# PHYS 3142 Spring 2021
# Computational Methods in Physics
# Assignment 5
# Due: 11:59 p.m. 15th March 2021

Before you submit your assignment, do remember:

1. the due day
2. submit a report which contains your figures and results along with your code
3. make sure your code can run
4. do not forget to write comments in your codes.
5. label your figures and describle your results

The basic scoring rubric is :

1. **If you submit the assignment after the deadline or do not submit the report, you can only get up to 80% of grade**
2. **If there is any kind of plagiarism, all of the student involving will get zero mark! (except that the one can really prove the code is written by himself or herself and others copied it without telling him or her)**

**1. Numerical integrals**

Please calculate the following integral by using different methods:

$$I = \int_0^1 \frac{x^{-1/4}}{e^x + x^{3/4} + 2} dx \tag{1}$$

1. Please choose one of the numerical methods including : rectangle method, adaptive trapezoidal, adaptive simpson, gaussian quadrature; with the accuracy $10^{-5}$ of to do the integration

2. Use importance smapling method to do the integration and compare the results with the uniform sampling mean value method. Show the figure as the slide: Lec9 No.6. Note that you need to show the derivation for choosing the $w(x)$ and transforing the integrand.

3. Use MCMC (Markov chain Monte Carlo) to calculate the result and show the final result with error.

**2. Balance principle**

Please proof that, in Metropolis Algorithm, transition matrix $T(x_i \to x_j) = \min\left\{1, \frac{p(x_j)}{p(x_i)}\right\}$ satisfy detailed balance principle:$T_{ij}p(x_i) = T_{ji}p(x_j)$.

**3. Monty Hall Simulation (Optional, just for exercise and will not be marked)**

The Monty Hall problem is a brain teaser, in the form of probability puzzle and named after it s original host, Monty Hall.

Suppose you're on a game show, and you're given the choice of three doors: Behind one door is a car; behind the others, goats. You pick a door, say No. 1, and the host, who knows what's behind the doors, opens another door, say No. 3, which has a goat. He then says to you, "Do you want to pick door No. 2?" Is it to your advantage to switch your choice?

Let's define the statement more clearly:

1. The contestant have to pick a door without knowing where the car is.

2. The host must know what's behind every door.

3. The host must always open one of the remaining door and offer the chance to switch between the originally chosen door and the remaining closed door.

4. The host will always open the door behind what is goat which means: 1. if the contestant picks the goat door, the host must open the other goat; 2. if the contestant picks the car door, the host will randomly open the remaining doors (with equal possibility).

1. Please write the code with the input choice "Switch No.1 to No.2, yes or no" and give the answer (you win the car or you lose the car) based on the choice.

In this question, we suppose that every time the car door is No.1. First, you need to generate the random number between 1 to 3 which will be the original choice of the contestant; then generate the random number between 2 to 3 which will be the possible door the host will open without a car(be careful here since we cannot open the door the contestant chosen already); finally you need to give the output based on the choice by the input.

2. Please write the code with N $=10^6$ simulation times and tell the possibilty to win if you switch the door ($P_1$) and don't switch the door ($P_2$).

Note, here we don't need to print the answer every time, just save it as list or just do the counting.

3. Now, if we change the assumption to that host doesn't know what's behind every door and if the host opens the door with a car behind, this simulation won't count. Show the possibilty to win if you switch the door ($P_1$) and don't switch the door ($P_2$).