}{C}$

$$I = \frac{dQ}{dt} \qquad Q = CV \qquad V = IR$$

Charging Circuit (Cap initially uncharged)





$Q_f = CV$

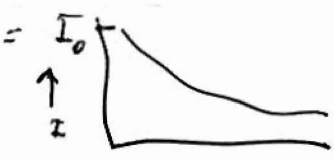
$$\boxed{Q = Q_f\left[1 - e^{-t/\tau}\right]}$$ charge on cap

Current flowing thru resistor

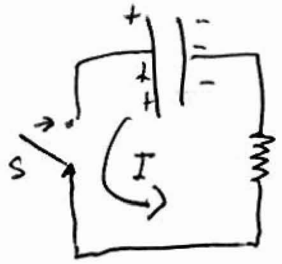
$$I = \frac{dQ}{dt} = \frac{d}{dt}\left[Q_f - Q_f e^{-t/RC}\right]$$

$$I = 0 - \frac{\cancel{C}V_0}{-R\cancel{C}} e^{-t/RC} = \boxed{I_0 e^{-t/RC} = I}$$

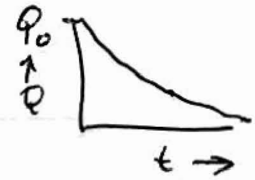
$\frac{V}{R} = I_0$



Discharging Circuit

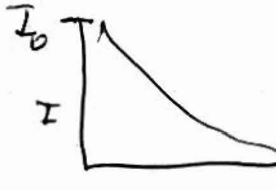


$$Q = Q_0 e^{-t/RC}$$



$$I = \frac{dQ}{dt} = -\frac{\cancel{C}V}{R\cancel{C}} e^{-t/RC}$$

$$\boxed{I = -I_0 e^{-t/RC}}$$



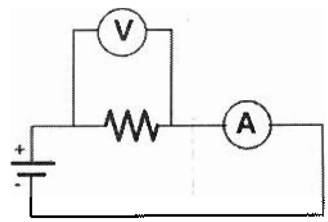
just denotes direction of flow

Physics 24 Test-Level Problems for Recitation 14

_D_ 1. You wish to study a resistor in a circuit. To simultaneously measure the current in the resistor and the voltage across the resistor, you would place an ammeter in _________ with the resistor and a voltmeter in _________ with the resistor.

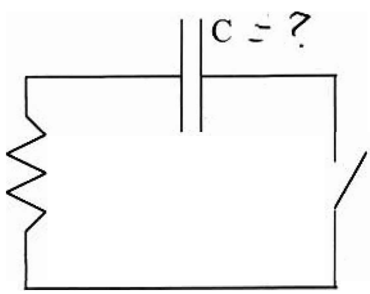
[A] series, series | [B] series, parallel
[C] parallel, series | [D] parallel, series

_D_ 2. The resistance of a resistor is to be determined by simultaneously measuring the current through the resistor and its voltage, then calculating the ratio R=V/I. The figure to the right shows one possible set-up for this experiment. Which of the statements below is true about this experimental set-up?



[A] This set-up will provide an accurate measure of the resistance.
[B] The voltage measured by the voltmeter is greater than the actual voltage of the resistor.
[C] The current measured by the ammeter is smaller than the current that actually goes through the resistor.
[D] The current measured by the ammeter is larger than the current that actually goes through the resistor.

3. The capacitor in the circuit below initially has a potential difference of 100 V. It is discharged through a 10 kΩ resistor when the switch is closed. 10 seconds after the switch is closed the potential across the capacitor is 1 V.
(a) What is the capacitance of the capacitor?
(b) What is the current in the resistor 10 seconds after the switch is closed?



a) $V_0 = 100\,V$

Discharging circuit

$Q = Q_0 e^{-t/RC}$

$Q = CV$

$\cancel{C}V = \cancel{C}V_0 e^{-t/RC}$

$1.0\,V = (100\,V)\, e^{-t/RC}$

$-4.605 = -\frac{t}{RC}$

$4.605 = \frac{10.0\,s}{(10\times10^3)C}$

$C = \frac{10}{(10\times10^3)(4.605)} = \boxed{217\times10^{-6}\,F = 217\,\mu F}$

