Aircraft Powerplant Electrical Systems

AMT 109C
Course Outline

• Introduction – Outline
• Properties of Matter
• Review of DC theory
  – Circuits – series/parallel
  – Ohm’s, Kerchoff’s and Henry’s Laws
Course Outline

• Power Sources
  – Power storage devices
    • Batteries
    • Capacitors
  – Power producing devices
    • Electro-mechanical
    • Electro-chemical
    • Alternate – solar, etc.
Course Outline

• AC theory
  – AC Power generation
  – Inductance, capacitance and resistance
Course Outline

- Schematics
  - Purpose, use and types
  - Schematic devices and diagrams
  - Logic theory
    - facts vs assumptions
Course Outline

• Wiring
  – Connectors
  – Identification, routing and mounting
• Busses
• Controllers
  – Mechanical
  – Solid State
Course Outline

• Circuit rating and protection
• Load devices
  – Electro-mechanical - Motors
  – Lights/heaters
  – Others
Course Outline

• Circuit diagnosis
  – Plan of attack
  – Testing techniques and analysis
  – Verification

• Failures – causes and patterns
Course Outline

• Circuit repair
  – Component replacement
  – Soldering
Properties of matter

• Properties of matter
• Atom = the smallest particle that will retain the properties of an element.
• The combined properties of an element are specific to that element although other elements may have similar properties.
Properties of matter

• An element can be composed of single atoms, or they may be compose of multiple atoms of the same nature.
• When two or more atoms combine they form into a molecule.
• A molecule of the same atoms is still an element, but if they have more than one type of atom they become a compound.
Properties of matter

• Atoms “combine” for various reasons usually relating to a change in their mutual state of energy.

• The process of combining, or uncombining requires energy to initiate it, and will use or release energy to complete the transition.
Properties of matter

• All atoms are made up of three types of particles, Neutrons, Protons and Electrons.

• Neutron and protons make up the atom’s core, and the electrons orbit about the core in various “shell” levels.

• Electrons can be convinced to move from one atom to another.
Properties of matter

• Electrons exist in a orbital shell around a core that has a limit to the number of electrons for each shell level.
• The inner level allows for two electrons, then 8, then 8, 18, 32, 18 etc. with the outer shell always being no more than 8.
Properties of matter

• Depending on the number of electrons in the outer shell some atoms allow electron movement easily, some not so easily, and some resist such movement a lot.

• These are conductors, semi-conductors and insulators, respectively.
Properties of matter

• Typically when atoms combine they will share electrons in their outer shells.
• This may or may not effect the conductivity of the resultant compound.
Properties of matter

• Typically an atom that has one outer shell electron is a good conductor, and if the outer shell is full (stable) it will be a good insulator.

• By mixing certain elements we can make a semi-conductor that can vary its conductivity.
Properties of matter

- The sub-atomic particles exert various types of force upon each other.
- The three predominate forces are electrostatic force, magnetic force, and gravitational force.
- Neutrons react to the gravitational force but are neutral to the other two.
Properties of matter

• Electrostatic force and magnetic force are polarized, gravitational isn’t.

• Electrostatic and gravitational forces exist at all times, magnetic force only exists when electrons are moving.
  – Exception: some materials will easily retain their magnetic properties without electron movement.
Properties of matter

- Electrostatic polarization is between electrons and protons.
- Two likes repel, opposites attract.
- The polarity is labeled positive for protons, negative electrons.
Properties of matter

- Magnetic polarity is established by the direction of force lines in a magnetic object.
- This is labeled as the North and South ends, flowing from North to South externally.
- Like poles repel, opposites attract.
Properties of matter

- But like directions of “flux” lines attract, and opposite directions repel.
Properties of matter

- Electrons moving in matter will cause magnetic lines of force (flux).
- Magnetic lines of force moving through matter can cause electrons to move.
- A few materials are very receptive to this interaction such as iron, and a few other metals.
Properties of matter

• A good electron conductor isn’t necessarily a good flux conductor.
• A good electron insulator isn’t necessarily a good flux insulator.
Properties of matter

• All forces weaken exponentially with relative distance.

• As these forces interact, and electrons are moved, heat is generated, and therefore this energy is usually lost.
Properties of matter

• The temperature of any material will effect its qualities including its conductivity.

