PHY132H1F Introduction to Physics II
Class 17 – **Outline:**

- Review and summary of Chapter 32 – worked problems
- Review of Chapters 26, 27, 29, 30, 31 – worked problems

Test Tuesday Nov. 16
6:00pm-7:30pm
SF 3201

Review: The **big ideas** of Chapter 32

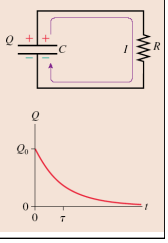
RC circuits

The discharge of a capacitor through a resistor satisfies:

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

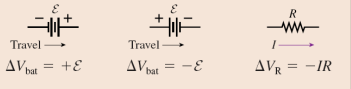
$$I = -\frac{dQ}{dt} = \frac{Q_0}{\tau} e^{-t/\tau} = I_0 e^{-t/\tau}$$

where $\tau = RC$ is the **time constant.**



Review: The **big ideas** of Chapter 32

Signs of ΔV



Review: The **big ideas** of Chapter 32

The energy used by a circuit is supplied by the emf $\mathcal{E}$ of the battery through the energy transformations

$$E_{chem} \rightarrow U \rightarrow K \rightarrow E_{th}$$

The battery *supplies* energy at the rate

$$P_{bat} = I\mathcal{E}$$

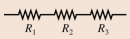
The resistors *dissipate* energy at the rate

$$P_R = I\Delta V_R = I^2R = \frac{(\Delta V_R)^2}{R}$$

Review: The **big ideas** of Chapter 32

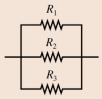
Series resistors

$$R_{eq} = R_1 + R_2 + R_3 + \cdots$$



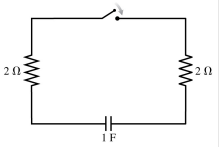
Parallel resistors

$$R_{eq} = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots\right)^{-1}$$



Chapter 32 Review Question.

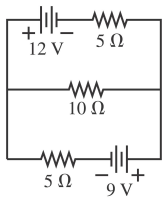
The time constant for the discharge of this capacitor is



A. 5 s.
B. 1 s.
C. 2 s.
D. 4 s.
E. The capacitor doesn't discharge because the resistors cancel each other.

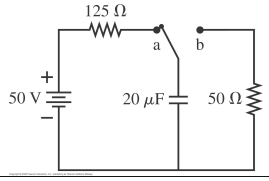
E.O.C. Suggested Problem 32.65

- What is the current through the 10 Ω resistor? Is the current from left to right or right to left?



E.O.C. Suggested Problem 32.75

- The switch in the figure has been in position **a** for a very long time. It is suddenly flipped to position **b** for 1.25 ms, then back to **a**. How much energy is dissipated by the 50 Ω resistor?



Review for test tomorrow: Ch. 26

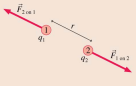
Coulomb's Law

The forces between two charged particles q_1 and q_2 separated by distance r are

$$F_{1\text{ on }2} = F_{2\text{ on }1} = \frac{K|q_1||q_2|}{r^2}$$

These forces are an action/reaction pair directed along the line joining the particles.

- The forces are repulsive for two like charges, attractive for two opposite charges.
- The net force on a charge is the sum of the forces from all other charges.
- The unit of charge is the coulomb (C).
- The electrostatic constant is $K = 9.0 \times 10^9\ \text{N m}^2/\text{C}^2$.

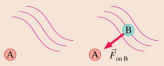


Review for test tomorrow: Ch. 26

The Field Model

Charges interact with each other via the electric field $\vec{E}$.

- Charge A alters the space around it by creating an electric field.



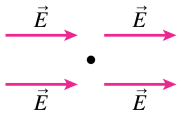
- The field is the agent that exerts a force. The force on charge q_B is $\vec{F}_{\text{on B}} = q_B\vec{E}$.

An electric field is identified and measured in terms of the force on a **probe charge** q:

$$\vec{E} = \vec{F}_{\text{on } q}/q$$

Chapter 26 Review Question.

An electron is placed at the position marked by the dot. The force on the electron is



A. to the right.
B. to the left.
C. zero.
D. There's not enough information to tell.

Sources of $\vec{E}$ Ch. 27

Electric fields are created by charges.

Two major tools for calculating $\vec{E}$ are

- The field of a point charge:

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r}$$

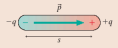
- The principle of superposition

Multiple point charges

Use superposition: $\vec{E} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + \cdots$

Review for test tomorrow: Ch. 27

Electric dipole



The electric dipole moment is

$\vec{p} = (qs$, from negative to positive$)$

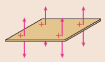
Field on axis: $\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{p}}{r^3}$

Field in bisecting plane: $\vec{E} = -\frac{1}{4\pi\epsilon_0}\frac{\vec{p}}{r^3}$

Infinite line of charge with linear charge density λ

$\vec{E} = \left(\frac{1}{4\pi\epsilon_0}\frac{2\lambda}{r}$, perpendicular to line$\right)$

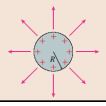
Infinite plane of charge with surface charge density η



$\vec{E} = \left(\frac{\eta}{2\epsilon_0}$, perpendicular to plane$\right)$

Sphere of charge

Same as a point charge Q for $r > R$



Review for test tomorrow: Ch. 29

Consequences of V

A charged particle has potential energy

$$U = qV$$

at a point where source charges have created an electric potential V.

