1a) The major nuclear data libraries are NJOY-2012.53 and SCAMP I, but we deal with ENDF. The data is managed by USA, Europe, Japan, Russia, and China.

b) ^{235}U shows an isolated resonance @ 10^{-5} MeV
^{238}U shows an isolated resonance @ 10^{-5} MeV
^{239}Pu shows an isolated resonance @ $5 \cdot 10^{-6}$ MeV
^{240}Pu shows an isolated resonance @ $5 \cdot 10^{-5}$ MeV
^{241}Pu shows an isolated resonance @ $5 \cdot 10^{-6}$ MeV
^{242}Pu shows an isolated resonance @ $5 \cdot 10^{-6}$ MeV

Calculated by generating cross-section plots from nndc.bnl.gov, identifying appropriate plots and finding first set of peaks.

c) We care about isolated resonance because we need to write code to model energies in a reactor core/reflector.

2b) Deterministic methods are fast, but involve simplification which can become tedious for larger problems. Our ability to discretize variables dictates the processing and quality of our solution. The most accurate predictions involve millions of mesh points, through hundreds of energy groups, making accurate solutions very intensive.

[Please note this is 2b! 2a is here]

(a)

	Differ.	Determ.	MC
Strengths	• Discretized and homogenous spacial calculation • ~~Hard to input~~ • Discretized Energy • Accurate	• Fast • Global solution • Homogenous solution quality • Simple inputs	• General geometry • Continuous angle/Energy • Easy to parallelize
Weaknesses	• Hard to input • Tedious calculations	• Quality depends on discretization • Hard to parallelize • Truncation Error	• Slow • Memory Intensive • complicated • Statistical Error

3a) The main challenge with deriving our multigroup transport equation lies in our need to discretize every variable.

b)
$$\Omega \cdot \nabla \psi^0(\vec{r},\hat{\Omega}) + \Sigma_t^0(\vec{r})\psi^0(\vec{r},\hat{\Omega}) = \int \Sigma_s^{0\to 0} \psi_0(\vec{r},\Omega')d\Omega' + \frac{\chi_0}{4\pi}\left[\nu_0 \Sigma_{f,0}' \phi_0(\vec{r})\right]$$
$$\Omega \cdot \nabla \psi^1(\vec{r},\Omega) + \Sigma_t^1(\vec{r})\psi^1(\vec{r},\hat{\Omega}) = \int \Sigma_s^{1\to 1} \psi_1(\vec{r},\Omega')d\Omega' + \frac{\chi_1}{4\pi}\left[\nu_1 \Sigma_{f,1}' \phi_1(\vec{r})\right]$$
$$\Omega \cdot \nabla \psi^2(\vec{r},\Omega) + \Sigma_t^2(\vec{r})\psi^2(\vec{r},\hat{\Omega}) = \int \Sigma_s^{2\to 2} \psi_2(\vec{r},\Omega')d\Omega' + \chi_2/4\pi\left[\nu_2 \Sigma_{f,2}' \phi_2(\vec{r})\right]$$
$$\Omega \cdot \nabla \psi^3(\vec{r},\Omega) + \Sigma_t^3(\vec{r})\psi^3(\vec{r},\hat{\Omega}) = \int \Sigma_s^{3\to 3} \psi_3(\vec{r},\hat{\Omega}')d\Omega' + \chi_3/4\pi\left[\nu_3 \Sigma_{f,3}' \phi_3(\vec{r})\right]$$
$$\Omega \cdot \nabla \psi^4(\vec{r},\Omega) + \Sigma_t^4(\vec{r})\psi^4(\vec{r},\hat{\Omega}) = \int \Sigma_s^{4\to 4} \psi_4(\vec{r},\Omega')d\Omega' + \chi_4/4\pi\left[\nu_4 \Sigma_{f,4}' \phi_4(\vec{r})\right]$$

4) $\int_{-1}^{1} P_i(x)P_j(x)\,dx = \delta_{i,j} = 0$ when $i \neq j$ [According to wikipedia] for orthonormal Legendre Polynomials

