ID-2023

Assignment 1: Particle Distribution

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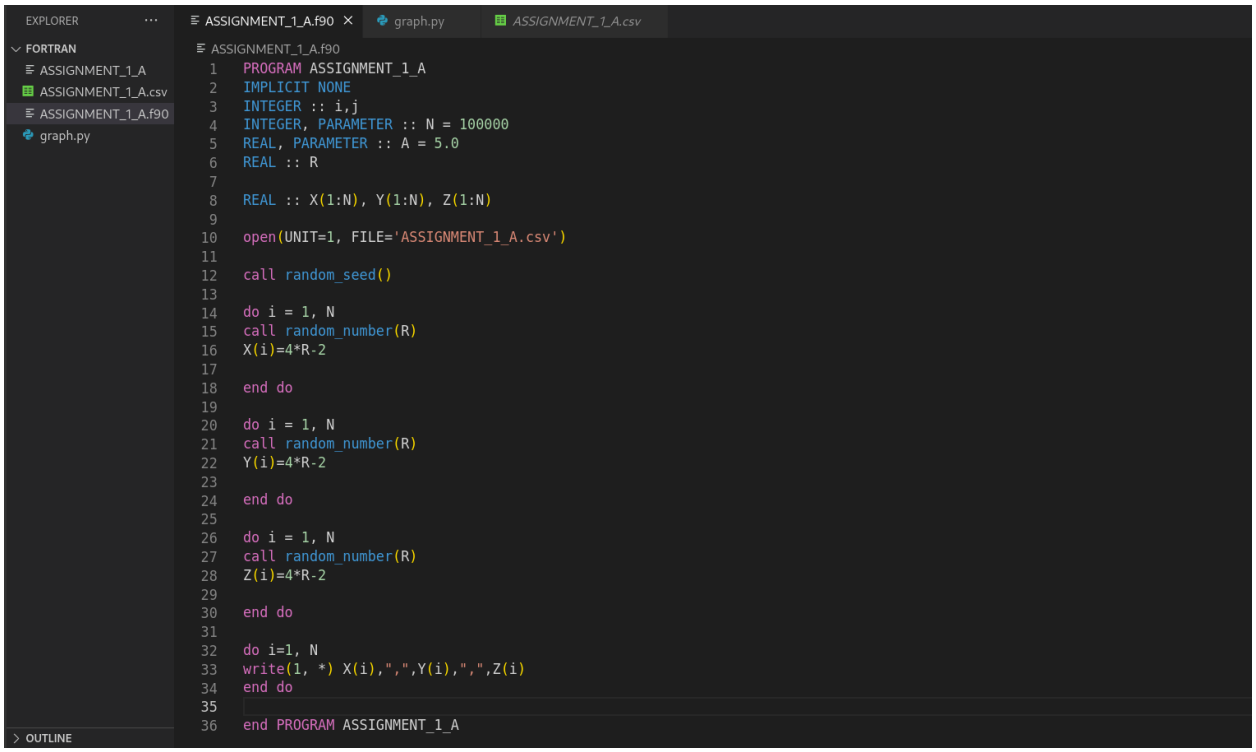
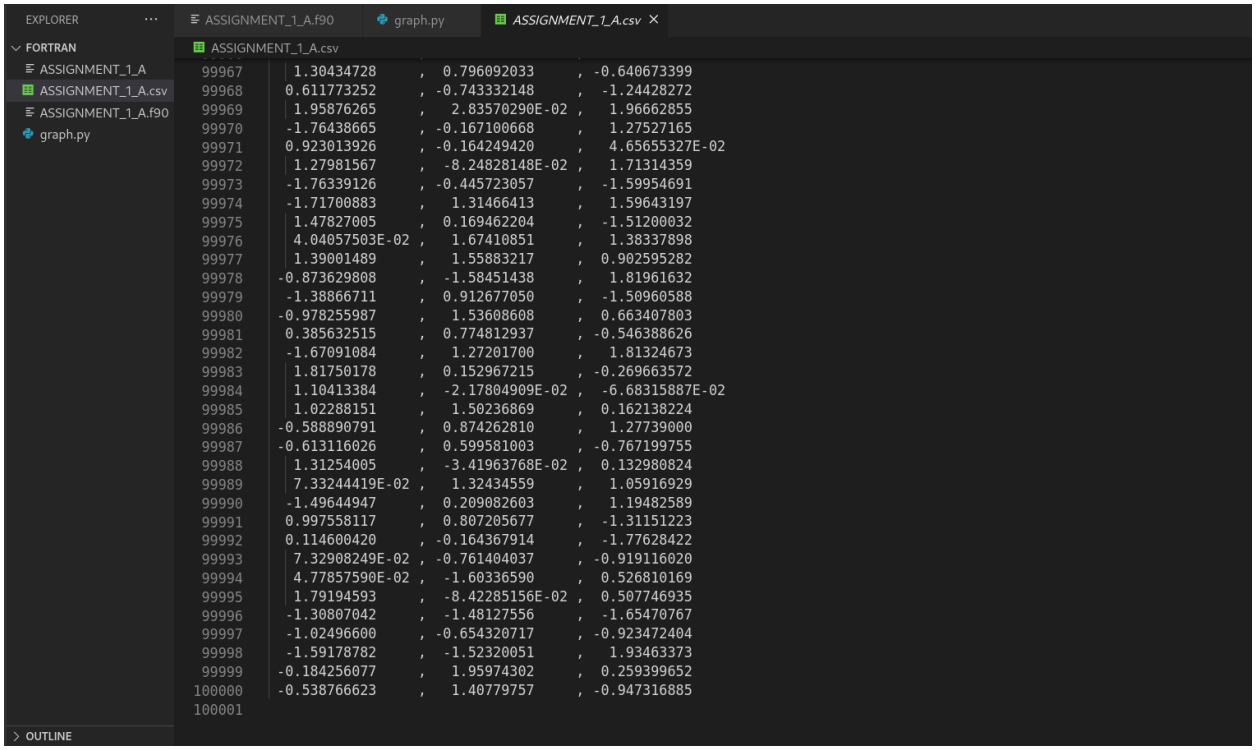
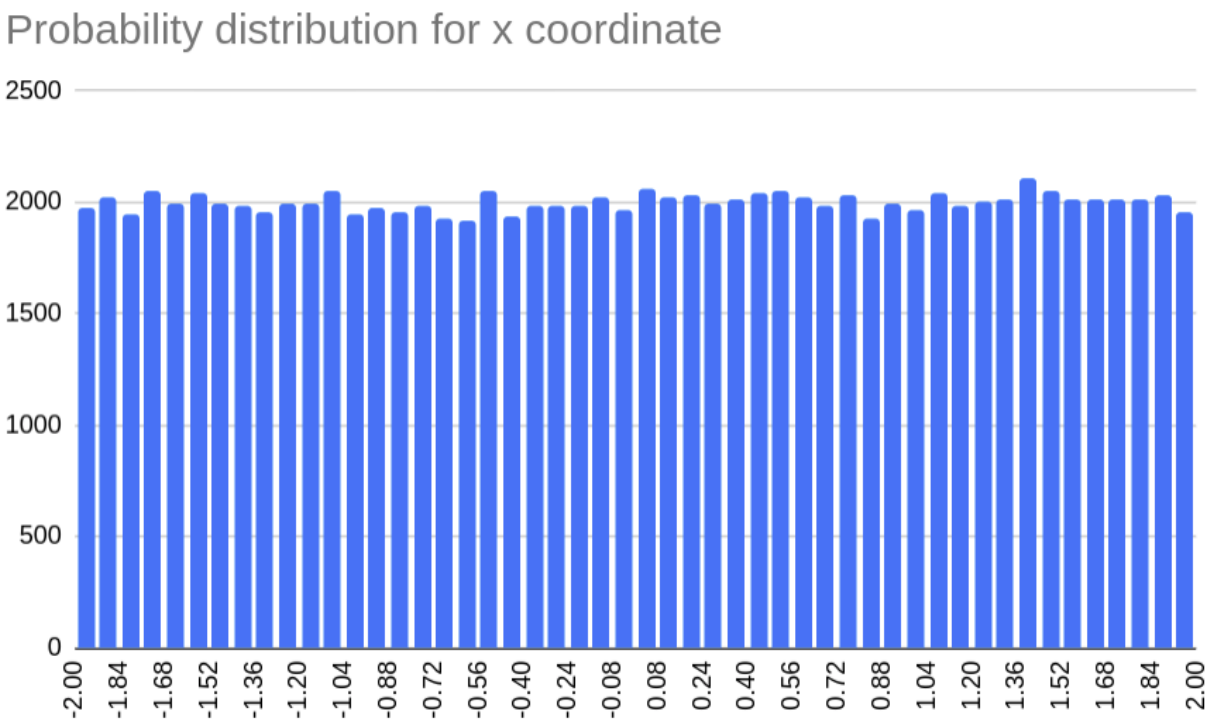
Part A1

