- Show your work.
- This work must be submitted online as a `.pdf` through Canvas.
- Work completed with LaTeX or Jupyter earns 1 extra point. Submit source file (e.g. `.tex` or `.ipynb`) along with the `.pdf` file.
- If this work is completed with the aid of a numerical program (such as Python, Wolfram Alpha, or MATLAB) all scripts and data must be submitted in addition to the `.pdf`.
- If you work with anyone else, document what you worked on together.

---

1. (Hetrick 6-3, 6-4, 6-5, 6-6, 6-7, 6-8) Below, G(s)H(s) is the open-loop transfer function. For each, plot the stable region for the closed-loop system in the $K(\alpha)$ plane.
   (a) (5 points) $G(s)H(s) = \frac{K}{(s+2)(s+\alpha)}$
   (b) (5 points) $G(s)H(s) = \frac{K+\alpha}{(s+2)(s+\alpha)}$
   (c) (5 points) $G(s)H(s) = \frac{K\alpha}{(s+2)(s+\alpha)}$
   (d) (5 points) $G(s)H(s) = \frac{K+\alpha}{(s+2)^2(s+\alpha)}$
   (e) (10 points) $G(s)H(s) = \frac{K+\alpha}{(s-1)(s+2)(s+\alpha)}$
   (f) (10 points) $G(s)H(s) = \frac{K(s+1)}{(s-1)(s+2)(s+\alpha)}$
2. (20 points) (D&H 6-26) Explicitly perform the Laplace transform inversion of the zero power transfer function, $Z(s)$ to obtain the impulse response function $\mathscr{Z}(t)$.
3. (30 points) (D&H 6-23) Calculate the amplitude and phase angle for the zero power transfer function and plot these as functions of frequency. Assume one group of delayed neutrons with $\beta = 0.0065$, $\lambda = 0.08s^{-1}$, and $\Lambda = 10^{-4}s$.
4. (10 points) (D&H 6-32) In a prompt critical reactor excursion, a large amount of reactivity (measured above prompt critical) ρ_0 is instantaneously inserted in an equillibrium reactor at $t = 0$. Assume that:
   - the effect of delayed neutrons is negligible on the time scales under consideration.
   - the reactor shuts itself down by thermal expansion of the core in such a way that negative reactivity is "added" proportional to the total heat energy generated up to time t. That is, $\rho = \rho_0 - \gamma \int_0^t P(t')dt'$.

   Find the power level $P(t)$ where t is measured from the time of reactivity insertion, and is measured in units of the prompt neutron lifetime. [This is known as the Fuchs-Hansen model of reactor excursion.]