Nuclear Engineering 150 – Discussion Section
Team Exercises #1

*Problems 1 & 2 borrowed from Nuclear Engineering 101 homework problem sets, Fall 2016

Problem 1

The radioactive isotope ^{233}Pa can be produced following neutron capture by ^{232}Th when the resulting ^{233}Th decays to ^{233}Pa. In the neutron flux of a typical reactor, neutron capture in 1 g of ^{232}Th produces ^{233}Th at of a rate of 2.0×10^{11} s^{-1}.

a) What are the activities (in Ci) of ^{233}Th and ^{233}Pa after this sample is irradiated for 1.5 hours?

b) The sample is then placed in storage with no further irradiation so that the ^{233}Th can decay away. What are the activities (in Ci) of ^{233}Th and ^{233}Pa after 48 hours of storage?

c) The decay of ^{233}Pa results in ^{233}U, which is also radioactive. After the above sample has been stored for 1 year what is the ^{233}U activity in Ci? (Hint: it should not be necessary to set up an additional differential equation to find the ^{233}U activity.)

Nucleus	Half-life
^{233}Th	22.3 min
^{233}Pa	27.0 days
^{233}U	1.592×10^5 yr

$$1 \text{ Ci} = 3.7 \times 10^{10} \text{ s}^{-1}$$

Problem 2

Use the following masses for parts (a) and (b):

Nucleus	Atomic Mass
n	1.008665 u
^{1}H	1.007825 u
^{2}H	2.014102 u
^{56}Fe	55.934939 u
^{98}Y	97.922203 u
^{135}I	134.910048 u
^{235}U	235.043924 u

$$1\text{u} \cdot c^2 = 931.502 \text{ MeV}$$

a) Calculate the Q-value of the reaction:

$$^{235}\text{U} + n \rightarrow {}^{135}\text{I} + {}^{98}\text{Y} + 3n$$

b) Calculate the average binding energy per nucleon (in MeV) of ^{2}H, ^{56}Fe, and ^{235}U.

Problem 3

a) Solve the first order differential equation

$$\frac{dy}{dx} + 3y = 0$$

b) Solve the second order differential equation (A and B are constants)

$$\frac{d^2y}{dx^2} - A^2 y = B$$

The boundary condition is $y(\pm\frac{1}{A}) = 0$.

Problem 4

Classify the following cross section plots. They are, in no particular order:

