NENG 685 Fall 2017
HW 4 Due Nov. 29, 2017

Name:

On homework:

- Well organized and documented work scores better. If I cannot figure out what is going on, then I am less likely to "intuit" what you intended, and the score will be reflective of this fact.
- If you work with anyone else, document what you worked on together.
- Show your work.
- Always clearly label plots (axis labels, a title, and a legend if applicable).
- Homework should be done "by hand" (i.e. not with a numerical program such as MATLAB, Python, or Wolfram Alpha) unless otherwise specified. You may use a numerical program to check your work.
- If you use a numerical program to solve a problem, submit the associated code, input, and output.
- ***I should not have to run your code to see your answers.*** The attached code is an additional form of feedback for me and a method to give partial credit. If you want full credit, then include the outputs (plots, tables, answers, etc.) in your write-up.

Do not write in the table to the right.

Problem	Points	Score
1	30	
2	30	
3	15	
4	25	
Total:	100	

1. (30 points) Using the direct inversion of CDF sampling method, derive sampling algorithms for

   (a) The neutron direction in 3D if the neutron source is isotropic. *Note: each unit direction should have a specified sampling.*

(b) The distance to the next collision in the direction of neutron motion if the neutron is in the center of the spherical volume that consists of three concentric layers with radii R_1, R_2, and R_3, each made of different materials with total cross sections Σ_{t1}, Σ_{t2}, and Σ_{t3}, respectively. *Note: Do not use the mfp algorithm to determine the distance; sample the distance explicitly.*

(c) The type of collision if it is assumed that the neutron can have both elastic and inelastic scattering, and can be absorbed in fission or (n,gamma) capture interactions. Assume monoenergetic neutron transport.

2. A sample of MCNP input is given below:

```
PWR Single Pin
1 1 -10.41 -1 -10 20 imp:n=1
2 0 1 -2 -10 20 imp:n=1
3 3 -6.55 2 -3 -10 20 imp:n=1
4 4 -0.7 3 -5 6 -7 8 -10 20 imp:n=1
5 0 5:-6:7:-8:10:-20 imp:n=0

c Rods dimensions
1 cz 0.41
2 cz 0.42
3 cz 0.48
c Basic lattice cell
*5 px 0.63
*6 px -0.63
*7 py 0.63
*8 py -0.63
c Axial limits
*10 pz 200.0
*20 pz -200.0

c Material 1
m1 8016.13c 2.0
92235.63c 0.05
92238.63c 0.95
c Material 4
m4 1001.78c 2
8016.78c 1
mt4 lwtr.04t
c Material 3
m3 40000.12c 1.
c ——— Tallies ———
fc4 Tally 4
f4:n 1 3 4
e4:n 1e-6 1. 20.
fc14 Tally 14
f14:n 1
fm14 (1 1 (-2) (-6))
c ——————————————
kcode 1000 1.00 50 250
ksrc 0. 0. 0.
print
mode n
```

(a) (10 points) Next to each line in this sample input add a short explanation what that line represents.

(b) (5 points) Using so-called reverse engineering determine the dimensions, material properties (isotopic composition, enrichment, densities), and cross-section data used for this fuel pin. Specify corresponding units when appropriate.

(c) (15 points) Prepare the MCNP/SERPENT input for this case (using reflective boundary conditions) and determine:

1. k_inf.

2. The average neutron flux in the fuel, clad and moderator (the actual onegroup scalar flux!).

3. The average one-group absorption and fission rates in the fuel zone.

4. The neutron flux spectra in the fuel and water zones, separately, with a minimum of 20 energy groups (structure should be fine enough to see resonance capture regions). Plot the neutron spectra. Also determine the two-group

neutron flux in the fuel and water zones.

5. The spatial distribution of a two-group flux (fast and thermal) along the central line of the fuel pin. You might want to add more cylindrical zones in the fuel region, and more zones in the water region. Explain why additional spatial subdivision is needed?

6. Comment of the spectral and energy distribution of neutron flux in the fuel pin.

3. In Lesson #9, an outline was created for a simple 1D MC transport program. In class a notebook was started to implement the MC algorithm, but it was not fully completed. Complete the code by:

   (a) (5 points) Adding in the algorithm to transport the particle if $s_b < s_c$ in the transport function

   (b) (5 points) Writing the main controller program to use the functions and classes defined in the notebook and transport N number of particles.

   (c) (5 points) Outputting the flux tally in each cell in units of n/cm^2/src particle. Include the relative error for each flux.

4. In lesson 14, a miniature city was created and exposed to neutrons from a fission weapon (nw_effects.in). The small scale of the city made it easy to get reasonable statistics. Now let's investigate something closer to reality:

   (a) (5 points) Add in a ground made of asphalt. Make the internal volume of the buildings 30% wood, 20% aluminum, 20% steel, and 30% air by mass (this should be one homogenized material).

   (b) (5 points) Scale the geometry by a factor of 10 and determine the flux for a car located between each block (use the previous definition of a "car"). Report the FOM and flux spectrum with errors (plot) for each.

   (c) (10 points) Use ADVANTG to create weight windows for the problem considered in part b). Run the MCNP with the ADVANTG weight windows with the same number of particles and report the FOM and flux spectrum with errors (plot) for each car.

   (d) (5 points) Comment on your findings regarding the FOM and uncertainties between the analog and ADVANTG variance reduction models.

BONUS (5 points): submit your code by providing read/clone access to an online version control repository where your code is stored (e.g. github or bitbucket).