PHYS 4134, Fall 2016, Homework #11

Due Friday, December 2

Design a Nuclear Fission Reactor!

In the table below are your own, personal design parameters. You can feel free to work with others in the class, but your design must be for your own numbers:

Name	**^{235}U Enrichment**	**Fuel:Moderator Ratio in Core**
Justin Alvarez	2%	1:300
Luis Angeles	2.2%	1:350
Abdul Ansari	2.4%	1:400
Ryan Buzon	2.6%	1:400
Justin Cata	2.8%	1:450
Tolga Erbora	3%	1:475
David Gesua	3.2%	1:500
Joseph Maerovitz	3.4%	1:550
James Perez-Sanchez	3.6%	1:600
Michael Regalado	3.8%	1:650
Ivan Soto	4.0%	1:700

1. Power and fuel

If the reactor is to produce 100MW of power, and uses 20% of the fuel each year: A) Calculate the number of ^{235}U atoms in the fuel. B) How much ^{235}U is in the reactor? C) How much ^{238}U? D) And what is the total for the fuel? [Give all these answers in kilograms, please. You can use the energy release per fission of E = 200 MeV.]

2. Reactor numbers

The rating is the output power per tonne (metric ton) of fuel. A) Calculate the rating of your reactor. B) Knowing that your reactor produces 100 MW of power, find the fission reaction rate, R_f. [Hint: Use eqn. 10.38] C) Using all of this information, find the flux of neutrons, Φ, in units of $cm^{-2}s^{-1}$. [Hint: Use eqn. 10.37]

3. Fast neutrons

Calculate the η factor and the microscope thermal-neutron absorption cross section $\sigma_a(U)$ for your uranium enrichment.

4. **Physical Size of the Core**

For all of you, the moderator will be purified water. A) What is the total volume of the uranium for your specific case? [Hint: you need the density of uranium. You can use that of naturally occurring uranium for this part.] B) What is the total volume of the moderator? C) Assuming that the control rods add 10% to this volume, you can now write the total volume of your reactor core.

5. **Design!**

Make a sketch of your reactor. This will take a little bit since you need to include: core elements such as fuel rods, control rods, pressure vessel, reflector, biological shield, and the basics of the steam turbine, including heat exchangers, turbines, generators, condensers, etc. Be sure and read the article in Blackboard about the Turkey Point reactor, it will have useful information. Describe safety issues you can think of (both "engineered" or hardware/architectural features and protocols such as not closing all valves to the heat exchangers at once.