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 __________.

A charge {does / doesn't}experience its own electric field.

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 {parallel/perpendicular} to the surface. The area vector points {inward/outward} 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 {parallel/perpendicular} 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{directly / inversely} proportional to their {separation / separation-squared}.

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 {far apart / close together}.

Two like charges have the greatest potential energy when they are very {far apart / close together}.

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 {scalar / vector} quantity. The voltage due to multiple charges is the {vector / algebraic} 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 analagous 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 A separated by a gap of width d. Its capacitnce 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 (__= 1/ρ) .

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 = ___, 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 τ = ____.

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, (mu 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.

Faraday's Law and Inductance

Magnetic flux is a measure of the _____________ component of the _______ _______ passing through a surface area.

Magnetic flux is proportional to the number of _________ _________ _________ that cross a surface.

Magnetic flux depends on the magnitude of the _________ _________, and the _________ and _________ of the surface : _____(equation)_____.

Faraday's law of induction states that a(n) _________ is induced around any closed path through which there is a _________-varying _________ _________. The magnitude of the induced EMF is proportional to the rate of change of _________ _________ through the closed path : _____(equation)_____

_________'s law states that the direction of the induced _______ (and any resulting induced _______) will be oriented so as to _________ the change that induced them.

When a conductor moves with a component of its velocity ____________ to a magnetic field, magnetic forces will induce a _________ _________ that results in an EMF (called _________ EMF) across the conductor.

When a closed loop is rotated in a magnetic field so that the magnetic flux through the loop is ________________, then a _______-varying induced EMF will develop on the loop. This forms the basis of an _____ _________.

When a time-varying current flows in a __________, an induced EMF arises in it that _________ the change in the current. This phenomenon is called _____________ and forms the basis of devices called _________.

An inductor stores energy in the form of a _________ ________. The stored energy is ½ times the ______________ of the coil times the square of the ____________in/on the coil.

The (self)-inductance of a coil depends only on the _________ and _________ properties of the coil.

The S.I. unit for the (self)-inductance of a coil is the _________ : _____(unit defining relation)_______

A series RL circuit consists of a _________ and an _________ in series and has a characteristic _________ _________ that is equal to : _____(equation)_____.

When an RL circuit is first connected to a voltage source, a(n) __(supporting / opposing)__ induced EMF forms on the inductor that acts to _________ the __(rise / fall)__ of the _________ through the circuit.

When an RL circuit is first disconnected from an attached voltage source, a(n) _(supporting / opposing)_ induced EMF forms on the inductor that acts to _________ the __(rise / fall)__ of the _________ through the circuit.