=73/100

HW3

Mihal

(1) Σ_s of UO_2

$\#\text{atoms } ^{235}U = \frac{6.022\times10^{23}}{235} = 2.56\times10^{21} \rightarrow 2.55\times10^{22}$

$\#\text{atoms } ^{238}U = \frac{6.022\times10^{23}}{238} = 2.58\times10^{21} \rightarrow 2.53\times10^{22}$

$\#\text{atoms } ^{16}O = \frac{6.022\times10^{23}}{16} = 7.50\times10^{22} \rightarrow 7.53\times10^{23}$

For 10 g/cm^3

Now must calculate enrichment factor

-4pts: you can't just separate the components and use the density

$\gamma = \frac{N_{235}}{N_{238}} = \frac{2.56}{2.53} = 1.012$

$\Sigma_{total} = \sum_i \sigma_i N_i = (8.9\times10^{-24} \cdot 2.56\times10^{22})_{U^{235}} + (8.9\times10^{-24} \cdot 2.53\times10^{22})_{U^{238}} + 2(3.75\times10^{-24} \cdot 7.53\times10^{23})_{O_2}$

$= 0.228 + 0.225 + 5.645 = 6.100$ barns multiply by γ for

total, $= \boxed{6.17 \text{ barns}}$

-2pts: wrong units and answer; should be 0.366 cm^-1

(2)

a) Isotropic source, assume emitted spherically with radius R

CDF:

$C(r) = \frac{\int 4\pi r^2 dr}{\frac{4}{3}\pi R^3} = \frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi R^3} = \rho_1$

Invert CDF: $r = R\rho_1^{1/3}$

θ = polar angle ϕ = azimuthal angle

Sample PDF assume uniform neutron transport

$p(\theta,\phi)\,d\theta\,d\phi = \frac{\sin\theta\, d\theta}{2} \cdot \frac{d\phi}{2\pi}$

Set $\mu = \cos\theta = (1-2\rho_2)$ and $\theta = \cos^{-1}(1-2$

-3pts: CDF for theta is off; using the substitution, you should get sqrt(1-(2*RN-1); I can't see above because it is cut off, but below it isn't right

$C(\phi) = \int_0^\phi \frac{d\phi}{2\pi} = \frac{\phi}{2\pi} = \rho_2 \qquad \phi = 2\pi\rho_2$

$x = r\sin\theta\cos\phi = R\rho_1^{1/3}(1-\mu^2)^{1/2}\cos(2\pi\rho_2)$

$y = r\sin\theta\sin\phi = R\rho_1^{1/3}(1-\mu^2)^{1/2}\sin(2\pi\rho_2)$

$z = r\cos\theta = R\rho_1^{1/3}\mu$

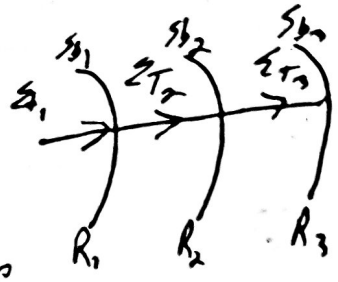
-1pt: no R to define a direction

2b $\Sigma_T e^{-\Sigma_t s}\, ds$ $\quad C(s) = \int_0^s \Sigma_t e^{-\Sigma_t s'} ds' = \frac{-\Sigma_t}{\Sigma_t} e^{-\Sigma_t s'} \Big|_0^s = 1 - e^{-\Sigma_t s}$

set $C(s) = \xi$ and solve for s: $\xi = 1 - e^{-\Sigma_t s}$

$$s = \frac{-\ln(1-\xi)}{\Sigma_t}$$

s_c = distance to collision
s_b = distance to boundary



For each random number,
if $s_{c_1} < s_{b_1}$, use Σ_t, otherwise
move to next region and repeat
for s_{c_2} and s_{b_2}, and so on

-2pts: Need to update sigma for each region.

2c See Jupyter notebook

-3 pts: Didn't run the algo from 2b and handle the interfaces.

2d $\Sigma_t = \Sigma_s + \Sigma_y$ $\quad P(s) = \frac{\Sigma_s}{\Sigma_T}$ $\quad P(y) = \frac{\Sigma_y}{\Sigma_T}$

s = scatter
y = absorption

For random number, if $> P(s)$, tally absorption, otherwise tally scattering

-4pts: Missing (n,f) and (n,n')

3a See text file

-1pt: see file

3b Dimensions: cylinder w/ radius = .41 cm, length = 400 cm
cylinder w/ radius = .42 cm, length = 400 cm
cylinder w/ radius = .48 cm, length = 400 cm
box w/ dimensions of 1.26 cm for L/R/H

Isotropic composition: ^{235}U, ^{238}U
Enrichment: 5% ^{235}U, 95% ^{238}U

3b continued

Mihal

Density

10.41 g/cm³ for Uranium Oxide

6.55 g/cm³ for Zirconium

0.7 g/cm³ for water

Cross sections:

UO_2 = 0.73 cm from ENDF 7, fission $\bar{\nu}$, prompt

H_2O = 0.71 cm ENDF 7 → total cross section thermal

Zr = 0.58 cm ENDF 7 → Fission Q library

3c 1) k_{inf} = 1.3862, supercritical

2) Avenge neutron flux in fuel, cladding, and moderator

Fuel = 6.9354×10^{-2} 1/cm²

cladding = 6.9504×10^{-2} 1/cm²

moderator: 6.9488×10^{-2} 1/cm²

-2 pts: Always include uncertainty!

3) Average one group absorption + fission rates in fuel zone

Absorption: 2.74324×10^{-2} 1/cm²

Fission rate: 3.82242×10^{-2} 1/cm²

-2pts: I get an order of magnitude smaller;

3c 4) See Jupyter Notebook 3c 5-6) See text file and Jupyter notebook

4) See Jupyter notebook

3) c) 4) -1pts: Incorrect answer for two group

Collaboration. Worked 1 & 2a with John Florio. Worked 2b - 3c with Major Freeman and Capt Chapman, who walked us through a lot of Problem 4 is from Ashwin because I could not figure it out on my own.

4) -2 pts: Answers are slightly off, but trend correctly.