HW3 Mihal

① Σ_s of UO_2

$\#$ atoms $^{235}U = \frac{6.022\times10^{23}}{235} = 2.56\times10^{21} \rightarrow$ 2.55×10^{22}

$\#$ atoms $^{238}U = \frac{6.022\times10^{23}}{238} = 2.58\times10^{21} \rightarrow$ 2.53×10^{22}

$\#$ atoms $^{16}O = \frac{6.022\times10^{23}}{16} = 7.50\times10^{22} :$ 7.53×10^{23}

for $18\,g/cm^3$

Now must calculate enrichment factor

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

$$\overset{total}{\sum_i} = \sum_i \sigma_i N_i = (\overset{U^{235}}{8.9\times10^{-27}} \cdot 2.56\times10^{22}) + (\overset{U^{238}}{8.9\times10^{-24}} \cdot 2.53\times10^{22}) + 2(\underset{O_2}{3.75\times10^{-24}} \cdot 7.53\times10^{23})$$

$= 0.228 + 0.225 + 5.645 = \underline{6.100 \text{ barns}}$ multiply by γ for total, $= \boxed{6.17\text{ barns}}$

②

a) Isotropic source, assume emitted spherically with radius R

CDF:

$$C(r) = \frac{\int_0^r 4\pi r^2 dr}{\frac{4}{3}\pi R^3} = \frac{\frac{4}{3}\pi r^3}{\frac{4}{3}\pi R^3} = \rho_1$$

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

$$c(\phi) = \int_0^\phi \frac{d\phi}{2\pi} = \frac{\phi}{2\pi} = \rho_3 \qquad \phi = 2\pi\rho_3$$

$x = r\sin\theta\cos\phi = R\rho_1^{1/3}(1-\mu^2)^{1/2}\cos(2\pi\rho_3)$

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

$y = r\sin\theta\sin\phi = R\rho_1^{1/3}(1-\mu^2)^{1/2}\sin(2\pi\rho_3)$

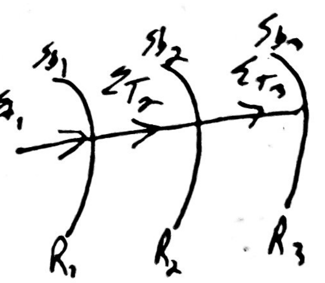
$\rightarrow$

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

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_1}, otherwise
move to next region and repeat
for s_{c_2} and s_{b_2}, and so on

2c See Jupyter notebook

2d $\Sigma_t = \Sigma_s + \Sigma_\gamma$ $\qquad P(s) = \frac{\Sigma_s}{\Sigma_T}$ $\qquad P(\gamma) = \frac{\Sigma_\gamma}{\Sigma_T}$

s = scatter
γ = absorption

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

3a See text 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/W/H

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

3b continued

Mihal

Density

10.41 g/cm^3 for Uranium Oxide

6.55 g/cm^3 for Zirconium

0.7 g/cm^3 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) Average neutron flux in fuel, cladding, and moderator

Fuel = 6.9354×10^{-2} $1/cm^2$

cladding = 6.9504×10^{-2} $1/cm^2$

moderator: 6.9488×10^{-2} $1/cm^2$

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

Absorption: 2.74324×10^{-2} $1/cm^2$

Fission rate: 3.82242×10^{-2} $1/cm^2$

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

4) See Jupyter notebook

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.