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		

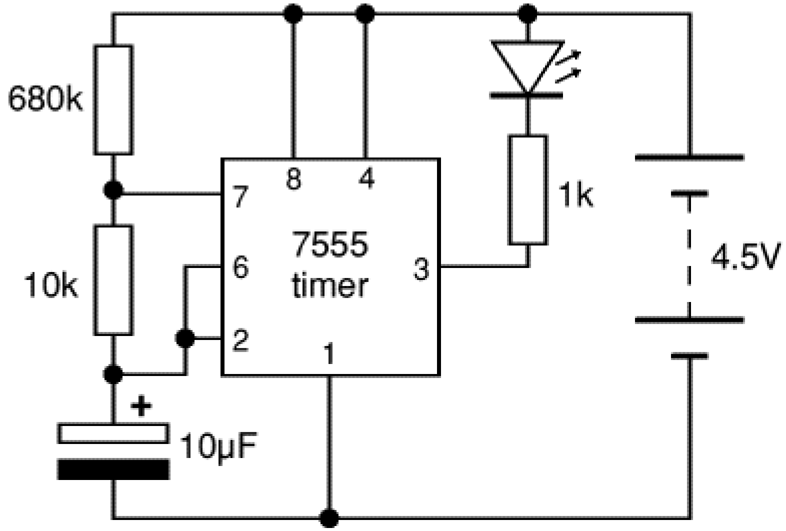
Remember to send in your chapter reading questions…

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:

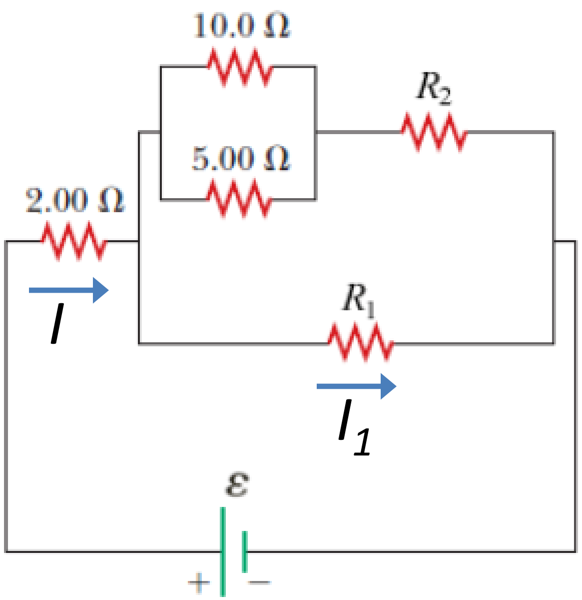
Example project from web page

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

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

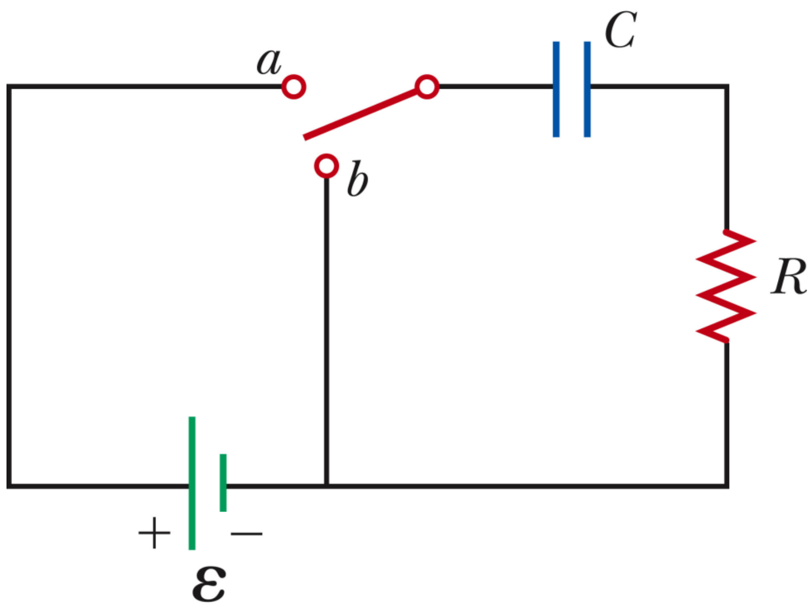
$$\Delta V_1 = R_1 I_1 = \mathcal{E} - 2I$$

among the many ways to find I :