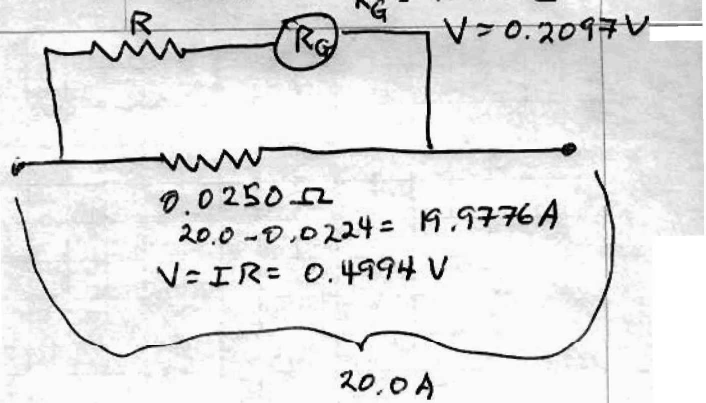
b) $V = IR$

$I = \frac{1.0\,V}{10\times10^3\,\Omega} = \boxed{0.1\times10^{-3}\,A}$

$\boxed{I = 0.10\,mA}$

26.29 The resistance of the coil of a pivoted-coil galvanometer is 9.36 Ω, and a current of 0.0224 A causes it to deflect full scale. We want to convert this galvanometer to an ammeter reading 20.0 A full scale. The only shunt available has a resistance of 0.0250 Ω. What resistance R must be connected in series with the coil (see Fig. 26.43)?

Figure 26.43 Exercise 26.29.

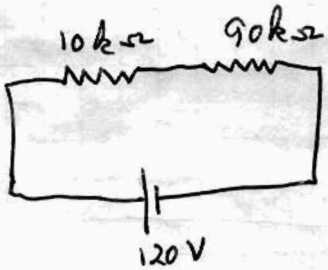


In parallel, same voltage difference across each

$$0.4994 = R(0.0224) + 9.36(0.0224)$$

$$\boxed{R = 12.94\,\Omega}$$

26.32 Two 150-V voltmeters, one with a resistance of 10.0 kΩ and the other with a resistance of 90.0 kΩ, are connected in series across a 120-V dc line. Find the reading of each voltmeter. (A 150-V voltmeter deflects full scale when the potential difference between its two terminals is 150 V.)



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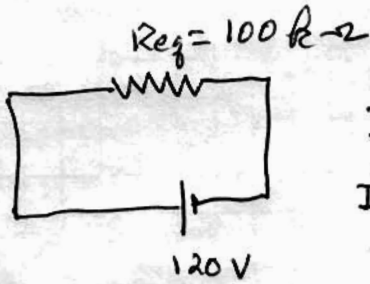

$I = V/R$

$I = \dfrac{120}{100\times10^3} = 1.2\times10^{-3}\,\Omega$

$$V_{10} = IR = (1.2\times10^{-3})(10\times10^3) = \boxed{12.0\text{ V}}$$

$$V_{90} = (1.2\times10^{-3})(90\times10^3) = \boxed{108.0\text{ V}}$$

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26.38 A capacitor is charged to a potential of 12.0 V and is then connected to a voltmeter having an internal resistance of 3.40 MΩ. After a time of 4.00 s the voltmeter reads 3.0 V. What is the capacitance?

