- Scheduled for Monday, May 5 at 6:00pm in Workman 113.

- No books, notes, calculators or collaboration.

- Show all work neatly and clearly for full credit.

- Final exam will be cumulative and covers material taken from lectures, reading assignments, exams and homeworks.

**Topics:**

1. Concept/definition of

    (a) voltage, $v$
    (b) current, $i$
    (c) power, $p$; PSC and conservation
    (d) loops and nodes
    (e) KCL
    (f) KVL
    (g) node-voltages, reference node, and relationship to voltages across elements
    (h) series and parallel

2. Circuit elements

    (a) ideal voltage and current sources (symbols and general behavior)
    (b) resistors (symbol, Ohm's Law, series and parallel equivalents, and general concept)
    (c) capacitors (symbol, v-i equation in general and DC, series and parallel equivalents, and general concept)
    (d) op-amps (symbol, ideal assumptions with negative feedback, and saturation)

3. Circuits with resistors, independent sources and/or op-amps with negative feedback

    (a) analyze via KCL, KVL, Ohm's Law, and/or reduction
    (b) find equivalent resistance, voltages (element- or node-), currents, powers, and gain

4. Charging and discharging circuits with voltage source, resistors and capacitors

    (a) mathematical expression for capacitor's voltage which can be used to find expressions for resistor's voltage and current
    (b) time-constant, $\tau$
    (c) sketches of voltages and current using time-constant

5. Measurement of voltage, current and resistance

    (a) instruments (voltmeter, ammeter, ohmmeter) and appropriate connections

6. SPICE - netlist

7. Alternating Current (AC) and cosines

    (a) General form: $v(t) = V_P \cos(\omega t - \phi_v)$, $i(t) = I_P \cos(\omega t - \phi_i)$

    (b) equation $\leftrightarrow$ sketch

    (c) peak value (amplitude)

    (d) peak-to-peak value

    (e) root-mean-square (RMS) value

    (f) period

    (g) frequency

    (h) angular frequency

    (i) time-shift

    (j) phase-shift

8. Digital electronics

    (a) binary numbers $\leftrightarrow$ decimal numbers

    (b) logic gates (two input AND, one input NOT, two input OR)

    (c) combinational logic circuit

    (d) truth table

    (e) Boolean (logical) expression

    (f) sum-of-products (SOP) expression

    (g) simplified SOP expression via Karnaugh maps (K-maps)

9. Thevenin and Norton equivalent circuits at terminals

    (a) analyze appropriate representation to find $V_{TH}$, $R_{TH}$ and/or $I_N$; $V_{TH} = R_{TH} I_N$

    (b) draw and label equivalent circuits

10. Digital-to-Analog Converters (DACs) based on summing op-amp circuit

    (a) analyze/design

    (b) input/output (I/O) table

    (c) resolution