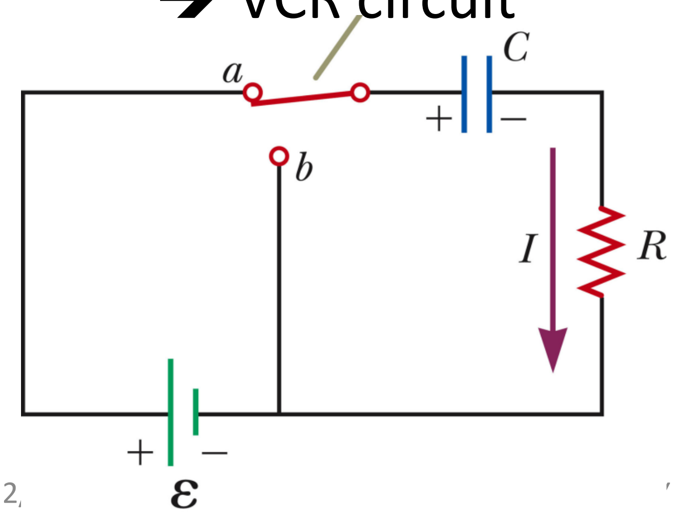
$$I = \frac{\mathcal{E}}{R_{eq}}$$

Circuits involving Voltage, Capacitance, and Resistance

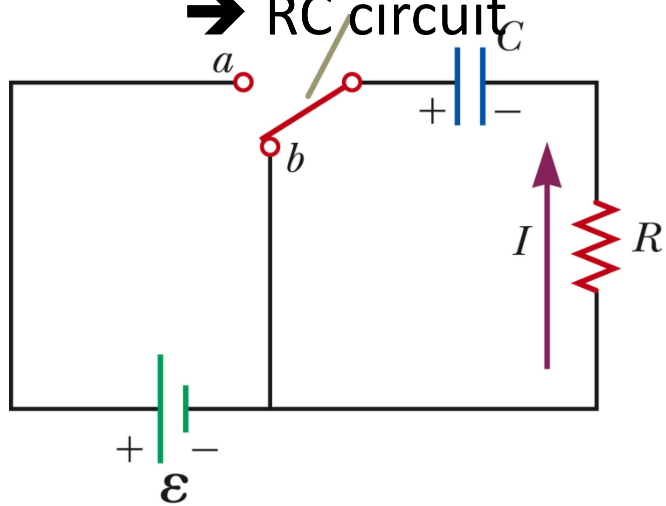
Open switch
➔ no charge or current

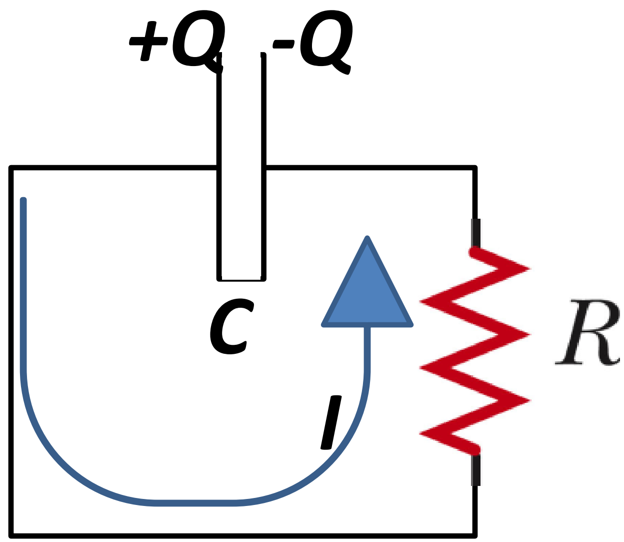


Switch closed
➔ VCR circuit



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:

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

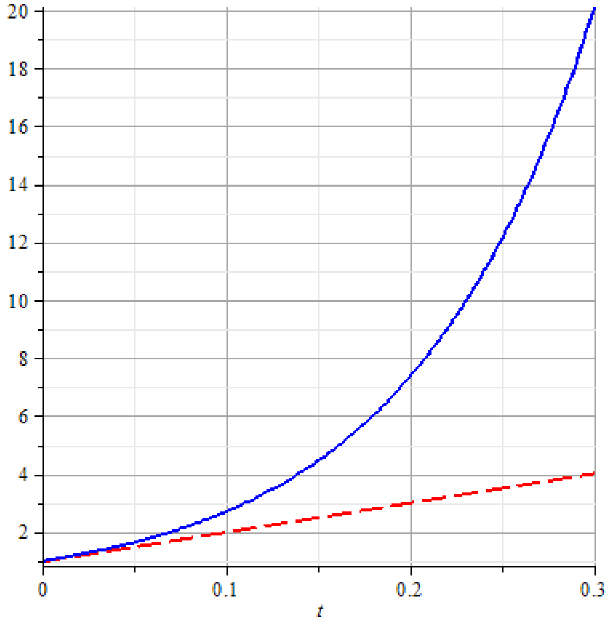
$$r = \text{ rate of increase}$$

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

Analysis:

