NUCLEAR ENGINEERING, UC BERKELEY

HW4 for Numerical Simulation of Radiation Transport

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PROBLEM 1

Calculate an integration $I = \int_{x_{min}}^{x_{max}} f(x)dx$ using rejection Monte Carlo method procedures:

1) Sample random points in the rectangle area [xmin, xmax]*[0, fmax]:

$$\begin{aligned} x_p = x_{min} + (x_{max} - x_{min}) * \xi_1 \\ y_p = 0 + fmax * \xi_2 \end{aligned} \tag{1}$$

2) For each random point P (px, py), check if it's under the function curve, i.e. if $y_p \leq f(x_p)$. If this is true, accept the point, otherwise reject the point.

3) The probability for a point to be accepted is approximately

$$prob = \frac{N_{accept}}{N_{tot}} \tag{2}$$

4) The integral is I = Area * prob where Area = (xmax- xmin)*fmax

Assuming the true value for π is 3.14159, the result for $\pi = 4\int_0^1 sqrt(1-x^2)dx$ and $\pi = 4\int_0^1 \frac{1}{1+x^2}$ with different numbers of samples is listed in table 2:

nb	f1 relative error	f2 relative error
10	0.036	0.108
100	0.082	0.0196
1000	0.0186	0.0377
10000	0.0025	0.0013

Table 1: Relative error of rejection Monte Carlo method for integral calculation

PROBLEM 3

N_{TOT}	P_{escR}	P_{escL}	f2 relative error
125	10	0.036	0.108
250	100	0.082	0.0196
500	1000	0.0186	0.0377
1000	10000	0.0025	0.0013

Table 2: Relative error of rejection Monte Carlo method for integral calculation

PROBLEM 4

a) The photon from the beam incident to the face of the slab, at z0=0 with the angle $\mu = 1$.

The total collision cross section can be found online as attenuation coefficient:

$$\rho_{concrete} = 2.3(g/cm^3)$$
$$\mu_{tot} = 4.557 * 0.01 * rho(cm) \tag{3}$$

Sample the distance to collision:

$$dist = -1/\mu_{tot} ln(\xi_3) \tag{4}$$

b) So the first interaction would be at $z1 = z0 + dist = dist$ if z1 is within the slab [0, 5]cm.

c) Determine the collision type: absorption or scattering: To do so, we need to at first calculate the scattering cross section. The mocroscopic total Compton scattering

isotope Z	weight fraction(%)
1	0.022100
6	0.002484
8	0.574930
11	0.015208
12	0.001266
13	0.019953
14	0.304627
19	0.010045

Table 3: Ordinary concrete composition

cross section can be obtain as:

$$\begin{aligned}
\sigma_{cs} &= 2\pi r_0\{\frac{1+\alpha}{\alpha^2}[\frac{2(1+\alpha)}{1+2\alpha} - \frac{1}{\alpha} ln(1+2\alpha)] + [\frac{1}{2\alpha} ln(1+2\alpha) - \frac{1+3\alpha}{(1+2\alpha)^2}]\}[cm^2] \\
\alpha &= \frac{E_{in}}{m_0 c^2} \\
r_0 &= \frac{e^4}{(m_0 c^2)^2}
\end{aligned} \tag{5}$$

The macroscopic Compton scattering cross section is:

$$\mu_{cs} = \sigma_{cs} * N \tag{6}$$

The atomic number density N can be calculated from :

$$N = \rho * Av/A \tag{7}$$

The average atomic mass A for ordinary concrete can be calculated from the material composition in table 3

the Z/A ratio for ordinary concrete is 0.50932.