Engineering Physics 6D3
Modular Course Problem Set #3
Due 2003 October 31

Problems 1 – 2: 10 marks each
Problem 3: 25 marks
Problem 4: 15 marks
Problem 5: 40 marks
Total: 100 marks

1. Plot the fuel-temperature reactivity coefficient against average exit burnup (using the reaction-rate-averaged option in PPV). Does it ever change sign?

2. Using the result from #1, and assuming only fuel temperature changes with power level, can you estimate the reactivity coefficient of reactor power around full power? i.e., how much does the reactivity range change for a 1% increase in power from full power?
Assume that fuel temperature at "hot shutdown" ~ 270 ^{o}C and that it is ~700 ^{o}C at 100% power.

3. The lattice void reactivity in milli-k is defined in terms of the infinite-lattice multiplication constants for the cooled and voided lattice:

$$\rho_{void} = 1000\left[\frac{1}{k_\infty(cooled)} - \frac{1}{k_\infty(voided)}\right]$$

Calculate the coolant-void reactivity as a function of exit irradiation from reaction-rate-averaged runs. Plot also the change in each of the 4 factors in the 4-factor formula on voiding against irradiation. Which of the 4 curves features the most dramatic change against irradiation? Can you think why?

4. Consider a planar source of neutrons in an infinite medium consisting of mixture of cadmium, water and aluminum. Use the following properties for the mixture:
$S = 100$ n/cm2 sec, $\Sigma_a = 12.56$ cm^{-1}, $D = 0.5252$ cm, $L = 0.2045$ cm.
a. Solve for and plot the steady state flux profile as a function of distance from the source using analytical methods.
b. If you were to solve this problem numerically, as you will in Question 5, you'd need to approximate infinity somehow. Determine, from your answer to part (a), the distance (in terms of the diffusion length L, ie 1 L, 2L, 10L, 100L) at which the flux is effectively zero.

5. Using the boundary conditions determined in Question 4, calculate the steady state flux profile numerically. Compare the steady state flux profiles for Questions 4 and 5. Comment.

```
// For Problem Set #3, question 5
// Case: Source in the middle of a slab, steady state
// Method: Gauss-Seidel

#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <conio.h>


int main(int argc, char **argv)
{
 int i, j, num_cell=11, num_iter=20;
 float flux[13];  //make room for real cells + phantoms at the edges
                  //size = num_cell+2
 float s[13];
 float S=???;      //source strength #/cm^2/s
 float h=2.0/num_cell;  //cell size = 2 cm / number of cells
                        // ie +/- 1 cm about the origin
 float D=???;  // diffusion length
 float e=???;   //absorption cross section

 for (i=1;i<=num_cell;i++)
 {
   flux[i]=0.0;   // initial guess at flux
   s[i]=0;      // set source = 0
 }
 s[(num_cell+1)/2]=???;   // set source strength at centre
 flux[0]=0.0;
 flux[num_cell+1]=0.0;      // flux is zero at edges

 for (j=0;j<num_iter;j++)
 {
   printf("\n%d",j);
   /* this is the equation derived from the difference formula */
   for (i=1;i<=num_cell;i++)
   {
     flux[i]=???;
     printf("\t%.4f",flux[i]);
   }
  }
 getch(); /* allows the outbox to vanish by hitting any key*/
return 0;
}
//----------------------------------------------------------------------
```