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

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

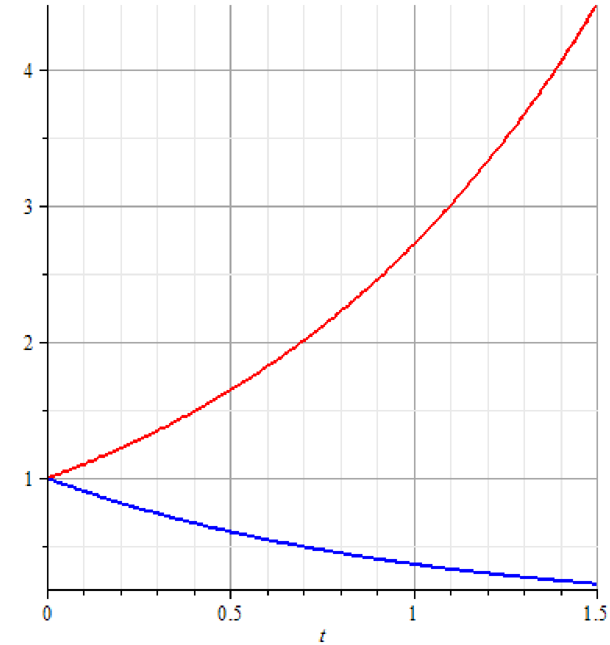


Simple rate equation for decrease:

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

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

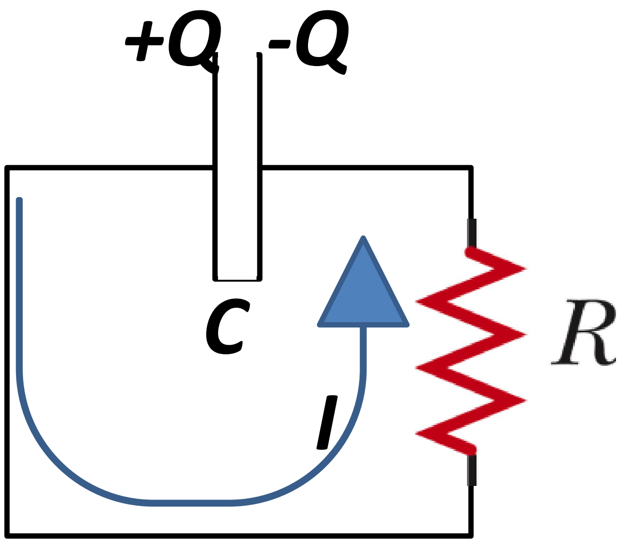
$$M = M(t) = \text{ money at time } t$$



Analysis:

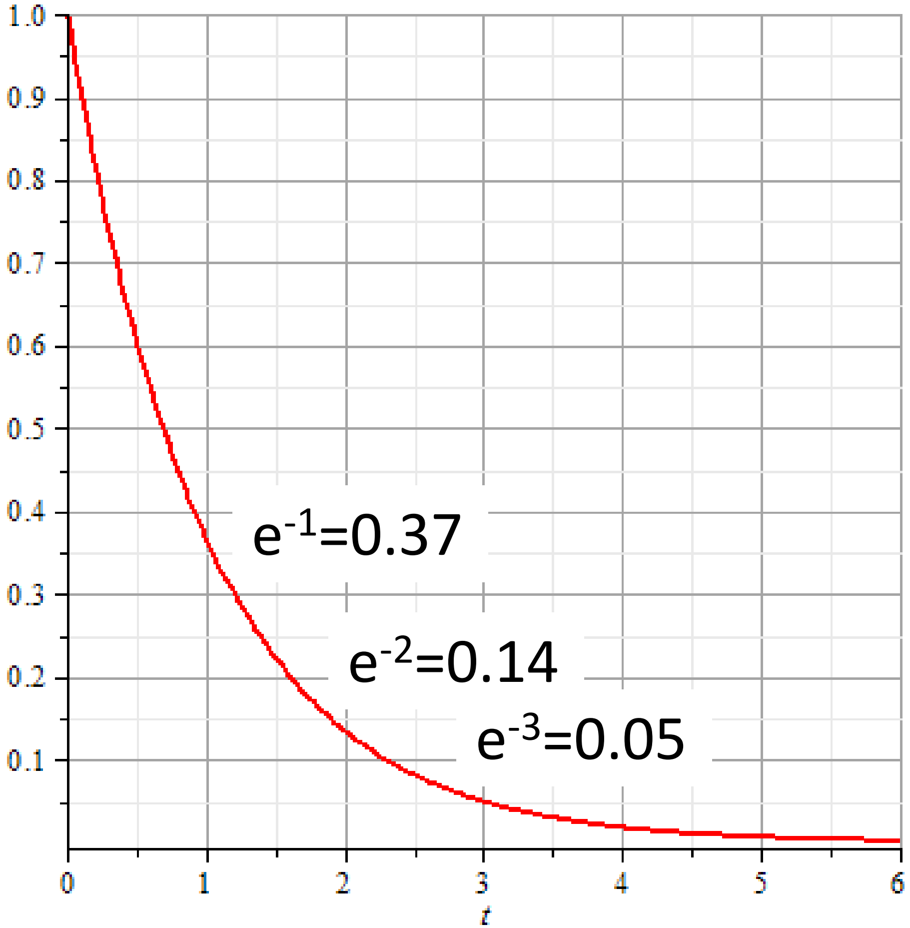
$$\frac{dM}{dt} = -rM \quad \Rightarrow \quad \frac{dM}{M} = d\ln(M) = -rdt$$

