- 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. (50 points) What is the savings in natural uranium if both uranium and plutonium are recycled in LWRs, assuming the following (Tsoulfanidis, 7.3):
   - 3% enriched fuel
   - with 0.22% tails
   - 0.78% ^{235}U in spent fuel
   - $6.9\frac{gfPu}{kg_{SNF}}$
   - $0.90\frac{kg_{recovered}}{kg_{fresh}}$
   - 0.8 Pu-^{235}U equivalence.

   Solution: For the given specifications, the fuel savings is 36.0%.

   To solve, first calculate the feed factor w/ Eq. 3.6:

   $$FF = \frac{x_p - x_w}{x_f - x_w} \tag{1}$$

   Then use Eq. 7.12 to find the percent savings.

   $$savings = \frac{u \cdot s \cdot p}{x_p - x_w} + \frac{u\left(x_s - x_w\right)}{x_p - x_w} = 36.0\% \tag{2}$$

2. (50 points) What are the SWU savings for the for the conditions given in the previous problem? (Tsoulfanidis, 7.4)

Solution: By recycling used nuclear fuel, we can save 19.475% of the SWU used to fabricate the fuel from natural uranium.

To solve, use Eq 3.10 to find the separation potentials:

$$V(x) = (2x-1)\ln\frac{x}{1-x} \tag{3}$$

Then, find the SWU factor using Eq. 3.11:

$$SF = V(x_p) + \frac{W}{P}V(x_w) - \frac{f}{p}V(x_f) \tag{4}$$

Finally, find the SWU saved using Eq. 7.16:

$$savings_{SWU} = \frac{u}{x_p - x_w}\left[s \cdot p + (x_s + x_w)\left(1 - \frac{SF_s}{SF}\right)\right] = 19.475\% \tag{5}$$