Distribute 1 Lakh particles randomly and uniformly in a box of size -2 units to +2 units in all x, y and z-directions. Plot the probability distribution of the random numbers as a function of the value of the random number.

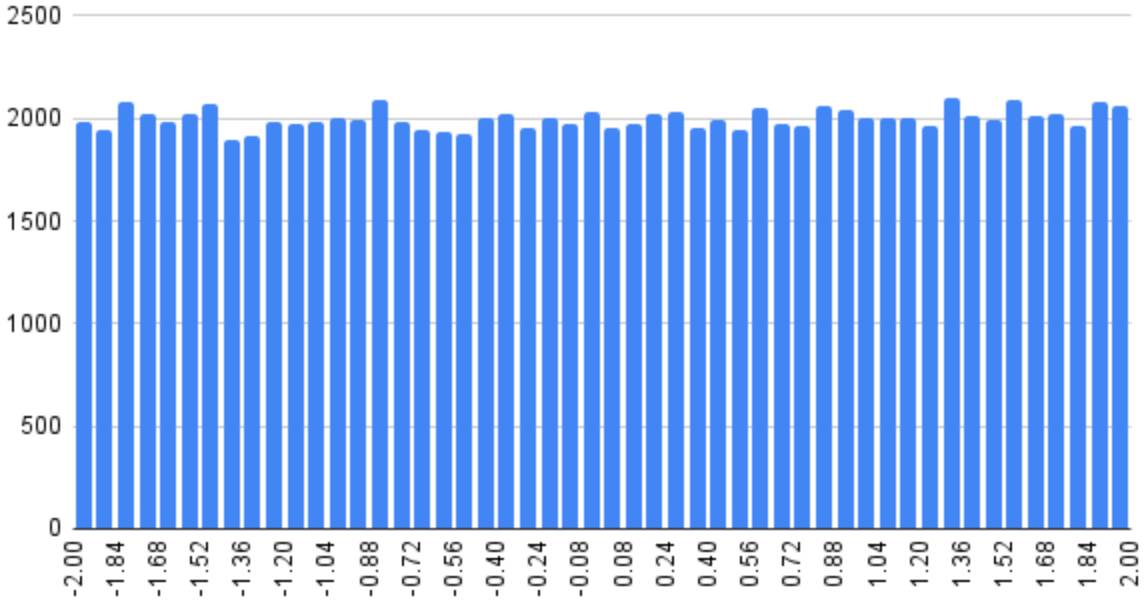
In this question we will execute the programme indicated below to generate a CSV file containing the x, y, and z values of our 1 lakh particles, and then we will draw the Probability distribution for them.