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



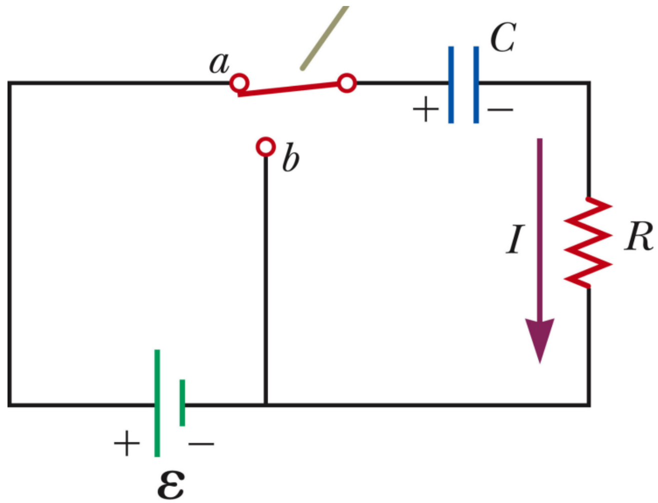
$$\frac{dQ}{dt} = -\frac{1}{RC}Q = -\frac{1}{\tau}$$

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



Charging capacitor:

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

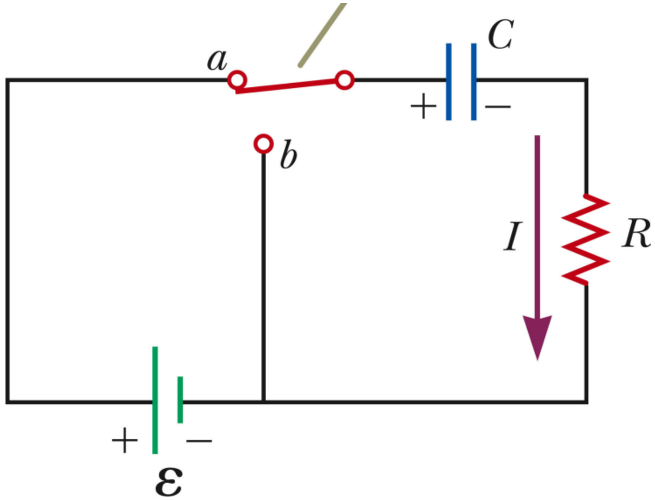


$$\mathcal{E} - \frac{Q}{C} - IR = 0 = \mathcal{E} - \frac{Q}{C} - \frac{dQ}{dt}R$$

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

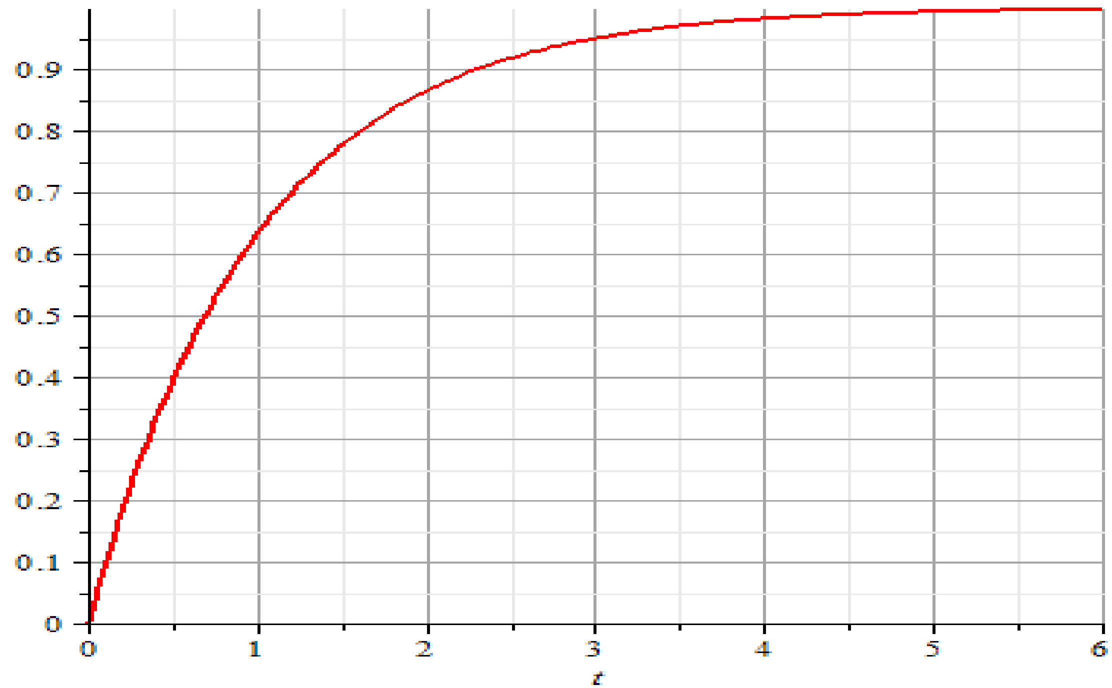
Charging capacitor:

