

Phil's Orderly Physics Curriculum Important Concepts List (POPCICL) - 1B - Interactive

[Warning : This list is not intended to be comprehensive, but rather to highlight a few key concepts]

Charge & Electric Force

There are only two types of charges : _____ and _____.

Opposite charges _____ each other. Like charges _____ each other.

With the exception of _____, all neutral objects are made of _____.

A special characteristic of charge is that it is _____ (similar to energy and momentum).

Charge is _____. The smallest possible isolated charge is _____.

The unit of charge is the _____. An electron has a charge of _____.

A(n) _____ is a material in which many of the charges are free to move throughout the material.

A(n) _____ is a material in which the charges are not free to move throughout the material.

The electric force between two charged particle is described by _____ Law : _____.

The electric force between two particles acts along _____ {what direction?}.

The strength of the electric force falls off {linearly / quadratically} with distance.

The electric force obeys the _____ principle. The net electric force on a charged particle due to a collection of charges is the _____ of the electric forces between the charged particle and every other charge, taken one pair at a time.

Electric Field

Electric force can be viewed as a two-step process: A source charge produces a(n) _____ that permeates space, and a test charge some distance away experiences a _____ due to that _____.

The electric field at some distance, r , from a charge Q is given by _____ {formula}.

The electric field is a map of the _____ that would be experienced by a _____ placed at any location.

The electric field is a vector quantity with the units of _____.

The electric field points away from _____ charges and towards _____ charges.

The electric field is the electric force on a test charge divided by _____ : _____ {formula}.

The electric field obeys the _____ principle. The net electric field due a collection of charges is the _____ of the electric fields due to the individual charges considered _____.

Electric fields are visualized by electric field lines that originate on _____ charges (or at ∞ , for a single isolated _____ charge) and terminate on _____ charges (or at ∞ , for a single isolated _____ charge).

The number of electric field lines that originate/terminate on a particle is proportional to its _____.

The _____ of electric field lines is proportional to the local magnitude of the electric field

The tangent to the electric field lines represents the local _____ of the electric field.

Electric field lines can never _____. The direction of the electric force is unique at each point.

The electric field above a uniform, infinite plane of charge points _____.

The electric field due to a uniform, infinite filament of charge points _____.

The electric field due to a uniform sphere or uniform spherical shell of charge points _____.

If a charged particle of mass, m , and charge, q_0 , is place in an electric field, E , it will experience an acceleration given by _____ law : _____ {formula}

Electric Flux

Electric flux is a measure of the _____ component of the electric field passing through a _____.

Electric flux is proportional to the _____ of electric field lines that cross a surface.

Electric flux depends on the magnitude of the _____, and the _____ and _____ of the surface.
_____ {formula}.

The area vector of a surface has a magnitude equal to _____ and a direction that is _____ to the surface. The area vector points _____ for closed surfaces.

Gauss's Law states that the electric flux through any _____ surface is equal to the _____ (divided by the constant, ϵ_0). _____ {formula}

For charge distribution with sufficient symmetry (infinite plane or filament, sphere, or spherical shell), you can equate combine _____ with the definition of flux to determine the electric field at a particular location relative to the charge distribution. _____ {formula(s)}

Electrostatic Equilibrium

In steady state, the electric field is _____ everywhere inside of a solid or hollow conductor

In steady state, any excess charge (positive or negative) on a conductor will reside _____.

In steady state, the electric field immediately outside a conductor is _____ to the local surface.

In steady state, excess charge density on the surface of an irregularly-shaped conductor will be _____ at edges, sharp points, or tightly curved corners. The electric field outside the conductor will be _____ around these sharp regions of high charge density.

Electric Potential Energy & Electric Potential

A pair of charges has an electric P.E. that is _____ proportional to their _____.

Potential energy can be thought of as the potential to _____ by converting it from the energy stored in _____.

Two unlike charges have the greatest potential energy when they are very _____.

Two like charges have the greatest potential energy when they are very _____.

Electric potential (voltage) can be thought of as a map of the _____ that would be experienced by a standard _____ test charge if it were placed at any location relative to other charges.

Electric potential (voltage) is a _____ quantity. The voltage due to multiple charges is the _____ sum of the electric potential (voltage) due to each charge individually.

When a test charge moves from a position at one electric potential (voltage) to another, its change in electric potential energy is given by : _____ (formula)

The electric potential energy is analogous to _____ in the analogy to gravity.

The electric potential (voltage) is analogous to _____ in the analogy to gravity.

The electric field is analogous to the _____ in the analogy to gravity : _____ (E vs V formula)

Equipotential lines indicate regions that are at the same value of _____ - they are analogous to _____ on a geographic contour map.

The electric potential nearby a positive point charge is a _____ value and it _____ as you move infinitely far away from the positive point charge.

The electric potential nearby a negative point charge is a _____ value and it _____ as you move infinitely far away from the negative point charge.