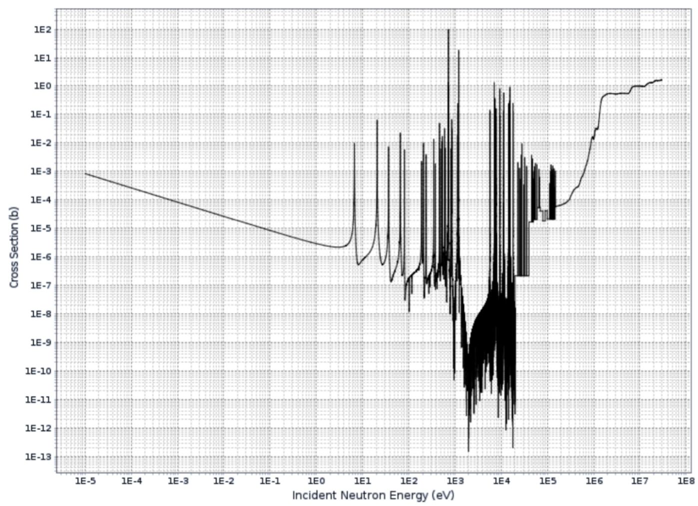
(1) ^{155}Gd absorption

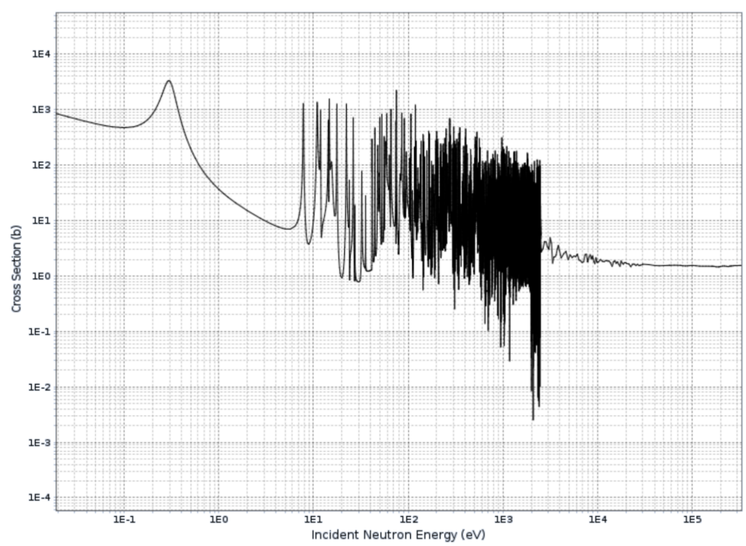
(2) ^{235}U fission

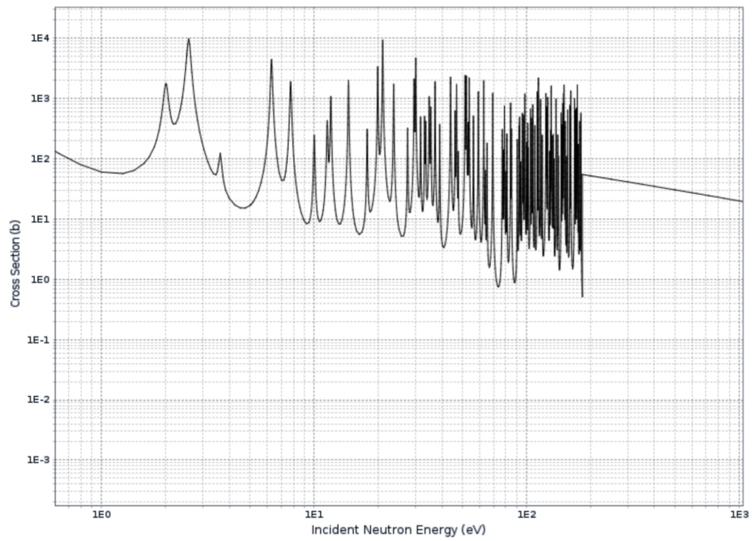
(3) ^{238}U absorption

(4) ^{238}U fission

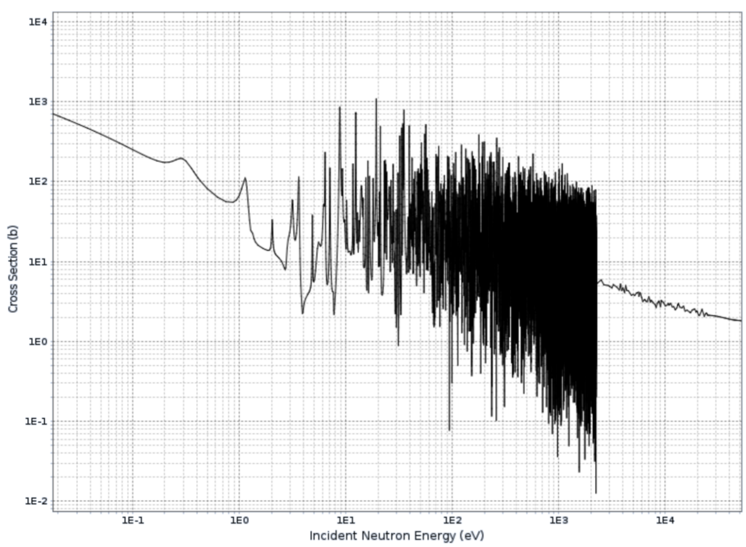
(5) ^{239}Pu fission



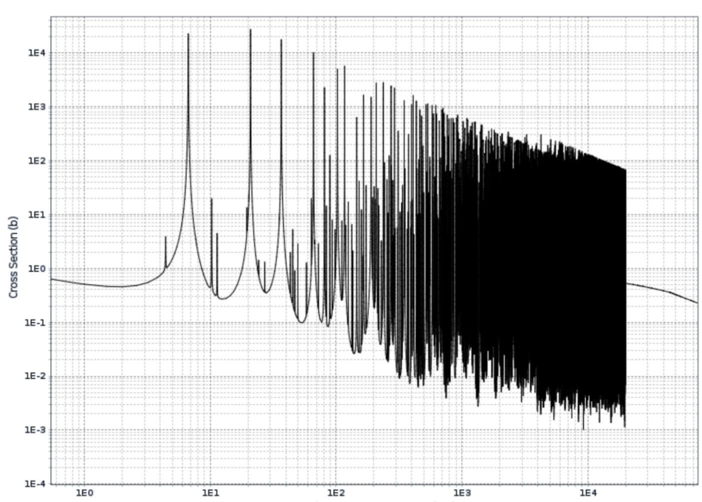




1E4
1E3
1E2
1E1
1E0
1E-1
1E-2
1E-3
Cross Section (b)
1E0
1E1
1E2
1E3
Incident Neutron Energy (eV)



1E4
1E3
1E2
1E1
1E0
1E-1
1E-2
Cross Section (b)
1E-1
1E0
1E1
1E2
1E3
1E4
Incident Neutron Energy (eV)



1E4
1E3
1E2
1E1
1E0
1E-1
1E-2
1E-3
1E-4
Cross Section (b)
1E0
1E1
1E2
1E3
1E4
Incident Neutron Energy (eV)