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



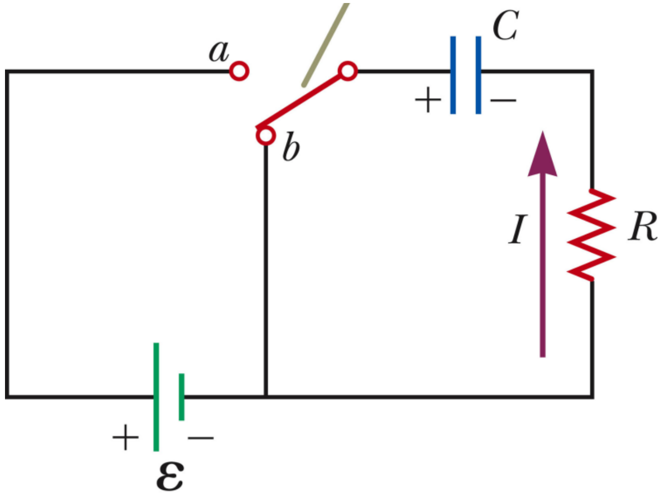
$$\frac{dQ}{dt} = -\frac{1}{RC}(Q - C\mathcal{E}) \equiv -\frac{1}{\tau}(Q - C\mathcal{E})$$

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



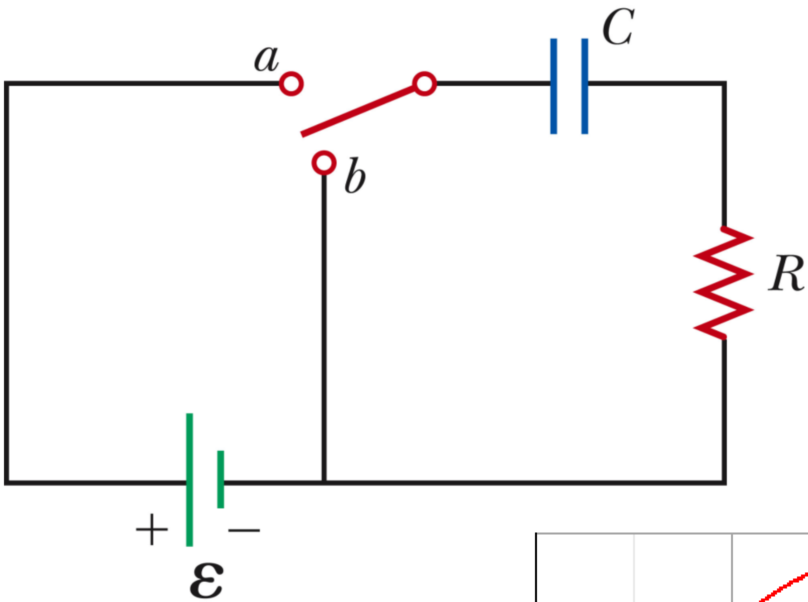
Discharging capacitor

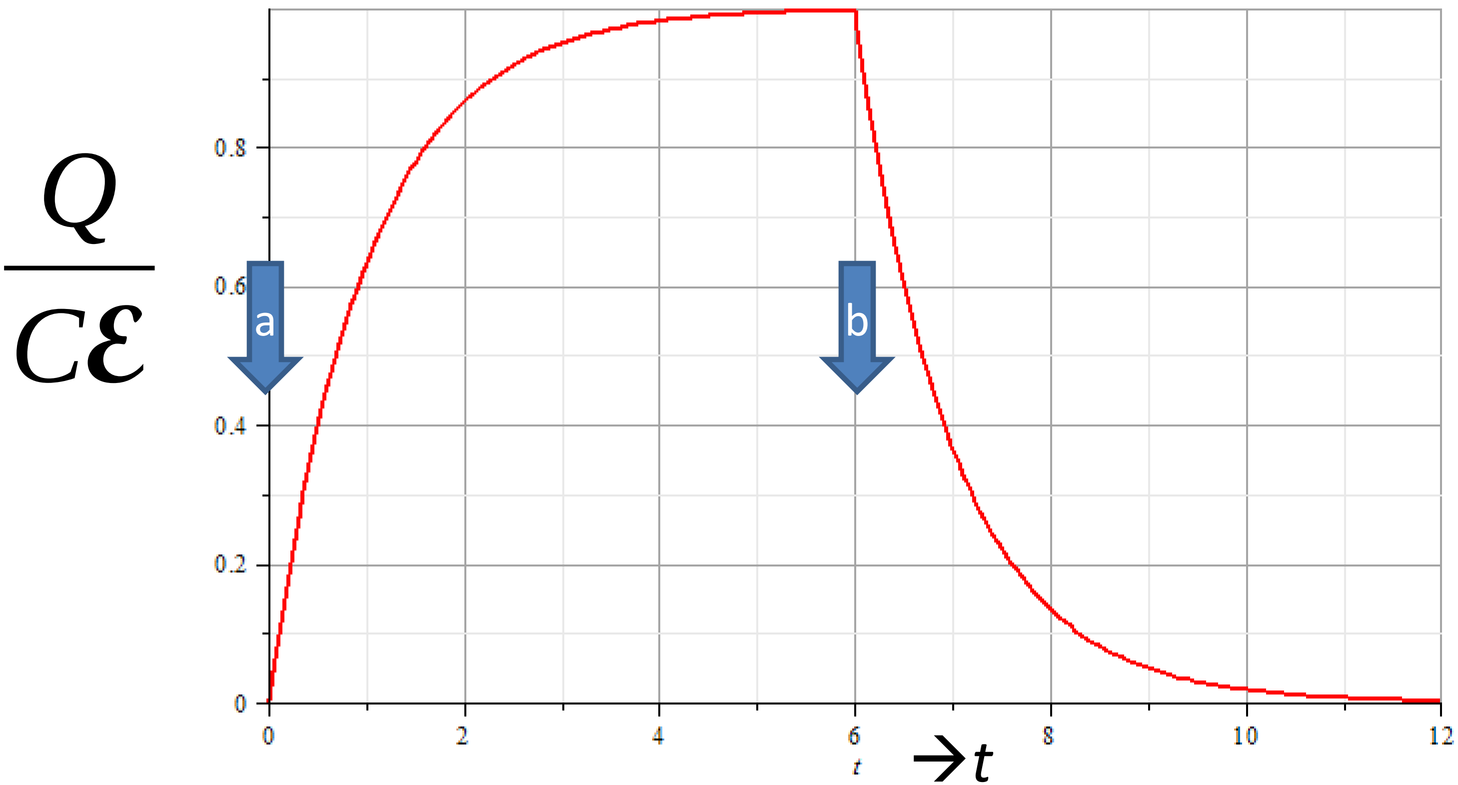
When switch closed $Q(t_c)=C\mathcal{E}$

