**PHY 114 A General Physics II**
**11 AM-12:15 PM TR Olin 101**

**Plan for Lecture 9 (Chapter 28):**

1. **Direct-current circuits continued**
2. **Voltage, resistor, and capacitor circuits**



| | | | | | |
|---|---|---|---|---|---|
| 5 | 02/02/2012 | Electric potential | 25.5-25.8 | (Review for exam) | |
| | 02/07/2012 | Exam | | | |
| 6 | 02/09/2012 | Capacitance and dielectrics | 26.1-26.7 | 26.4,26.13,26.30 | 02/14/2012 |
| 7 | 02/14/2012 | Current and resistance | 27.1-27.6 | 27.3,27.12,27.29 | 02/16/2012 |
| 8 | 02/16/2012 | Direct current circuits | 28.1-28.2 | 28.3,28.7,28.19 | 02/21/2012 |
| 9 | 02/21/2012 | Direct current circuits | 28.3-28.5 | 28.23,28.25,28.34 | 02/23/2012 |
| 10 | 02/23/2012 | Review | 26.1-28.5 | (Review for exam) | |
| | 02/28/2012 | Exam | | | |
| 11 | 03/01/2012 | Magnetic fields | 29.1-29.6 | 29.5,29.12,29.47 | 03/06/2012 |
| 12 | 03/06/2012 | Magnetic field sources | 30.1-30.6 | | |
| 13 | 03/08/2012 | Faraday's law | 31.1-31.5 | | |
| | 03/13/2012 | *No class (Spring Break)* | | | |
| | 03/15/2012 | *No class (Spring Break)* | | | |
| 14 | 03/20/2012 | Induction and AC circuits | 32.1-32.6 | | |

Remember to send in your chapter reading questions…

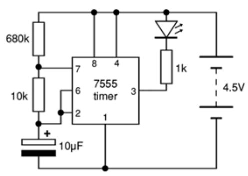


Professor George Holzwarth (gholz@wfu.edu)
will administer the exam on 2/28/2012
and will lecture on magnetic fields, electric motors, etc. on 3/1/2012.

Circuit diagram:

Example project from web page

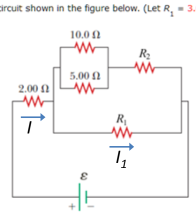
http://www.kpsec.freeuk.com/projects/dummy.htm






From webassign:

Consider the circuit shown in the figure below. (Let $R_1$ = 3.00 Ω, $R_2$ = 4.00 Ω, and $\mathcal{E}$ = 6.00 V.)




(a) Find the voltage across $R_1$.

V

(b) Find the current in $R_1$.

A

$$\mathcal{E} - 2I - R_1 I_1 = 0$$

$$\Delta V_1 = R_1 I_1 = \mathcal{E} - 2I$$

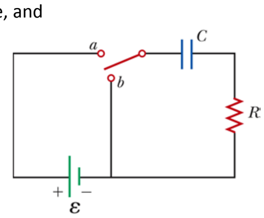
among the many ways to find $I$:

$$I = \frac{\mathcal{E}}{R_{eq}}$$

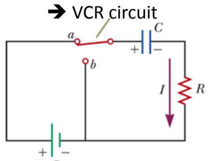


Circuits involving Voltage, Capacitance, and Resistance

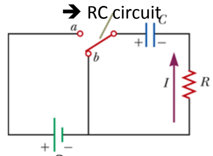
Open switch
➔ no charge or current

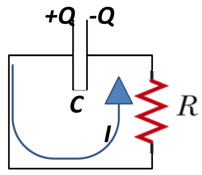



Switch closed
➔ VCR circuit




Switch closed
➔ RC circuit






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

$$I = \frac{dQ}{dt}$$

$$-\frac{Q}{C} - \frac{dQ}{dt}R = 0$$

$$\frac{dQ}{dt} = -\frac{1}{RC}Q$$



What are the units of RC?