• System design is always limited by these qualities, and must take into account the heating that occurs from the interaction of these forces.
Properties of matter

• Atoms can exist in a state where they are missing an electron, or have one extra electron. These are called ions.
• Chemically induced ions can be used to inspire electron movement much like magnetism.
Properties of matter

• Electrons will not move unless they are being forced to move.
• They are commonly moved by friction, magnetism, or chemical reaction.
• These are electromotive sources. (They inspire electron movement)
Properties of matter

• Electrons traveling in a common direction, typically through a conductor, are called “current”, are measured in units of Ampere, labeled “I”
Properties of matter

• An electromotive source will create a difference of electrostatic potential between its conductive input/outputs.
• One end will have many extra electrons, the other will be missing an equal amount.
• The difference is measured in units of Voltage, labeled “E” or “V”.
Properties of matter

• This potential can exist without actual current flow.

• If matter is place across the “poles” of the source electrons may flow through the matter.

• The amount of electron flow will depend upon the difference of potential between the poles, and the conductivity of the matter.
Properties of matter

• All matter has some resistance to electron flow.
• This always increases with the length of flow path.
• This resistance always converts electron kinetic energy into heat.
• Resistance is measured in Ohms, labeled “R”.
Properties of matter

- The relationship between voltage, amperage and resistance is known as Ohm’s law.
- \( E = I \times R \)
- \( R = \frac{E}{I} \)
- \( I = \frac{E}{R} \)
Properties of matter

- Conductors, insulators and semi-conductors that are so arranged with any electromotive source in a manner that causes the electrons to move only in those directions so designed are called a circuit.
Properties of matter

- Electrons move at the speed of light, but because of the chain effect within the “tube” of a conductor as one electron enters into the tube, one electron instantaneously leaves the other end.
Review of D.C. Theory

• All circuits must have an electromotive source, one or more conductors, and a load.

• An optional device is a controller.
Review of D.C. Theory

- An electromotive source can move electrons in one direction through the circuit, or in both directions.
- In direct current circuits the electrons move in only one direction.
- In alternating current circuits the electrons move back and forth at a high rate of reversal.
Review of D.C. Theory

• The three basic types of circuits are:
  – Series
  – Parallel
  – Series/parallel, or combined
Review of D.C. Theory

• In a series circuit the electrons must travel in only one path from the source through the circuit and back to the source.

• In a parallel circuit there is more then one path.

• In a combined circuit there will be places where both occur.
Review of D.C. Theory

• Kirchhoff’s laws – The sum of the voltage drop’s across all the loads in a circuit must equal the source voltage.

• The current going into any point of a circuit must be equal to the current coming out.
Review of D.C. Theory

• In a series circuit the voltage drops partially across each load.
• The sum of the resistances times the current must equal the source voltage.
Review of D.C. Theory

• In a parallel circuit the voltage drops will be equal across all loads at the same parallel level.

• The sum of the currents must equal the total circuit current.
Review of D.C. Theory

• Within a circuit, current, voltage and resistance can be measured.
• Voltage, or voltage drop will be measured across a load, a conductor, a controller, or a source with the circuit on and off.
Review of D.C. Theory

• Current will be measured at the desired point along a circuit with the circuit on.
• Resistance will be measured across a load, a conductor or a controller with the circuit off, and the component disconnected and/or the circuit open.
Review of D.C. Theory

- Magnetism - caused by electrons moving.
- Electron orbit about core tends to cancel due to random movement from thermal action.
- Electron rotation can cancel if pairs spin opposite, or add up if many un-paired spin the same.
Review of D.C. Theory

- Henry’s Laws cover rules magnetism.
- Flux(\(\phi\)) = The entire field of magnetic lines that emit from a pole.
- Maxwell(Mx) = one magnetic field line.
- Weber(Wb) = 10^8 Maxwells
Review of D.C. Theory

• 2 systems of magnetic units
• Centimeter-gram-second = cgs
• Meter-kilogram-second = mks = Systeme linternationale
• Mx = cgs, Wb = mks or SI
Review of D.C. Theory

- **Gauss (G)** = flux density (B) = Mx per cm²
- **Tesla (T)** = flux density (B) = Wb per M²
- **Magnetomotive Force (mmf) (Gb)** = Current X No. of turns in a coil.
- **Field Intensity (H) (Oe)** = mmf per meter = I*N/Meters
Review of D.C. Theory

- Permeability ($\mu$) = a material’s ability to produce lines of flux = B/H or G/Oe
  - Ferromagnetic material easily allows unpaired electrons spinning in same direction.
- Reluctance = inverse of $\mu$ = resistance to production of flux.
Review of D.C. Theory

• Hysteresis = Changes in flux lag behind force causing change.

• Hysteresis Loss = the energy loss due to hysteresis, energy is lost as heat.
Review of D.C. Theory

• Magnetizing = to subject a magnetic material to a magnetizing force (flux) using current coil or permanent magnet.
• Degaussing = using alternating current to demagnetize the material.
Review of D.C. Theory

- Electrostatic flux increases with voltage increase.
- Magnetic flux increases with current increase.