Things you must know

Relationship between electric field and electric force
Relationship between magnetic field and magnetic force
Electric field of a point charge
Magnetic field of a moving point charge
Conservation of charge
The Superposition Principle

Other Fundamental Concepts

$\Delta U_{el} = q\Delta V$

$\Delta V = -\int_i^f \vec{E} \bullet d\vec{l} \approx -\sum \left(E_x \Delta x + E_y \Delta y + E_z \Delta z\right)$

Specific Results

$\vec{E}$ due to uniformly charged spherical shell: *outside* like point charge; *inside* zero

$\left|\vec{E}_{dipole,axis}\right| \approx \frac{1}{4\pi\epsilon_0}\frac{2qs}{r^3}$ (on axis, $r \gg s$)

$\left|\vec{E}_{dipole,\perp}\right| \approx \frac{1}{4\pi\epsilon_0}\frac{qs}{r^3}$ (on $\perp$ axis, $r \gg s$)

$\left|\vec{E}_{rod}\right| = \frac{1}{4\pi\epsilon_0}\frac{Q}{r\sqrt{r^2+(L/2)^2}}$ ($r \perp$ from center)

$p = qs$ electric dipole moment ($p = \alpha E$)

$\left|\vec{E}_{rod}\right| \approx \frac{1}{4\pi\epsilon_0}\frac{2Q/L}{r}$ (if $r \ll L$)

$\left|\vec{E}_{ring}\right| = \frac{1}{4\pi\epsilon_0}\frac{qz}{(z^2+R^2)^{3/2}}$ (z along axis)

$\left|\vec{E}_{disk}\right| = \frac{Q/A}{2\epsilon_0}\left[1 - \frac{z}{(z^2+R^2)^{1/2}}\right]$ (z along axis)

$\left|\vec{E}_{disk}\right| \approx \frac{Q/A}{2\epsilon_0}\left[1 - \frac{z}{R}\right] \approx \frac{Q/A}{2\epsilon_0}$ (if $z \ll R$)

$\left|\vec{E}_{capacitor}\right| \approx \frac{Q/A}{\epsilon_0}$ ($+Q$ and $-Q$ disks)

$\left|\vec{E}_{fringe}\right| \approx \frac{Q/A}{\epsilon_0}\left(\frac{s}{2R}\right)$ just outside capacitor

$\Delta\vec{B} = \frac{\mu_0}{4\pi}\frac{I\Delta\vec{l}\times\vec{r}}{r^2}$ (short wire)

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

$\left|\vec{B}_{wire}\right| = \frac{\mu_0}{4\pi}\frac{LI}{r\sqrt{r^2+(L/2)^2}} \approx \frac{\mu_0}{4\pi}\frac{2I}{r}$ ($r \ll L$)

$\left|\vec{B}_{loop}\right| = \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{(z^2+R^2)^{3/2}} \approx \frac{\mu_0}{4\pi}\frac{2I\pi R^2}{z^3}$ (on axis, $z \gg R$)

$\mu = IA = I\pi R^2$

$\left|\vec{B}_{dipole,axis}\right| \approx \frac{\mu_0}{4\pi}\frac{2\mu}{r^3}$ (on axis, $r \gg s$)

$\left|\vec{B}_{dipole,\perp}\right| \approx \frac{\mu_0}{4\pi}\frac{\mu}{r^3}$ (on $\perp$ axis, $r \gg s$)

$i = nA\bar{v}$

$I = |q|\, nA\bar{v}$

$\bar{v} = uE$

$\sigma = |q|\, nu$

$J = \frac{I}{A} = \sigma E$

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

$E_{dielectric} = \frac{E_{applied}}{K}$

$\Delta V = \frac{q}{4\pi\epsilon_0}\left[\frac{1}{r_f} - \frac{1}{r_i}\right]$ due to a point charge

$Q = C\,|\Delta V|$

Power $= I\Delta V$

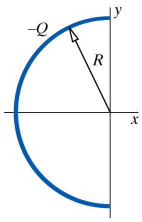
$I = \frac{|\Delta V|}{R}$ (ohmic resistor)

$K \approx \frac{1}{2}mv^2$ if $v \ll c$

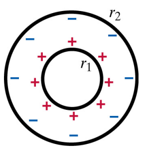
circular motion: $\left|\frac{d\vec{p}}{dt}_\perp\right| = \frac{|\vec{v}|}{R}\,|\vec{p}| \approx \frac{mv^2}{R}$