A. Seconds
B. Cycles per second
C. Meters
D. Coulombs
E. Volts



Simple rate equation for growth:

$$\frac{dM}{dt} = rM$$

$\frac{dM}{dt} =$ rate of accumlation of money

$r$ = rate of increase

$M = M(t) =$ money at time $t$

Analysis:

$$\frac{dM}{dt} = rM \quad \Rightarrow \quad \frac{dM}{M} = d\ln(M) = rdt$$

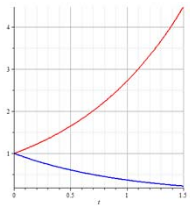
$$\ln(M)\Big|_{M_0}^{M} = rt\Big|_{t_0}^{t} \quad \Rightarrow M(t) = M_0 e^{r(t-t_0)}$$

Simple rate equation for decrease:

$$\frac{dM}{dt} = -rM \qquad \frac{dM}{dt} = \text{ rate of accumlation of money}$$

$$r \;=\; \text{rate of decrease}$$

$$M = M(t) = \text{ money at time } t$$

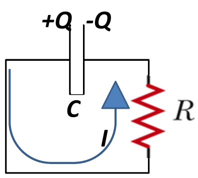


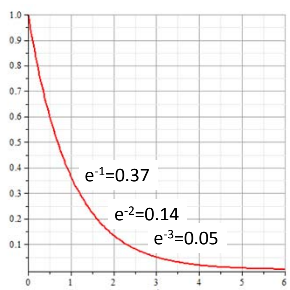
Analysis:

$$\frac{dM}{dt} = -rM \quad \Rightarrow \quad \frac{dM}{M} = d\ln(M) = -rdt$$

$$\ln(M)\Big|_{M_0}^{M} = -rt\Big|_{t_0}^{t} \quad \Rightarrow M(t) = M_0 e^{-r(t-t_0)}$$





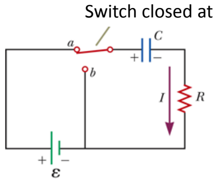

$$\frac{dQ}{dt} = -\frac{1}{RC}Q = -\frac{1}{\tau}$$

$$Q(t) = Q_0 e^{-(t-t_0)/\tau}$$



Charging capacitor:

Switch closed at t=0; Q(t=0)=0

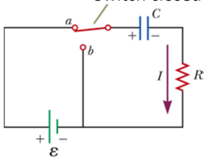



$$\mathcal{E} - \frac{Q}{C} - IR = 0 = \mathcal{E} - \frac{Q}{C} - \frac{dQ}{dt}R$$

$$\frac{dQ}{dt} = -\frac{1}{RC}(Q - C\mathcal{E}) \equiv -\frac{1}{\tau}(Q - C\mathcal{E})$$

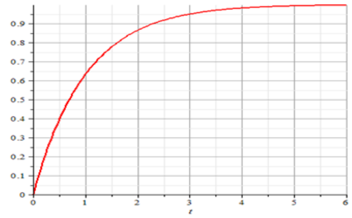
Charging capacitor:

Switch closed at t=0; Q(t=0)=0




$$\frac{dQ}{dt} = -\frac{1}{RC}(Q - C\mathcal{E}) \equiv -\frac{1}{\tau}(Q - C\mathcal{E})$$

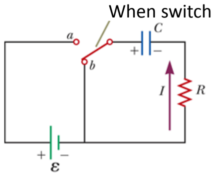
$$Q(t) = C\mathcal{E}\left(1 - e^{-t/\tau}\right)$$






Discharging capacitor

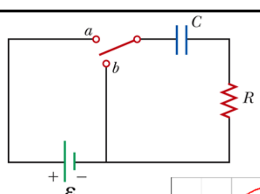
When switch closed $Q(t_c)=C\mathcal{E}$

