
These are your formula sheets

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Derivatives:

$$\frac{d}{dx} ax^n = anx^{n-1}$$

$$\frac{d}{dx} \sin ax = a \cos ax$$

$$\frac{d}{dx} \cos ax = -a \sin ax$$

$$\frac{d}{dx} e^{ax} = ae^{ax}$$

$$\frac{d}{dx} \ln ax = \frac{1}{x}$$

Integrals:

$$\int ax^n dx = a \frac{x^{n+1}}{n+1}$$

$$\int \frac{dx}{x} = \ln x$$

$$\int \sin ax dx = -\frac{1}{a} \cos ax$$

$$\int \cos ax dx = \frac{1}{a} \sin ax$$

$$\int e^{ax} dx = \frac{1}{a} e^{ax}$$

$$\int \frac{dx}{\sqrt{a^2 - x^2}} = \arcsin \frac{x}{a}$$

$$\int \frac{dx}{\sqrt{x^2 + a^2}} = \ln \left(\sqrt{x^2 + a^2} + x \right)$$

$$\int \frac{dx}{x^2 + a^2} = \frac{1}{a} \arctan \frac{x}{a}$$

$$\int \frac{dx}{(x^2 + a^2)^{3/2}} = \frac{1}{a^2} \frac{x}{\sqrt{x^2 + a^2}}$$

$$\int \frac{x dx}{(x^2 + a^2)^{3/2}} = -\frac{1}{\sqrt{x^2 + a^2}}$$

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Physics 208 — Formula Sheet for Exam 3

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Forces:

The force on a charge q moving with velocity \vec{v} in a magnetic field \vec{B} is

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

and the force on a differential segment $d\vec{l}$ carrying current I is

$$d\vec{F} = I d\vec{l} \times \vec{B}$$

Magnetic Flux:

Magnetic flux is defined analogously to electric flux (see formula sheet 1)

$$\Phi_B = \int \vec{B} \cdot d\vec{A}$$

The magnetic flux through a closed surface seems to be zero

$$\oint \vec{B} \cdot d\vec{A} = 0$$

Magnetic dipoles:

A current loop creates a magnetic dipole $\vec{\mu} = I\vec{A}$ where I is the current in the loop and \vec{A} is a vector normal to the plane of the loop and equal to the area of the loop. The torque on a magnetic dipole in a magnetic field is

$$\vec{\tau} = \vec{\mu} \times \vec{B}$$

Biot-Savart Law:

The magnetic field $d\vec{B}$ produced at point P by a differential segment $d\vec{l}$ carrying current I is

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \hat{r}}{r^2}$$

where \hat{r} points from the segment $d\vec{l}$ to the point P .

Magnetic field produced by a moving charge:

Similarly, the magnetic field produced at a point P by a moving charge is

$$\vec{B} = \frac{\mu_0}{4\pi} \frac{q \vec{v} \times \hat{r}}{r^2}$$

Ampere's Law: (without displacement current)

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{enc}}$$

Faraday's Law:

The EMF produced in a closed loop depends on the change of the magnetic flux through the loop

$$\mathcal{E} = -\frac{d\Phi_B}{dt}$$

When an EMF is produced by a changing magnetic flux there is an induced, nonconservative, electric field \vec{E} such that

$$\oint \vec{E} \cdot d\vec{l} = -\frac{d}{dt} \int_A \vec{B} \cdot d\vec{A}$$

Mutual Inductance:

When a changing current i_1 in circuit 1 causes a changing magnetic flux in circuit 2, and vice-versa, the induced EMF in the circuits is

$$\mathcal{E}_2 = -M \frac{di_1}{dt} \quad \text{and} \quad \mathcal{E}_1 = -M \frac{di_2}{dt}$$

where M is the *mutual inductance* of the two loops

$$M = \frac{N_2 \Phi_{B2}}{i_1} = \frac{N_1 \Phi_{B1}}{i_1}$$

where N_i is the number of loops in circuit i .

Self Inductance:

A changing current i in any circuit generates a changing magnetic field that induces an EMF in the circuit:

$$\mathcal{E} = -L \frac{di}{dt}$$

where L is the *self inductance* of the circuit

$$L = N \frac{\Phi_B}{i}$$

For example, for a solenoid of N turns, length l , area A , Ampere's law gives $B = \mu_0(N/l)i$, so the flux is $\Phi_B = \mu_0(N/l)iA$, and so

$$L = \mu_0 \frac{N^2}{l} A$$

LR Circuits:

When an inductor L and a resistance R appear in a simple circuit, exponential energizing and de-energizing time dependences are found that are analogous to those found for RC -circuits. The time constant τ for energizing an LR circuit is

$$\tau = \frac{L}{R}$$

LC Circuits:

When an inductor L and a capacitor C appear in a simple circuit, sinusoidal current oscillation is found with frequency f such that

$$2\pi f = \frac{1}{\sqrt{LC}}$$

Physics 208 — Formula Sheet for Exam 2

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Capacitance:

A capacitor is any pair of conductors separated by an insulating material. When the conductors have equal and opposite charges Q and the potential difference between the two conductors is V_{ab} , then the definition of the capacitance of the two conductors is

$$C = \frac{Q}{V_{ab}}$$

The energy stored in the electric field is

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

If the capacitor is made from parallel plates of area A separated by a distance d , where the size of the plates is much greater than d , then the capacitance is given by

$$C = \epsilon_0 A/d$$

Capacitors in series:

$$\frac{1}{C_{\text{eq}}} = \frac{1}{C_1} + \frac{1}{C_2} + \dots$$

Capacitors in parallel:

$$C_{\text{eq}} = C_1 + C_2 + \dots$$

If a dielectric material is inserted, then the capacitance increases by a factor of K where K is the dielectric constant of the material

$$C = KC_0$$

Current:

When current flows in a conductor, we define the current as the rate at which charge passes:

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

We define the current density as the current per unit area, and can relate it to the drift velocity of charge carriers by

$$\vec{J} = nq\vec{v}_d$$

where n is the number density of charges and q is the charge of one charge carrier.

Ohm's Law and Resistance:

Ohm's Law states that a current density J in a material is proportional to the electric field E . The ratio $\rho = E/J$ is called the *resistivity* of the material. For a conductor

with cylindrical cross section, with area A and length L , the *resistance* R of the conductor is

$$R = \frac{\rho L}{A}$$

A current I flowing through the resistor R produces a potential difference V given by

$$V = IR$$

Resistors in series:

$$R_{\text{eq}} = R_1 + R_2 + \dots$$

Resistors in parallel:

$$\frac{1}{R_{\text{eq}}} = \frac{1}{R_1} + \frac{1}{R_2} + \dots$$

Power:

The power transferred to a component in a circuit by a current I is

$$P = VI$$

where V is the potential difference across the component.

Kirchhoff's rules:

The algebraic sum of the currents into any junction must be zero:

$$\sum I = 0$$

The algebraic sum of the potential differences around any loop must be zero.

$$\sum V = 0$$

RC Circuits:

When a capacitor C is charged by a battery with EMF given by \mathcal{E} in series with a resistor R , the charge on the capacitor is

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

where $t = 0$ is when the the charging starts.

When a capacitor C that is initially charged with charge Q_0 discharges through a resistor R , the charge on the capacitor is

$$q(t) = Q_0 e^{-t/RC}$$

where $t = 0$ is when the the discharging starts.