The electric force is a conservative force, so the mechanical energy is conserved for a charged particle in an electric potential:

$$K_f + U_f = K_i + U_i$$

The potential energy of **two point charges** separated by distance r is

$$U_{q_1+q_2} = \frac{Kq_1q_2}{r} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r}$$

The **zero point** of potential and potential energy is chosen to be convenient. For point charges, we let $U = 0$ when $r \to \infty$.

The potential energy in an electric field of an **electric dipole** with dipole moment $\vec{p}$ is

$$U_{\text{dipole}} = -pE\cos\theta = -\vec{p}\cdot\vec{E}$$

Review for test tomorrow: Ch. 29

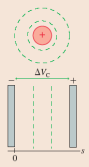
Sphere of charge Q

Same as a point charge if $r \geq R$

Parallel-plate capacitor

$V = Es$, where s is measured from the negative plate. The electric field inside is

$$E = \frac{\Delta V_C}{d}$$

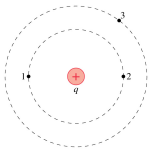


Units

Electric potential: 1 V = 1 J/C
Electric field: 1 V/m = 1 N/C

Chapter 29 Review Question.

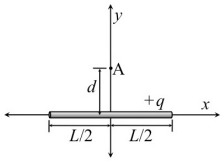
Rank in order, from largest to smallest, the potential differences ΔV_{12}, ΔV_{13}, and ΔV_{23} between points 1 and 2, points 1 and 3, and points 2 and 3.



A. $\Delta V_{13} > \Delta V_{12} > \Delta V_{23}$
B. $\Delta V_{13} = \Delta V_{23} > \Delta V_{12}$
C. $\Delta V_{13} > \Delta V_{23} > \Delta V_{12}$
D. $\Delta V_{12} > \Delta V_{13} = \Delta V_{23}$
E. $\Delta V_{23} > \Delta V_{12} > \Delta V_{13}$

MasteringPhysics Problem Set 5, "Potential of a Finite Rod" (Ch. 29 Material)

- A finite rod of length L has total charge q, distributed uniformly along its length. What is V_A, the electric potential at point A, located a distance d above the midpoint of the rod on the y-axis?

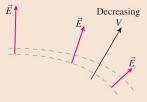


Review for test tomorrow: Ch. 30

The Geometry of Potential and Field

The electric field

- Is perpendicular to the equipotential surfaces.
- Points "downhill" in the direction of decreasing V.
- Is inversely proportional to the spacing Δs between the equipotential surfaces.

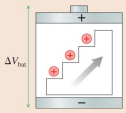


Review for test tomorrow: Ch. 30

A **battery** is a source of potential. The charge escalator in a battery uses chemical reactions to move charges from the negative terminal to the positive terminal:

$$\Delta V_{bat} = \mathcal{E}$$

where the emf $\mathcal{E}$ is the work per charge done by the charge escalator.

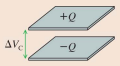


Review for test tomorrow: Ch. 30

Capacitors

The **capacitance** of two conductors charged to $\pm Q$ is

$$C = \frac{Q}{\Delta V_C}$$



A parallel-plate capacitor has

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

Filling the space between the plates with a dielectric of dielectric constant κ increases the capacitance to $C = \kappa C_0$

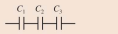
The energy stored in a capacitor is $u_C = \frac{1}{2}C(\Delta V_C)^2$

This energy is stored in the electric field at density $u_E = \frac{1}{2}\epsilon_0 E^2$.

Review for test tomorrow: Ch. 30

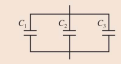
Combinations of capacitors

Series capacitors



$$C_{eq} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots\right)^{-1}$$

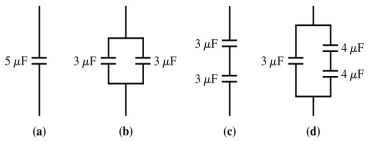
Parallel capacitors



$$C_{eq} = C_1 + C_2 + C_3 + \cdots$$

Chapter 30 Review Question.

Which of the circuit elements below has the largest equivalent capacitance?



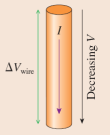
Review for test tomorrow: Ch. 31

The electric field causes a current

$$I = \frac{\Delta V_{wire}}{R}$$

where $R = \frac{\rho L}{A}$ is the wire's **resistance.**

This is **Ohm's law.**

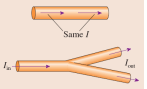


Conservation of Current

The current is the same at any two points in a wire.
At a junction,

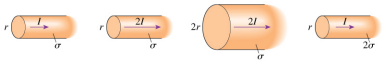
$$\sum I_{in} = \sum I_{out}$$

This is **Kirchhoff's junction law.**



Chapter 31 Review Question.

Which of the four wires below carries the highest current density, J?



- Test 2 will cover material from chapters 26, 27, 29, 30, 31 and 32
- Questions will be similar to
  - MasteringPhysics
  - Practicals Activities and discussion questions
  - End-of-Chapter suggested problems
  - In-class clicker questions
  - Examples from your reading
- Don't forget your calculator and one 8.5x11" aid sheet, which may be double-sided.

See you Tuesday Evening at 6:00 in **SF 3201.**