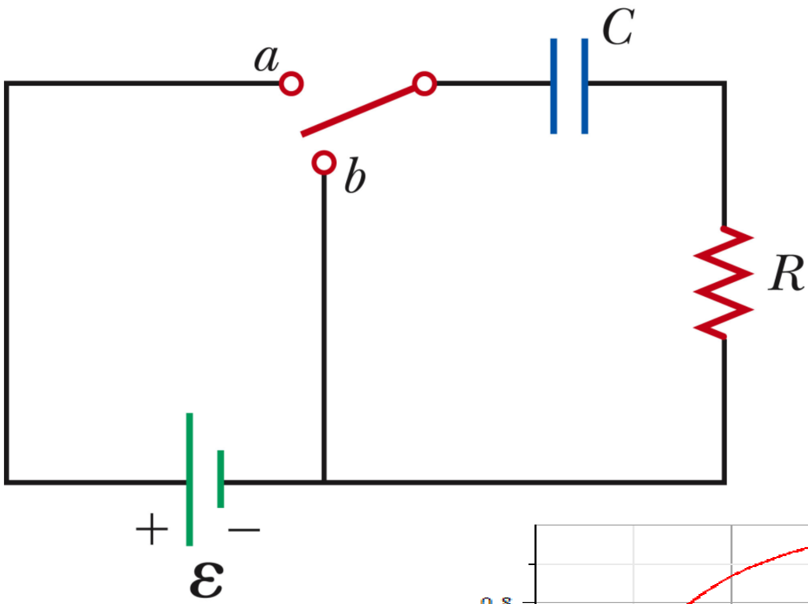


$$\frac{dQ}{dt} = -\frac{1}{RC}Q = -\frac{1}{\tau}Q$$

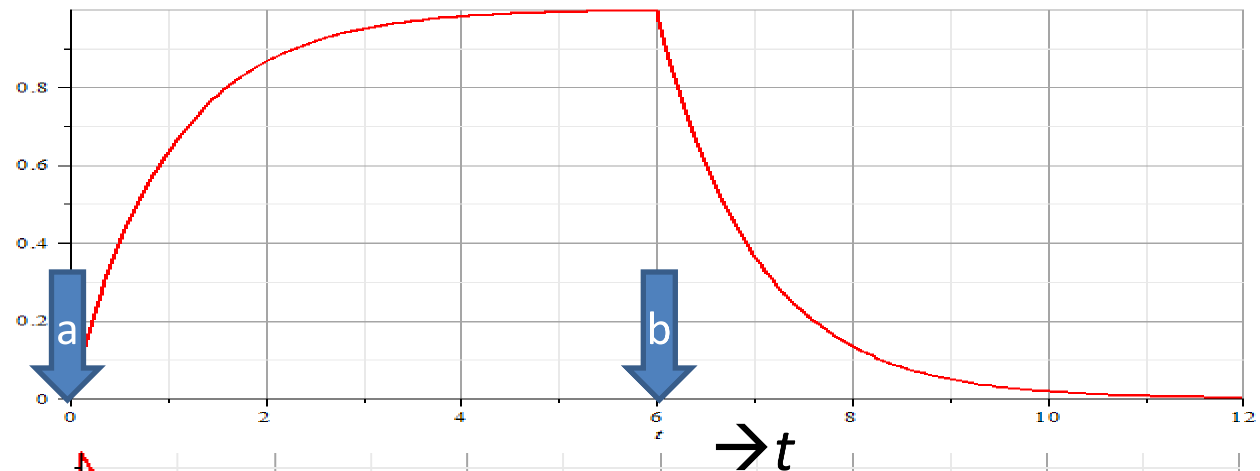
$$Q(t) = C\mathcal{E}e^{-(t-t_c)/\tau}$$


a
b
C
R
+
−
ε

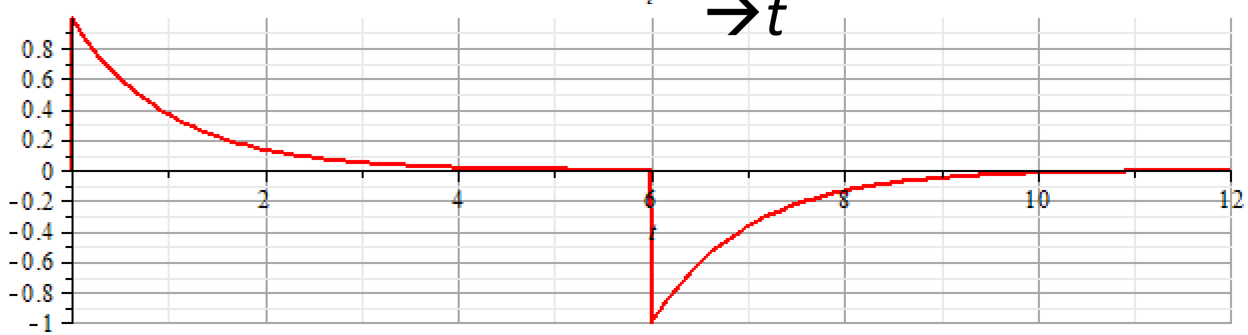