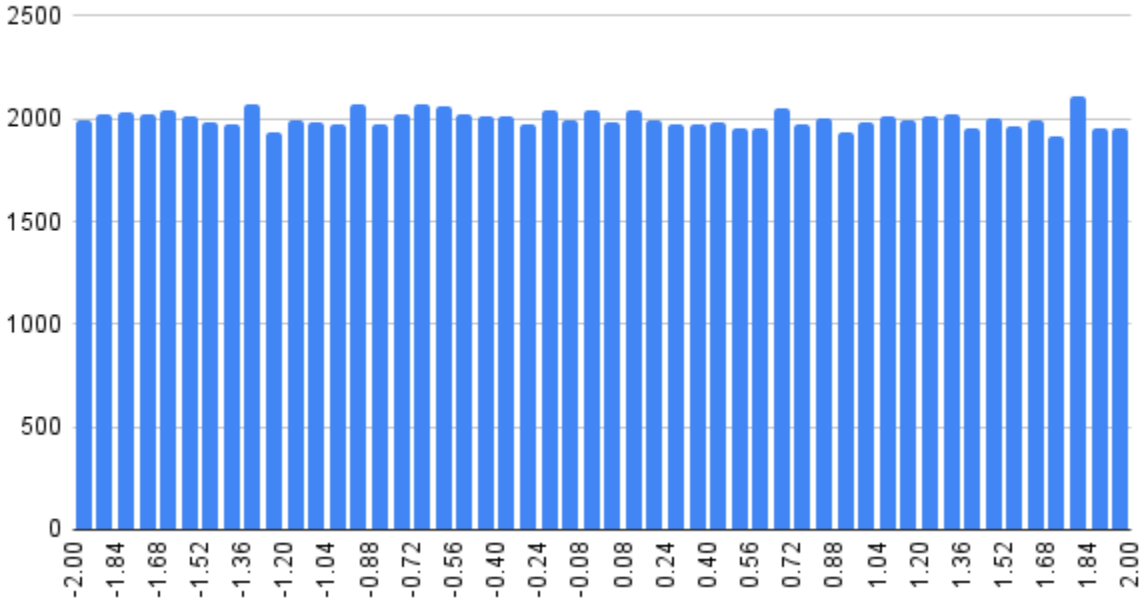

EXPLORER
FORTRAN
ASSIGNMENT_1_A
ASSIGNMENT_1_A.csv
ASSIGNMENT_1_A.f90
graph.py
OUTLINE
ASSIGNMENT_1_A.f90
graph.py
ASSIGNMENT_1_A.csv
ASSIGNMENT_1_A.csv
99967 1.30434728 , 0.796092033 , -0.640673399
99968 0.611773252 , -0.743332148 , -1.24428272
99969 1.95876265 , 2.83570290E-02 , 1.96662855
99970 -1.76438665 , -0.167100668 , 1.27527165
99971 0.923013926 , -0.164249420 , 4.65655327E-02
99972 1.27981567 , -8.24828148E-02 , 1.71314359
99973 -1.76339126 , -0.445723057 , -1.59954691
99974 -1.71700883 , 1.31466413 , 1.59643197
99975 1.47827005 , 0.169462204 , -1.51200032
99976 4.04057503E-02 , 1.67410851 , 1.38337898
99977 1.39001489 , 1.55883217 , 0.902595282
99978 -0.873629808 , -1.58451438 , 1.81961632
99979 -1.38866711 , 0.912677050 , -1.50960588
99980 -0.978255987 , 1.53608608 , 0.663407803
99981 0.385632515 , 0.774812937 , -0.546388626
99982 -1.67091084 , 1.27201700 , 1.81324673
99983 1.81750178 , 0.152967215 , -0.269663572
99984 1.10413384 , -2.17804909E-02 , -6.68315887E-02
99985 1.02288151 , 1.50236869 , 0.162138224
99986 -0.588890791 , 0.874262810 , 1.27739000
99987 -0.613116026 , 0.599581003 , -0.767199755
99988 1.31254005 , -3.41963768E-02 , 0.132980824
99989 7.33244419E-02 , 1.32434559 , 1.05916929
99990 -1.49644947 , 0.209082603 , 1.19482589
99991 0.997558117 , 0.807205677 , -1.31151223
99992 0.114600420 , -0.164367914 , -1.77628422
99993 7.32908249E-02 , -0.761404037 , -0.919116020
99994 4.77857590E-02 , -1.60336590 , 0.526810169
99995 1.79194593 , -8.42285156E-02 , 0.507746935
99996 -1.30807042 , -1.48127556 , -1.65470767
99997 -1.02496600 , -0.654320717 , -0.923472404
99998 -1.59178782 , -1.52320051 , 1.93463373
99999 -0.184256077 , 1.95974302 , 0.259399652
100000 -0.538766623 , 1.40779757 , -0.947316885
100001