Capacitors

A capacitor is a device that stores energy in the form of a(n) _____ between two separated _____.

Capacitance is a measure of _____ per _____. That is, the capacitance of a capacitor is the amount of _____ that can be stored when a particular _____ is applied across its two conductors (plates).

Capacitance is measured in units of _____, or more typically micro _____, nano _____, or pico _____.

A vacuum-filled _____ capacitor is the simplest example of a capacitor consisting of two plates of area _____ separated by a gap of width d . Its capacitance is given by _____ (formula).

There are three ways to increase the capacitance of a parallel plate capacitor : (1) increase the plate _____, (2) decrease the plate _____, (3) insert a(n) _____ inside the gap with high _____, _____ > 1.

Capacitors in parallel must have the same _____.

Capacitors in parallel can be replaced by a parallel equivalent capacitor whose value is given by : _____ (formula)

The {charge on / voltage across} the parallel equivalent equals the sum of those {on/across} the capacitors that it replaces.

Capacitors in series must have the same _____.

Capacitors in series can be replaced by a series equivalent capacitor whose value is given by : _____ (formula)

The {charge on / voltage across} the series equivalent equals the sum of those {on/across} the capacitors that it replaces.

The _____ is a property of an insulator that describe how much it increases the capacitance of a capacitor when inserted between the plates.

The _____ is a property of an insulator that describes how strong of a(n) _____ that it can withstand before the material "breaks down" and becomes conducting. (a lightning strike occurs across it).

Electrical Current & Resistance

An electric current in a conductor is equal to the amount of _____ that passes through a cross-sectional area of the conductor in a given _____.

The SI unit for current is the _____ which is equal to 1 _____ per _____.

Microscopically, the average velocity of an electron in the direction of the current is called the _____, which is typically {very slow / equal to / very fast} (compared to) the speed of an electrical signal in a circuit.

Electrical resistance, R , is a measure of how much a circuit element reduces _____ through the circuit. Resistance on an element depends on both _____ and _____ effects.

Electrical resistivity depends only on the _____ and its _____.

Electrical resistivity generally {increase/decreases} with temperature. The _____ is a material-dependent property that describes the rate of change in resistivity with increasing temperature.

Electrical _____ is the inverse of electrical resistivity ($\rho = 1/\rho$).

A _____ is a circuit element that provides electrical resistance in a circuit.

If two or more resistors are connected in a single line with only simple wires (with no junctions) between them, then they are said to be connected in _____.

Two or more resistors in series have an equivalent resistance given by : _____ (formula), and will be {larger / smaller} than any of the individual resistances.

If two or more resistors are connected so that the front (top) end of each resistor is connected to each other only by wires (through wire junctions) and the back (bottom) end of each resistor is connected to each other only by wires (through wire junctions), then they are said to be connected in _____.

Two or more resistors in parallel have an equivalent resistance given by _____ (formula), and will be {larger / smaller} than any of the individual resistances.

Batteries and Electric Circuits

Ohm's Law describes the a linear relationship between the _____, _____, and _____ in a circuit: _____ (formula) _____. An _____ material is one that obey's Ohm's Law.

An electrical circuit can be driven by an _____ that provides the “push” on electrical charges so that they flow as current through the circuit.

An ideal voltage source is described by an _____ that serves as an “enforcer of voltage”. An ideal _____ will provide whatever current is necessary to maintain its rated voltage difference across it.

A real battery can be visualized an ideal EMF in series with a(n) _____. The terminal voltage of a battery is taken across its _____ an includes the effect of its _____.

Because of its non-zero internal resistance, the terminal voltage of a real battery will be _____ to the ideal EMF, depending on the _____ (the effective resistance of the circuit to which it is attached).

The power associated with a circuit element may be calculated by the relationship : _____ (formula) _____.

Power has the units of energy per time. The SI unit of Power is Watts. 1 Watt = 1 Joule / sec.

Circuits involving multiple voltage sources can be solved using _____ Rules.

Kirchhoff's _____ Rule states that at any wire junction, the sum of the _____ must equal zero. That is, the total _____ into the junction must equal to the total _____ out of the junction.

Kirchhoff's _____ Rule states that around any _____, the sum of the _____ must equal zero. To apply this rule, you must first (arbitrarily) choose a proposed direction for the current through each element and (arbitrarily) choose a direction (CW or CCW) for each loop.

Kirchhoff's _____ Rule; when the loop runs in the same direction as the current, then a battery or EMF provides a(n) {increase/decrease} in voltage while a resistor provides a(n) {increase/decrease} in voltage. When the loop runs in the opposite direction of the current, then the reverse is true.

An RC circuit combines a resistor and a capacitor in a single circuit and introduces a characteristic _____ to the circuit. The characteristic _____ of an RC circuit is given by (formula) and has the units of _____.