$\frac{Q}{C\mathcal{E}}$
0.8
0.6
0.4
0.2
0
a
b
0
2
4
6
8
10
12
t
→t



$$\frac{Q}{C\mathcal{E}}$$

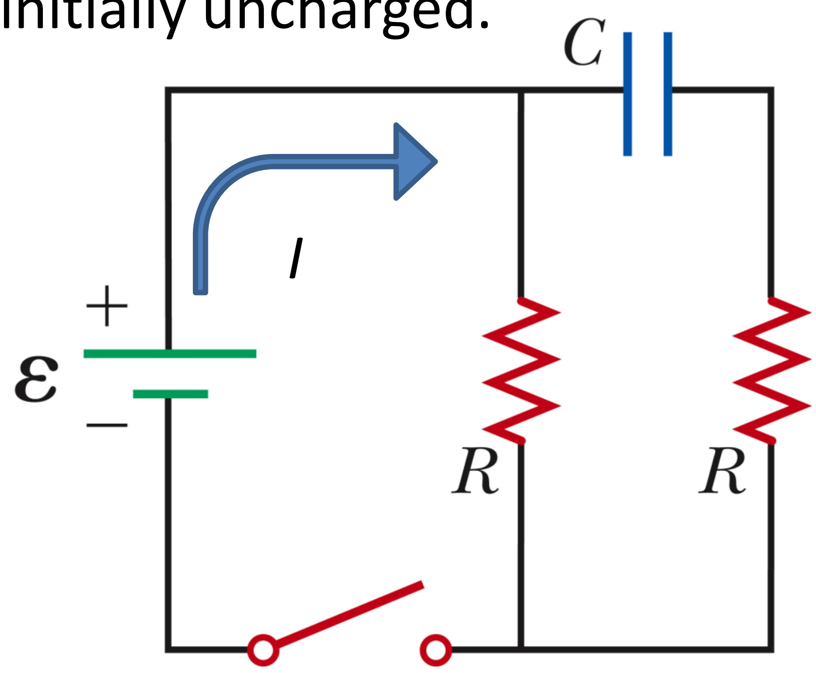


$$\frac{I}{\mathcal{E}/R}$$



Example 28.5 :

Assume the capacitor is initially uncharged.