Discharging: $Q = Q_0 e^{-t/RC}$

$I = \dfrac{dQ}{dt} = \dfrac{Q_0}{-RC} e^{-t/RC}$; $Q = CV$

$I = \dfrac{\cancel{C} V_0}{R\cancel{C}} e^{-t/RC}$; $V = IR$ $\quad I = V/R$

$\dfrac{V}{\cancel{R}} = \dfrac{V_0}{\cancel{R}} e^{-t/RC}$

$3.0 = 12e^{-4.0/RC} \Rightarrow -1.386 = -\dfrac{4.0}{RC}$

$RC = 2.885 = (3.40\times10^6)C$

$\therefore \boxed{C = 8.49\times10^{-7}\text{ F}}$

26.42 In the circuit shown in Fig. 26.45, $C = 5.90\ \mu F$, $\mathcal{E} = 28.0$ V, and the emf has negligible resistance. Initially the capacitor is uncharged and the switch S is in position 1. The is then moved to position 2, so that the capacitor begins to charge. a) What will be the charge on the capacitor a long time after the switch is moved to position 2? b) After the switch has been in position 2 for 3.00 ms, the charge on the capacitor is measured to be 110 μC. What is the value of the resistance R? c) How long after the switch is moved to position 2 will the charge on the capacitor be equal to 99.0% of the final value found in part (a)?

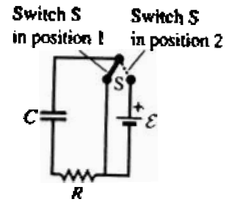


Figure 26.45 Exercises 26.42 and 26.43.

a) $Q = CV$

$= (5.90\times10^{-6}\text{F})(28.0\text{V}) = \boxed{1.65\times10^{-4}\text{C}}$

b) Charging

$Q = Q_f\left(1 - e^{-t/RC}\right)$

$110\mu C = 165\mu C\left(1 - e^{-t/RC}\right)$

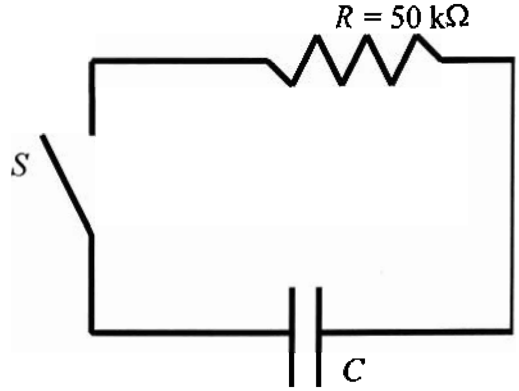
$0.667 = 1.0 - e^{-t/RC}$

$-1.0986 = -\dfrac{t}{RC} = -\dfrac{3.0\times10^{-3}\text{s}}{R(5.90\times10^{-6}\text{F})}$

$\boxed{R = 463\ \Omega}$

c) $0.99\cancel{Q_f} = \cancel{Q_f}\left(1 - e^{-t/RC}\right)$

$-4.605 = -\dfrac{t}{(463\ \Omega)(5.90\times10^{-6}\text{F})} \Rightarrow \boxed{\begin{aligned} t &= 1.26\times10^{-2}\text{s} \\ &= 12.6\text{ms}\end{aligned}}$



A capacitor is charged so that the potential difference across its plates is 100 V. The capacitor is then connected to a 50 kΩ resistor as shown. The current through the resistor is found to have a magnitude of 0.1 mA after the switch connecting the capacitor and resistor has been closed for 5 seconds. Work the following, keeping in mind that you must begin with starting equations.

(a) What is the maximum current (magnitude) that passes through the resistor?

(b) What is the capacitance of the capacitor?

) $q = q_0 e^{-t/RC}$

$I = \frac{dq}{dt} = -\frac{q_0}{RC} e^{-t/RC}$

$q_0 = CV_0$

$I = -\frac{\cancel{C}V_0}{R\cancel{C}} e^{-t/RC}$

$V_0 = I_0 R$

$\therefore I = -I_0 e^{-t/RC}$

$0.1\cancel{mA} = 2.0\cancel{mA}\, e^{-t/RC}$

$-2.996 = -\frac{t}{RC} = -\frac{5.0s}{(50\times10^{3}\Omega)C}$

$C = 3.34\times10^{-5}F = \boxed{33.4\mu F}$

a) $V_0 = I_0 R$

$I_0 = V_0/R = \frac{100V}{50\times10^{3}\Omega} = \boxed{2\times10^{-3}A}$