Final Exam Review

- ## <u>Midterm review</u>

- **Capacitors and inductors**
  1. Inductors and inductance
  2. The $v - i$ and $i - v$ equations for inductors, and capacitors
  3. Power and energy in inductors, and capacitors
  4. Series-parallel connected inductors, capacitors.
  5. An Inductor stores magnetic energy. It does not permit an instantaneous change in its terminal current, but permit an instantaneous change in its terminal voltage. It behaves as a short circuit in the presence of a constant terminal current.
  6. A capacitor stores electric energy. It does not permit an instantaneous change in its terminal voltage, but permit an instantaneous change in its terminal current. It behaves as an open circuit in the presence of a constant terminal voltage.

- **The operational amplifier**
  1. The inverting-amplifier circuit
  2. The summing-amplifier circuit
  3. The noninverting-amplifier circuit
  4. The difference-amplifier circuit
  5. CMRR

- **The definition of the Laplace transform**
  1. Functional Transforms: given a function in time domain, know how to find its Laplace transform based on the Laplace transform expression Impulse functions: $\mathcal{L}\{\delta(t)\} = 1$
     a. Step functions: $\mathcal{L}\{u(t)\} = \frac{1}{s}$
     b. Ramp functions : $\mathcal{L}\{t\} = \frac{1}{s^2}$
     c. Exponential functions: $\mathcal{L}\{e^{-at}\} = \frac{1}{s+a}$
     d. Sinusoidal functions: $\mathcal{L}\{sin(\omega t)\} = \frac{\omega}{s^2+\omega^2}$
  2. Operational Transforms:
     a. Multiplication by a constant
     b. Addition/subtraction
     c. Differentiation
     d. Integration
     e. Translation in the time domain

f. Translation in the frequency domain
g. Scale changing

- **Inverse Laplace transforms**
  1. Proper rational functions
     a. Distinct real roots of D(s)
     b. Distinct complex roots of D(s)
     c. Repeated real roots of D(s)
  2. Improper rational functions

- **Initial- and final-value Theorems**
  a. Initial-value theorem:
  $$\lim_{t \to 0^+} f(t) = \lim_{s \to \infty} sF(s)$$
  b. Final-value theorem:
  $$\lim_{t \to \infty} f(t) = \lim_{s \to 0^+} sF(s)$$
- **Circuit analysis in s domain**
  a. Given a circuit in the time domain, know how to redraw it in s domain (assume the initial conditions are zero)
  b. Can analyze the voltage/current based on the circuit analysis techniques you have learned
  c. Can find the voltage/current expressions in the time domain
  d. Can find the initial- and final values of the voltage/current based on their mathematical expressions in the s domain.

- **Second-order circuits:** understand how many different types of the responses that second-order circuits could have. Remember the name of each response.
  1. When $\alpha > \omega_0, s_1\ and\ s_2$ are real and distinct, the step response of the voltage is called overdamped. $v(t) = V_f + A_1 e^{s_1 t} + A_2 e^{s_2 t}$.
  2. When $\alpha < \omega_0, s_1 and\ s_2$ are distinct and complex, the step response of the voltage is called underdamped. $v(t) = V_f + B_1 e^{-\alpha t}\cos(\omega_d t) + B_2 e^{-\alpha t}\sin(\omega_d t) = V_f + Be^{-\alpha t}\cos(\omega_d t + \theta)$,

     where $\omega_d = \sqrt{\omega_0^2 - \alpha^2}$, which is called damped radian frequency.
  3. When $\alpha = \omega_0, s_1 and\ s_2$ are repeated real roots, the step response is called critically damped. $v(t) = V_f + D_1 te^{-\alpha t} + D_2 e^{-\alpha t}$
  4. When $\alpha = 0$, $s_1 and\ s_2$ are repeated complex roots, the response is unstable.
- **The definition of the transfer function.**
- **The steady-state sinusoidal responses of a circuit**

If the source of the circuit is $x(t) = A\cos(\omega t + \phi)$, and the transfer function is $H(s) = \frac{Y_{SS}(s)}{x(s)}$, the steady-state response to the source is $y_{ss}(t)$, then

$$y_{ss}(t) = A|H(j\omega)|\cos\left[\omega t + \phi + \theta(\omega)\right]$$