When an EMF is connected to a series RC circuit, the current through the resistor is initially {large/small} but the charge on the capacitor is initially {large/small} (_____ at the very first instant). As time progresses, the charge on the capacitor _____ as does the voltage across the capacitor; and as a result, the current through the resistor goes _____. Eventually, the capacitor reaches a maximum charge of $Q = \underline{\hspace{1cm}}$, the voltage across the capacitor becomes equal to that of the EMF source, \mathcal{E} , and the current through the resistor _____.

When a previously-charged capacitor is connected in a closed loop to a resistor, then capacitor will _____ through the resistor. Initially, the current through the resistor is {large/small}, but as time progresses, both the charge on the capacitor and the current through the resistor gradually _____.

The time-dependent behavior of RC circuits is characterized mathematically by _____ charging and discharging : {general formula form} _____, where $\tau = \underline{\hspace{1cm}}$.

Magnetic Forces & Fields

A magnetic field can be produced by _____ charges, such as the _____ in a wire.

The magnetic field lines that describe the magnetic field around a straight current-carrying wire form _____ centered on the wire and that _____ the wire in a direction given by the _____.

The current right-hand-rule states that if your point your _____ along the wire in the direction of the _____, your fingers will curl in the circulation direction of the _____.

The direction of the magnetic field at any point is _____ to the direction of the magnetic field line at that point.

Magnetic Forces & Fields (continued)

In the presence of a magnetic field, a moving charge will experience a magnetic force that is directed _____ to both the magnetic field and the instantaneous velocity vector of the particle. There are two possible directions for this _____ magnetic force (e.g., up/down, left/right, in/out, east/west, north/south). The appropriate choice between these two possible directions is given by the _____.

The force right-hand-rule dictates that you fully open your right hand and align your fingers with the direction of the _____ of the charged particle. You then roll your hand so that _____ appears to point straight out of your palm. You should now be able to use your fingertips to “push (rotate)” the _____ into the direction of the _____ by curling your fingers into a closed fist. In this orientation, your outstretched thumb will point in the direction of the magnetic force on a moving _____ charge. If the actual charge of the particle is negative, simply _____.

The magnitude of the magnetic force on a moving charged particle is proportional to four quantities: (i) the _____ of the particle, (ii) the charge's _____, (iii) the magnitude of the _____, and (iv) the _____ of the angle between the _____ vector and the _____ vector.

A charged particle moving _____ or _____ to a magnetic field will experience no magnetic force. A charged particle moving _____ to a magnetic field will be deflected with the maximal force.

In a uniform magnetic field, B , a charged particle or mass, m , moving with velocity, v , perpendicular to the magnetic field will undergo _____ with a radius, r , found by equating the magnitude of the _____ force to the _____ force required for that particular _____ motion.

The sum of the _____ force and _____ force on a moving charged particle is called the Lorentz force. The electric force is (dependent/independent) of/on the charged particle's velocity, but the magnetic force is (dependent/independent) of/on the charged particle's velocity.

A region that contain both a magnetic field and an electric field oriented perpendicular to each other, can act as a _____ for particles injected _____ to both fields.

A mass spectrometer utilizes a velocity selector followed by the _____ motion of a particle in a magnetic field to separate charged molecules and atoms based on the _____ ratio.

A current-carrying wire in a magnetic field will experience a force on the wire whose magnitude is proportional to four quantities: (i) the _____ (ii) the _____ of the wire exposed to the field, (iii) the magnitude of the _____, and (iv) the sine of the angle between the directions of the _____ and the _____.

For a loop of current, the magnetic field inside the loop due the current will _____ direction, but is (uniform? non-uniform? straight? divergent?)

We can associate a “magnetic moment” vector, (μ vector) with a current loop which has a magnitude proportional to the _____ and the _____, and whose direction is given by the right-hand-rule. (curl your right fingers in the _____; your outstretched thumb aligns with the _____)

An (infinitely) long, tightly wound spiral of current is called an (ideal) _____. The _____ has a _____ magnetic field inside of it that is (what direction?).

A loop of current in an external magnetic field can experience a _____ that will cause it to (what will it do? and in what direction will it do it?) _____ (i.e., so that its _____ vector aligns with the _____)

Biot-Savart Law and Ampere's Law

The magnitude of the magnetic field due to a current can be found by two different methods : _____ law or _____ Law.

The Biot-Savart law gives us the _____ at a point, P, some distance, r, from an infinitesimal segment (ds) of a wire carrying a current, I.

We can find the total magnetic field due to any wire by _____ the contributions given by Biot-Savart's law along the _____.

Ampere's law allows us to easily calculate the magnetic field due to current-carrying wires if the wire configuration has sufficient _____, such as a _____, a _____, or a _____.

To apply Ampere's law, draw an imaginary amperian loop that _____ in a way that the magnetic field is known (by symmetry) to be _____ or _____ over different segments of the loop.