Probability distribution for x coordinate
2500
2000
1500
1000
500
0
-2.00
-1.84
-1.68
-1.52
-1.36
-1.20
-1.04
-0.88
-0.72
-0.56
-0.40
-0.24
-0.08
0.08
0.24
0.40
0.56
0.72
0.88
1.04
1.20
1.36
1.52
1.68
1.84
2.00

Probability distribution for y coordinate



Probability distribution for Z coordinate



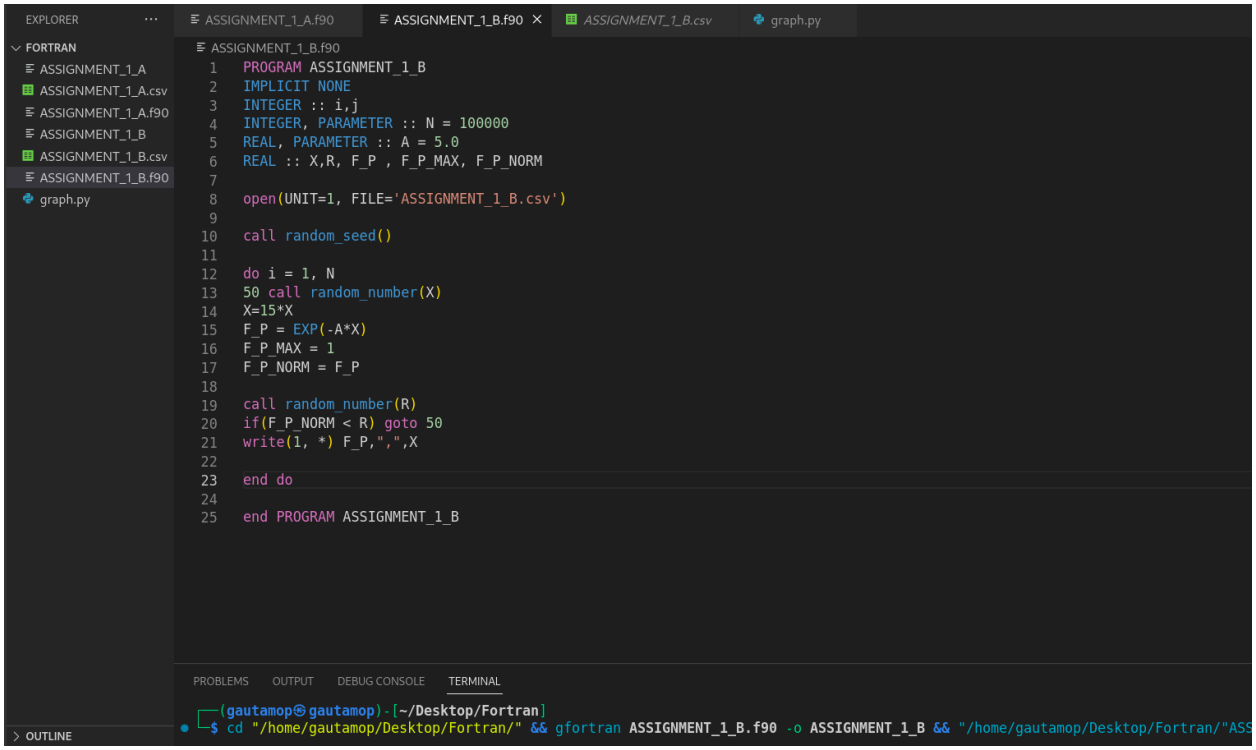
Part B

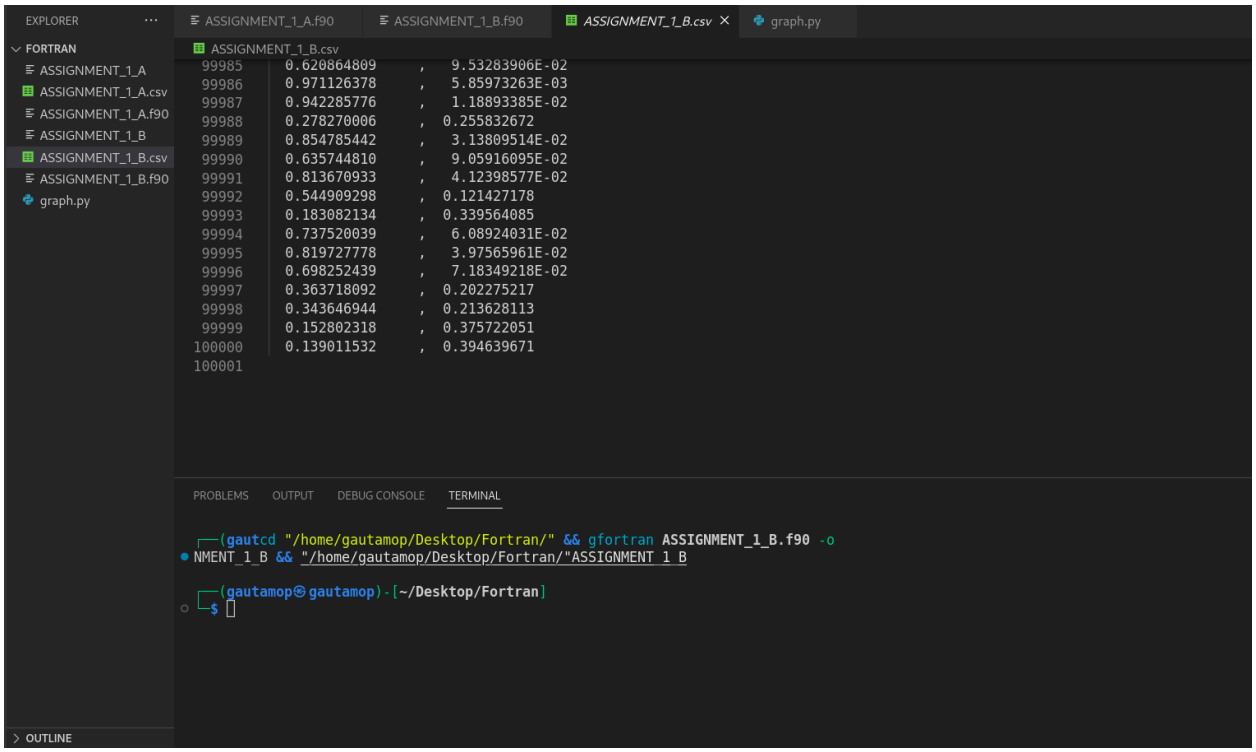
Distribute 1 Lakh particles following the thermal distribution for massless particles, say, f(p) = exp(-pc/kT) from p=0 to p=15 units. The values of the parameters are c = 1 unit, k = 1 unit, and T= 0.2 units.

a. Plot the probability distribution of the random numbers as a function of the value of the random number

b. Compare numerical and analytical probability distributions.

Assigning a momentum in the range of 0 to 15 based on a second random option to accept or reject the momentum depending on whether r < exp(-pc/ kT) is how we will mimic the distribution for part B. As demonstrated in the code below:


