Computational Physics

Problem Set 6, October 7, 2025

Due: Monday, October 13, 2025 **by 11:59 PM**

Link to join GitHub classroom to submit homework solution: **Click here**.

Submit to the TA a link to the repository checked into your GitHub account containing a Jupyter Notebook including solutions for homework problems. The directory tree of the repository should include a directory for "homework" with subdirectories for each individual homework assignment.

You *must* label all axes of all plots, including the units if applicable.

1 Neutron Scattering Analysis (25%)

Table 1: Experimental values for a scattering cross section $f(E)$.

$i =$	1	2	3	4	5	6	7	8	9
E_i (MeV)	0	25	50	75	100	125	150	175	200
$f(E_i)$ (mb)	10.6	16.0	45.0	83.5	52.8	19.9	10.8	8.25	4.7

Use the data in Table 1 above.

A) Write a script to perform Lagrange interpolation on the entire spectrum with one polynomial, i.e. fit all nine data points with an 8$^{\text{th}}$-order polynomial. Do NOT use a pre-written code, such as scipy.interpolate.lagrange.

B) Plot the points and the interpolating polynomial. Find the resonance energy E_r (the peak position) and Γ (the full-width at half-maximum) such that

$$\begin{aligned} \left.\frac{df}{dE}\right|_{E=E_r} &= 0 \\ f(E_r \pm \Gamma_\pm) &= \frac{f(E_r)}{2} \\ \Gamma &= \frac{\Gamma_+ + \Gamma_-}{2} \,. \end{aligned} \tag{1}$$

Do not use numerical root-finding or optimization methods. Just read it from the plot with a precision of 2 significant figures. Compare this result with the theoretical prediction $(E_r, \Gamma) = (78{,}55)$ MeV. Does this match?

C) Write a script to perform a Lagrange *local* interpolation using 3 points per interval.

D) Make a new plot with the points and the new interpolation. Do E_r and Γ match the theory numbers better?

2 Inverse Power Distribution (25%)

In this problem you will code a random number generator for an inverse power law distribution given by

$$f(x) \propto \frac{1}{(1+x)^n} \tag{2}$$

where $n > 1$ and $0 < x < \infty$.

A) Normalize $f(x)$ for a general $n > 1$ over the denoted x range.

B) Derive the transformation $x(r)$ where x is drawn from $f(x)$ and r is drawn from a uniform distribution $U(0, 1)$. Note: just providing $r(x)$ is unacceptable.

C) Write a script that draws random x from this distribution. Make a plot with a curve for the distribution and a histogram of 10,000 drawn values for $n = 4$. Does the histogram match the distribution $f(x)$?

3 Radioactive decay chain I (30%)

Exercise 10.2 in *Newman* (pg. 456).

4 Radioactive decay chain II (20%)

B) Exercise 10.4 in *Newman* (pg. 460).