# Physics 212

Exam 2 Study Guide

## 1 Capacitors

### 1.1 Main Concepts

- Capacitors in series have the same current.
- The formula for total capacitance in series is $\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2}$ i
- Capacitors in parallel have the same voltage.
- The formula for total capacitance in parallel is $C_{12} = C_1 + C_2$

## 2 Electric Current

### 2.1 Main Concepts

- The resistance of a resistor is calculated by $R = \frac{L}{\sigma A}$
- R = Resistance, L = length, A = Cross-sectional Area, $\sigma$ = Resistivity.
- Resistors in series have the same current.
- The formula for total resistance in series is $R_{12} = R_1 + R_2$
- Resistors in parallel have the same voltage/
- The formula for total resistance in parallel is $\frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2}$
- Ohm's Law is V=IR
- $J = \sigma E$
- J is current density at a location, $\sigma$ is conductivity, E is electric field at that location
- Electric Current is $I = \frac{dq}{dt}$
- $P = IV$
- P = Power, I = Current, V = Voltage

# 3 Kirchoff's Rules

## 3.1 Main Concepts

- Kirchoff's Voltage Law, In a closed loop $\Sigma \Delta V_n = 0$
- Kirchoff's Current Law, at any node $\Sigma I_{in} = \Sigma I_{out}$

# 4 RC Circuits

## 4.1 Main Concepts

- Resistors will cause capacitance to slowly gain voltage and slowly lose voltage once unplugged.
- Discharging Charge: $Q_0 e^{-\frac{t}{RC}}$
- Charging Charge: $Q_{/infty} 1 - e^{-\frac{t}{RC}}$
- Discharging Current: $I_0 e^{-\frac{t}{RC}}$
- Charging Current: $I_0 e^{\frac{-t}{RC}}$
- Discharging Voltage: $V_0 e^{-\frac{t}{RC}}$
- Charging Voltage: $V_\infty (1 - e^{-\frac{t}{RC}})$

## 4.2 Proof of Charge relationship

$$
\begin{aligned}
\Sigma V &= 0 \\
V_r + V_c &= 0 \\
\frac{dQ}{dt} R &= -\frac{Q}{C} \\
\frac{1}{Q} R dQ R &= -\frac{1}{C} dt \\
\int_0^{final} \frac{R}{Q} dQ &= -\int \frac{1}{c} dt \\
R \ln \frac{Q_{final}}{Q_0} &= -\frac{t}{c} \\
\ln \frac{Q_{final}}{Q_0} &= -\frac{t}{RC} \\
\frac{Q_{final}}{Q_0} &= e^{-\frac{t}{RC}} \\
Q_{final} &= Q_0 e^{-\frac{t}{RC}}
\end{aligned}
$$

# 5 Magnetism

## 5.1 Main Concepts

- Magnetic fields create electric Currents
- Magnetic Fields exert forces on electric currents (the charges in motion)
- $\vec{F} = q\vec{v}x\vec{B}$
- Force on a particle = the charge of particle multiplied by the cross product of its velocity and the magnetic field
- Right hand rule! Index finger is v, other is B, thumb is F!

# 6 Forces and Torques on Currents

## 6.1 Main Concepts

- $\vec{F} = I\vec{L}x\vec{B}$
- F = Force, I = current, L = length, B = Magnetic field
- $\vec{\mu} = NI\vec{A}$
- $\mu$ = Dipole moment N = num of coils, I = current A = Area
- $\vec{\tau} = \vec{\mu}x\vec{B}$
- $\tau$ = Torque, $\mu$ = Magnetic Dipole Moment, B = Magnetic Field
- $\Delta U = -\vec{\mu} \cdot \vec{B}$

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# 7 Biot-Savart Law

## 7.1 Main Concepts

- $\vec{dB} = \frac{\mu_0 I}{4\pi} \frac{\vec{ds}x\vec{r}}{r^2}$
- nfinite Line : $B = \frac{\mu_0 I}{2\pi r}$
- Current Loop: $B = \frac{\mu_0 I}{2} \frac{R^2}{(R^2+z^2)^{\frac{3}{2}}}$
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# 8 Ampere's Law

## 8.1 Main Concepts

- $\int \vec{B} \cdot \vec{dl} = \mu_0 I_{enclosed}$
- For a solenoid: $B = \frac{\mu_0 n I}{2}$

# 9 Motional EMF

## 9.1 Main Concepts

- $\vec{F} = q\vec{v} = \vec{B}$

# 10 Faraday's Law

## 10.1 Main Concepts

- $\Phi = \int \vec{B} \cdot \vec{dA}$
- $\varepsilon = -\frac{d\Phi}{dt} = \int \vec{E} \cdot \vec{dl}$