Constant	Symbol	Approximate Value
Speed of light	c	3×10^8 m/s
Gravitational constant	G	$6.7 \times 10^{-11}\ \mathrm{N \cdot m^2/kg^2}$
Approx. grav field near Earth's surface	g	9.8 N/kg
Electron mass	m_e	9×10^{-31} kg
Proton mass	m_p	1.7×10^{-27} kg
Neutron mass	m_n	1.7×10^{-27} kg
Electric constant	$\frac{1}{4\pi\epsilon_0}$	$9 \times 10^9\ \mathrm{N \cdot m^2/C^2}$
Epsilon-zero	ϵ_0	$8.85 \times 10^{-12}\ \mathrm{N \cdot m^2/C^2}$
Magnetic constant	$\frac{\mu_0}{4\pi}$	$1 \times 10^{-7}\ \mathrm{T \cdot m/A}$
Mu-zero	μ_0	$4\pi \times 10^{-7}\ \mathrm{T \cdot m/A}$
Proton charge	e	1.6×10^{-19} C
Electron volt	1 eV	1.6×10^{-19} J
Avogadro's number	N_A	6.02×10^{23} molecules/mole
Atomic radius	R_a	$\approx 1 \times 10^{-10}$ m
Proton radius	R_p	$\approx 1 \times 10^{-15}$ m
E to ionize air	E_{ionize}	$\approx 3 \times 10^6$ V/m
B_{Earth} (horizontal component)	B_{Earth}	$\approx 2 \times 10^{-5}$ T

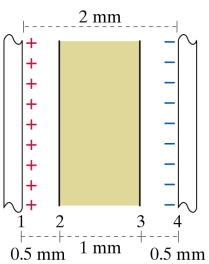
1. Consider a thin plastic rod bent into a semicircular arc of radius R with center at the origin. The rod carries a uniformly distributed negative charge $-Q$. Fine the electric potential (V) and the electric field $\mathbf{E}$ at the center contributed by the rod.



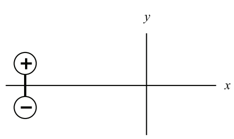
2. Use $Q = C|\Delta V|$ to find the capacitance of a spherical capacitor consists of a spherical metal shell of radius r_1 with a charge Q surrounded by a concentric spherical metal shell of radius r_2 with a charge $-Q$.



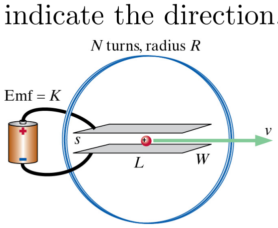
3. An isolated large-plate capacitor originally has a potential difference of 1000 V with an air gap of 2 mm. A plastic slab 1 mm thick, with dielectric constant 5 is inserted into the middle of the air gap as shown in the figure. What is $V_4 - V_1$?



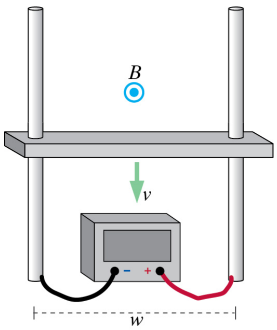
4. The center of the dipole shown in the diagram is at location $\langle -r, 0, 0\rangle$, and the distance between the two charges of the dipole is s. The magnitude of the charge of each end of the dipole is q. Assuming $r \gg s$, what is the electric field at the origin due to the dipole?



5. A battery with know emf $= K$ is connected to two large parallel metal plates. Each plate has a length L and width W, and the plates are a very short distance s apart. The plates are surrounded by a vertical thin circular coil of radius R containing N turns through which runs a steady conventional current I. The center of the coil is at the center of the gap between the plates. At a certain instant, a proton (charge $+e$, mass M) travels through the center of the coil to the right with speed v, and the net force on the proton at this instant is zero (neglecting gravitational force). What are the magnitude and direction of the conventional current in the coil? Draw a circle arrow (↻, ↺) to indicate the direction.



6. At a certain instant a horizontal metal bar h above a table is falling downward with speed v. There is good electrical contact along two vertical metal bars that are w apart. Throughout this region there is a uniform horizontal magnetic field out of the plane of the page made by large coils that are not shown. At this instant, what is the reading on the voltmeter? Remember that a voltmeter gives a positive reading if the lead labeled "+" is connected to the higher potential location.



7. In the circuit shown below, the emf of the battery is 7.4 V. Resister R_1 has a resistance of 31 Ω, resister R_2 has a resistance of 47 Ω, and resistor R_3 has a resistance of 52 Ω. A steady current flows through the circuit. (a) What is the equivalent resistance of all three resistors? (b) What is the current through R_3?