Concepts:

- Phasor analysis, Euler’s Identity
- Double-subscript notations
- Labeling V & I: Passive vs. Active elements
- Peak vs. RMS magnitudes
- Phasor value vs. RMS magnitude vs. angle
- Power Triangle, Impedance Triangle
- Leading vs. Lagging PF, PF angle \( \theta \)
- Power: Apparent, Average, Reactive
- Single-Phase vs. Three-Phase Circuits
- Positive vs. Negative sequence
- Voltages: L-N, L-L (“line”), phase voltage in Y or \( \Delta \)
- Currents: phase currents in Y or \( \Delta \), line currents
- Balanced 3-phase loads: Y or \( \Delta \) or “black box”
- Balanced 3-phase sources: Y or \( \Delta \) or “black box”
- Power factor correction - why and how
- Voltage phasor diagrams: “open” vs. “closed”
- Per phase analysis
- Solar Energy AM numbers
- Solar Cells/Panels: \( V_{OC}, V_{MP}, I_{SC}, I_{MP}, J_{SC}, FF \)
- Characteristic curve, Max Power Point
- $/kWhr costs of various generation types
- Battery electrolyte and plate materials
- Battery plate reactions - acid vs. alkaline
- S-curves, battery sizing considerations
- Fuel cells: PEM, fuel, chemical reaction
- Energy in wind vs. temp, pressure, elevation
- Shadowing effect, turbulence, vibrations
- Ampere’s Circuital Law
- Magnetic Permeability \( \mu = \mu_r \mu_0 \)
- Mean path length
- Cross-sectional area,
- Magnetic Reluctance \( \mathcal{R} \), Permeance \( \mathcal{p} \)
- Magnetic Flux, \( \phi \)
- Magnetomotive Force, MMF or \( \mathcal{F} \)
- Magnetic Flux Density, \( B \)
- Magnetic Field Intensity, \( H \)
- Flux Linked \( \lambda \)
- Inductance \( L \)
- Fringing around air gap, leakage
- Magnetic Saturation
- stacking factor or (lamination factor)
- Why use laminations?
- Ideal transformer
- Turns ratio, voltage ratio, current ratio
- Nonideal transformer behaviors
- Polarity markings
- Winding resistance
- Leakage reactance
- Core loss resistance
- Magnetizing Reactance Ideal transformer
- Turns ratio, voltage ratio, current ratio
- Nonideal transformer behaviors
- Polarity markings, Lenz’s Law
- Winding resistance
- Leakage reactance
- Core loss resistance
- Magnetizing Reactance
- Approximate equivalent circuit
- Effective turns ratio of three-phase transformer
- “Closed” voltage phasor diagrams, PRI & SEC
- DC motors - construction and operation
- Excitation - self, separately, compound, series
- “Back EMF”
- Speed, induced voltage, flux, torque relationships
- Load characteristics
- Efficiency, losses
- Speed-Torque Characteristics
- DC motor starting
- Induction motor - how does it work?
- Squirrel cage vs. wound rotor
- Speed: actual, slip speed, synchronous
- Slip - starting, running, braking.
- Induction motor equivalent circuit
- Approximate Equivalent circuit
- Induction motor classes, codes
- Power - input, air gap, developed, output
- Losses - Stator, core, mechanical, rotor
- Rotor equivalents (RCL vs. \( P_{DEV} \))
- Soft Starters, Resistive Starters
- Voltage Dip, power quality, harmonics
- Variable Frequency Drives (VFDs)
- Volts/Hz ratio
- Speed-Torque curves
- Matching motor with load
- Adding resistance to wound rotor
- Starting torque, max (pullout) torque
- Maximum slip
- Slip vs. efficiency

Calculations, Determinations:

- Relate solar cell maximum power to FF, \( V_{OC}, V_{MP}, I_{SC}, I_{MP}, \eta \)
- Designing solar array to supply a load of given current and voltage
- Designing battery banks for a given electrical load
- Power in wind: available, maximum extractable, realistic (after efficiencies are accounted for)
- Calculation of solar cell performance using diode equation (like in lab)
- Designing battery banks for a given electrical load
- Power in wind: available, maximum extractable, realistic (after efficiencies are accounted for)
- Calculations involving V, I, P, Q, S, Z, R, X, \( \theta \), \( \phi \) for single phase 60-Hz circuit
- Calculate V, I, PF, S, P, Q, using phasor diagrams and power triangles as visual aid.
- Delta to Wye and Wye to Delta conversion of sources and loads
- Use of closed voltage phasor diagrams to obtain equivalent L-N and L-L voltages
- Calculate line currents between single-phase or 3-phase sources and loads.
- Determine phase voltages and currents for any Y or \( \Delta \) source or load.
- Delta to Wye and Wye to Delta conversion of sources and loads
- Use of closed voltage phasor diagrams to obtain equivalent L-N and L-L voltages
- Calculate line currents between single-phase or 3-phase sources and loads.
- Determine phase voltages and currents for any Y or \( \Delta \) source or load.
- Determine phasor line currents flowing into “black box” load.
- Calculate V, I, PF, S, P, Q, using phasor diagrams and power triangles as visual aid.
- Power factor correction (using power triangle for calculations)
- Calculate W, and W\(_2\) for 2-element wattmeter
- Calculate primary and secondary voltages and currents for single phase transformer.
- Calculate high- and low-side voltages and currents for autotransformer. Also volt-amp advantage.
- \( V_1, I_1, V_2, I_2 \), Voltage regulation, efficiency (for leading, lagging, unity PF)
- Refer impedances back and forth between primary and secondary of transformer
- Magnitude of line-line and line-neutral voltages on primary and secondary of 3-phase transformer.
- “Closed” voltage phasor diagrams of primary and secondary voltages.
- Calculate phase A phasor line current at load, for given MVA, voltage, PF.
- Delta-wye and wye-delta conversion of source, load.
- Calculate phasor voltage & current anywhere in a 3-phase transformer circuit.
- DC Motor: Calculate speed, induced voltage, flux, torque, efficiency, losses, etc.
- Linear Motor: Calculate induced voltage, torque, velocity, etc.
- Induction motor: Calculate speed, slip, losses, efficiency.
- Calculate power & torque: in, air gap, developed, out.
- Calculate starting current 3 ways.
- Calculate \( S_{\text{MAX}}, T_{\text{MAX}}, T_{\text{START}} \)