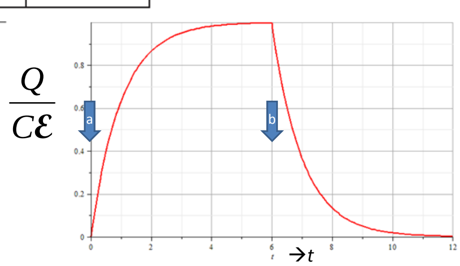


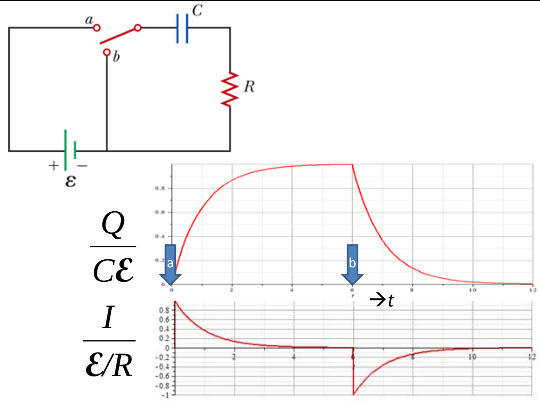

$$\frac{dQ}{dt} = -\frac{1}{RC}Q = -\frac{1}{\tau}Q$$

$$Q(t) = C\mathcal{E}e^{-(t-t_c)/\tau}$$



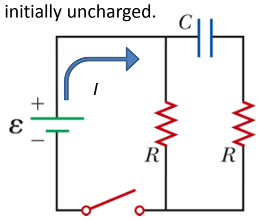







Example 28.5 :
Assume the capacitor is initially uncharged.



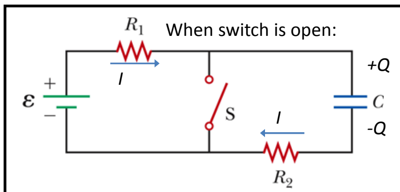

What is the current *I* flowing through the battery just when the switch is closed?

A. 0
B. $\mathcal{E}$/2R
C. $\mathcal{E}$/R
D. 2$\mathcal{E}$/R

What is the current *I* flowing through the battery after the switch has been closed for a long time?

A. 0
B. $\mathcal{E}$/2R
C. $\mathcal{E}$/R
D. 2$\mathcal{E}$/R






When switch is open:

$$\mathcal{E} - IR_1 - \frac{Q}{C} - IR_2 = 0$$

$$I(R_1 + R_2) = \mathcal{E} - \frac{Q}{C}$$

$$\frac{dQ}{dt}(R_1 + R_2) = \mathcal{E} - \frac{Q}{C}$$

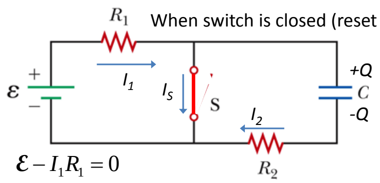
$$\frac{dQ}{dt} = -\frac{1}{(R_1 + R_2)C}(Q - C\mathcal{E})$$

$$Q(t) = C\mathcal{E}\left(1 - e^{-t/\tau}\right) \quad \text{where } \tau \equiv (R_1 + R_2)C$$

For $t >> \tau$: $Q(t \to \infty) = C\mathcal{E}$

$$I(t \to \infty) = \frac{C\mathcal{E}}{\tau} e^{-t/\tau}\Big|_{t\to\infty} = 0$$

When switch is closed (reset t=0):




$\mathcal{E} - I_1 R_1 = 0$

$-\frac{Q}{C} - I_2 R_2 = 0$

$I_2 = \frac{dQ}{dt} \quad \Rightarrow Q(t) = Q_0 e^{-t/\tau}$

$\tau \equiv R_2 C \quad \text{and} \quad Q_0 \equiv C\mathcal{E}$

$I_2 = \frac{dQ}{dt} = -\frac{C\mathcal{E}}{\tau} e^{-t/\tau} = -\frac{\mathcal{E}}{R_2} e^{-t/\tau}$

Current through switch :

$I_1 = I_2 + I_S = 0$

$I_S = I_1 - I_2 = \frac{\mathcal{E}}{R_1} + \frac{\mathcal{E}}{R_2} e^{-t/\tau}$

2/21/2012 PHY 114 A Spring 2012 -- Lecture 8 19