P_0 and P_1

$$\int_{-1}^{1} \frac{1}{\sqrt{2}}\left(\sqrt{\tfrac{3}{2}}x\right)dx$$
$$= \frac{\sqrt{3}}{2}\int_{-1}^{1} x\,dx = \frac{\sqrt{3}}{2}\left[\frac{x^2}{2}\right]_{-1}^{1}$$
$$= \frac{\sqrt{3}}{2}\left[\frac{1}{2} - \frac{1}{2}\right] = 0$$

P_0 and P_2

$$\int_{-1}^{1} \frac{1}{\sqrt{2}} \cdot \frac{\sqrt{5}}{\sqrt{2}}\left(\frac{3}{2}x^2 - \frac{1}{2}\right)dx$$
$$\frac{\sqrt{5}}{2}\int_{-1}^{1} \frac{3}{2}x^2 - \frac{1}{2}\,dx$$
$$= \frac{\sqrt{5}}{2}\left[\frac{1}{2}x^3 - \frac{1}{2}x\right]_{-1}^{1}$$
$$= \frac{\sqrt{5}}{2}\left[0 - 0\right] = 0$$

P_1 and P_2

$$\int_{-1}^{1} \frac{\sqrt{3}}{\sqrt{2}}x \cdot \frac{\sqrt{5}}{\sqrt{2}}\left(\frac{3}{2}x^2 - \frac{1}{2}\right)dx$$
$$= \frac{\sqrt{15}}{2}\int_{-1}^{1} \frac{3}{2}x^3 - \frac{1}{2}x\,dx$$
$$= \frac{\sqrt{15}}{2}\left[\frac{3}{8}x^4 - \frac{1}{4}x^2\right]_{-1}^{1}$$
$$= \frac{\sqrt{15}}{2}\left[\frac{1}{8} - \frac{1}{8}\right] = 0$$

∴ All 3 polynomials are orthonormal.

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NE 155
HW 2 Due 10/25

5a)

$$\int_{4\pi} |\hat{\Omega}|\, \partial\hat{\Omega} = 4\int_0^{\pi}\int_0^{\pi} \sin(\theta)\,\partial\theta\,\partial\phi \rightarrow 4\int_{\mu_1}^{\mu_2}\int_{\mu_1}^{\mu_2} \sin\theta\,\partial\theta\,\partial\phi \cdot w_1$$

$$= 4w\int_{\mu_1}^{\mu_2} -\cos\theta \Big|_{\mu_1}^{\mu_2} \partial\phi = 4w\int_{\mu_1}^{\mu_2} \cos\mu_1 - \cos\mu_2 \,\partial\phi = 4w(\cos\mu_1 - \cos\mu_2)(\mu_2-\mu_1)$$

$$= 4\left(\tfrac{1}{3}\right)\left[\cos(.3500212) - \cos(.8688903)\right](.8688903 - .3500212)$$

$$= .20138$$

5b) $\int_{4\pi} |\hat{\Omega}|\, \partial\hat{\Omega} \approx 4w_1w_3\int_{\mu_1}^{\mu_3}\int_{\mu_1}^{\mu_3} \sin\theta\,\partial\theta\,\partial\theta = 4w_1w_3(\cos\mu_1 - \cos\mu_3)[\mu_3-\mu_1]$

$= .0265723457$, we find that we can integrate more of the surface with higher-order quadratures.

In [8]:
```
import scipy.integrate as integrate
import math

def integrand (x, a, b):
    return math.sin(x)*a*b
```

In [24]:
```
#We gather the following values from table 4-1 to complete the S6 integration:
LBmu = .2666355 #Lower Bound Mu
UBmu = .9261808 #Upper-Bound Mu
w1 = .1761263 #Lower-bound weight
w2 = .1572071 #Upper-bound weight
a = 1
b = 1
c = scipy.integrate.quad(integrand, LBmu, UBmu)
ans = (4*w1*w2) * (UBmu-LBmu) * c[0]
print(ans)
```

```
0.026572345718464667
```