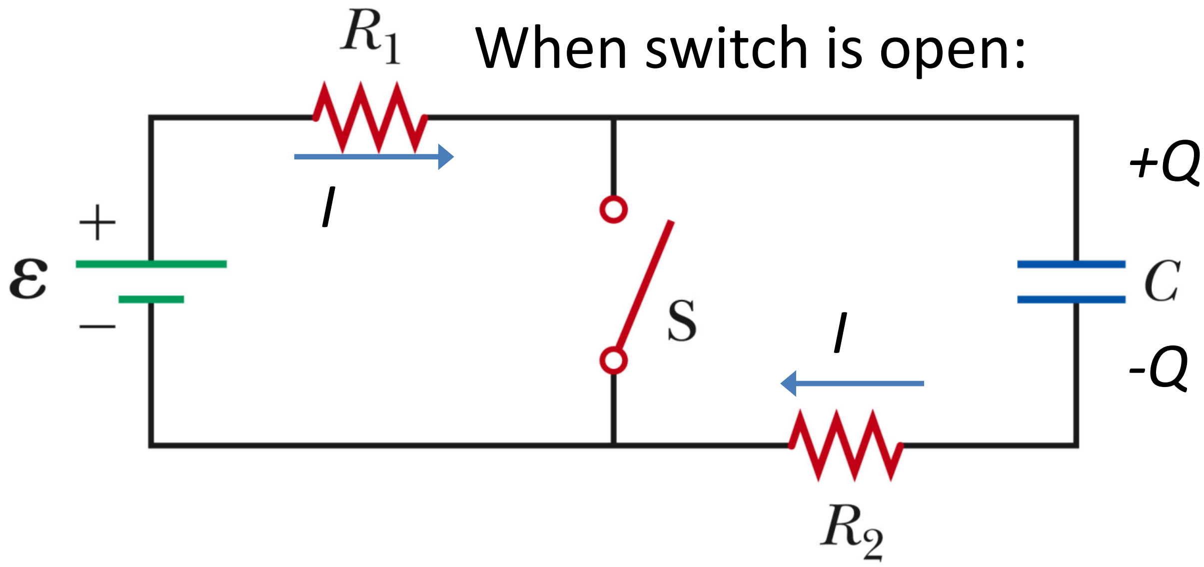


What is the current *I* flowing through the battery just when the switch is closed?

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. $2\mathcal{E}/R$



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

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

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

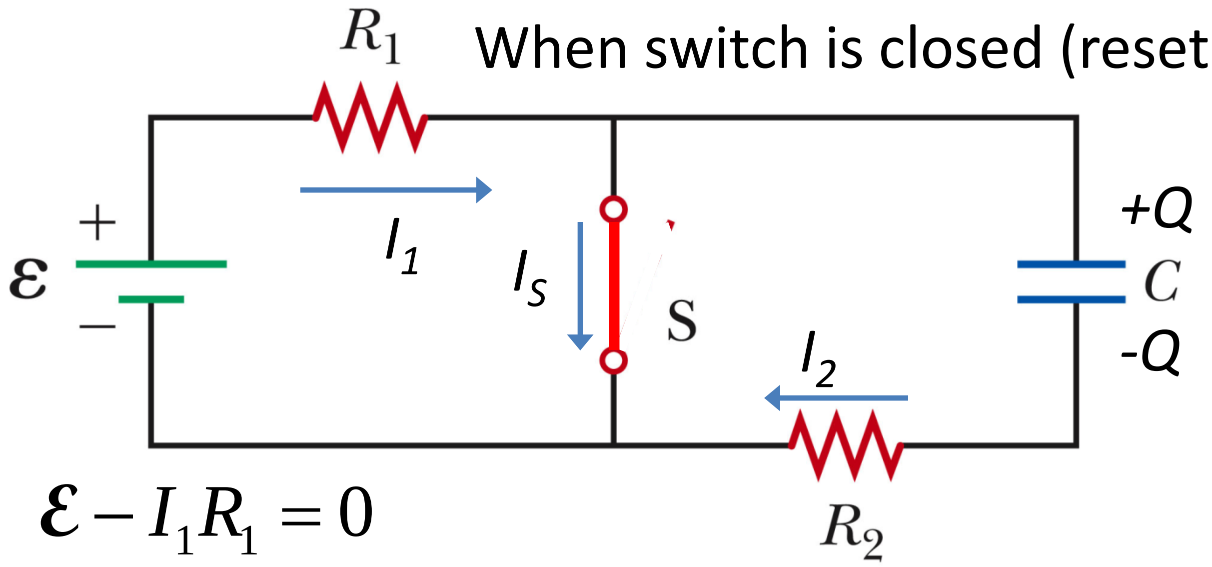
$$\frac{dQ}{dt} = -\frac{1}{\left(R_1 + R_2\right)C}\left(Q - C\mathcal{E}\right)$$

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

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

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

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 :

$$I_1 = I_2 + I_S = 0$$

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