

Setlist L10 (90 minutes)

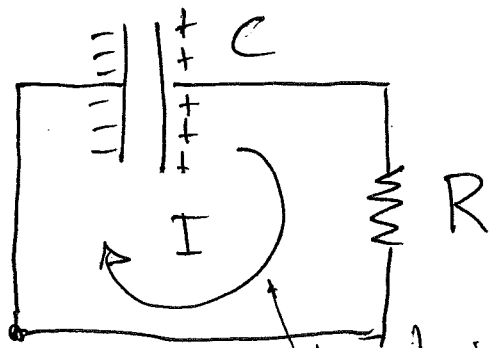
Resistance and circuit analysis.

prep: Circuit (AC+DC) PhET, Find/load capacitor circuits. Circuits galore worksheet.

1. Last class – My laptop is still borked. Go over Kirchhoff's laws and do a circuit analysis example.
2. Clicker Question – potential between 2 points in open circuit – E
3. Worksheet Q5, Q6 and Q7
4. Clicker Question – worksheet Q5 – D
5. Clicker Question – worksheet Q6 – A

6. Capacitance
7. Clicker Question – Does current flow? Show PhET demo.
8. Observing a two capacitors charging. Different charges but the same voltage. This ratio is capacitance.
9. Capacitors and their uses.
10. Capacitance is geometric.
11. Clicker Question – Charging cap, disconnect, move plates – D
12. Clicker Question – Voltage across cap after a long time – C
13. Worksheet Q8
14. Capacitors store energy, electric fields store energy, “empty space” has energy.
15. Discuss what we've done, and what we'll do.

Voltage across a discharging capacitor.



A charged capacitor is set up to discharge across R.

current in the direction of + charge flow.

The loop law says

$$\Delta V_c - IR = 0$$

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

We know that the current is the change in charge

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

negative because a decrease in charge leads to the appearance of current.

So

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

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

✓ differential equation

$$\Rightarrow Q(t) = Q_0 e^{-\frac{t}{RC}}$$

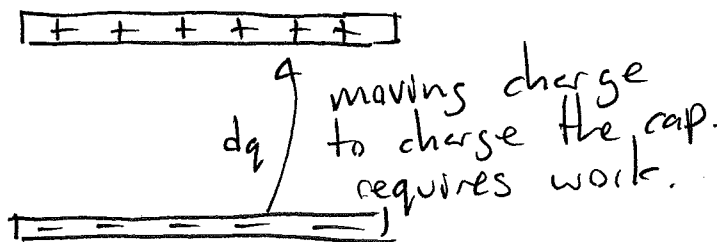
or $V(t) = V_0 e^{-\frac{t}{RC}}$

(because $Q = VC$)

A capacitor stores energy

$$dW = dU = V dq$$

$$= \frac{q}{C} dq$$



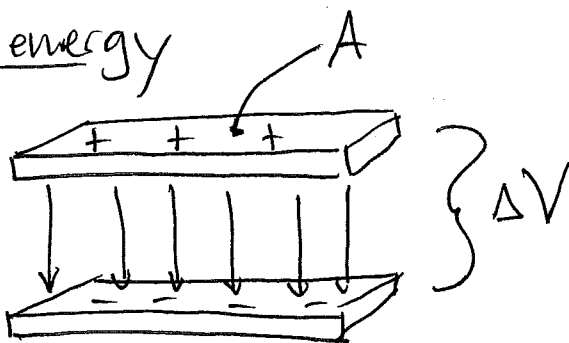
$$\Rightarrow \int_0^Q U = \int_0^Q \frac{q}{C} dq$$

$$U = \frac{Q^2}{2C} = \frac{1}{2} CV^2$$

Electric fields store energy

$$C = \frac{\epsilon_0 A}{d}$$

$$V = Ed$$



So

$$U = \frac{1}{2} \frac{\epsilon_0 A}{d} (Ed)^2 = E^2 \frac{\epsilon_0}{2} (Ad)$$

Volume of space between capacitors.

$$u = \frac{U}{V} = \frac{\epsilon_0}{2} E^2$$

energy density of space is proportional to E^2 . E carries energy!