EXPLORER
ASSIGNMENT_1_A.f90
ASSIGNMENT_1_B.f90
ASSIGNMENT_1_B.csv
graph.py
FORTRAN
ASSIGNMENT_1_A
ASSIGNMENT_1_A.csv
ASSIGNMENT_1_A.f90
ASSIGNMENT_1_B
ASSIGNMENT_1_B.csv
ASSIGNMENT_1_B.f90
graph.py
PROGRAM ASSIGNMENT_1_B
IMPLICIT NONE
INTEGER :: i,j
INTEGER, PARAMETER :: N = 100000
REAL, PARAMETER :: A = 5.0
REAL :: X,R, F_P , F_P_MAX, F_P_NORM
open(UNIT=1, FILE='ASSIGNMENT_1_B.csv')
call random_seed()
do i = 1, N
50 call random_number(X)
X=15*X
F_P = EXP(-A*X)
F_P_MAX = 1
F_P_NORM = F_P
call random_number(R)
if(F_P_NORM < R) goto 50
write(1, *) F_P,",",X
end do
end PROGRAM ASSIGNMENT_1_B
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
(gautamop㉿gautamop)-[~/Desktop/Fortran]
$ cd "/home/gautamop/Desktop/Fortran/" && gfortran ASSIGNMENT_1_B.f90 -o ASSIGNMENT_1_B && "/home/gautamop/Desktop/Fortran/"ASS
OUTLINE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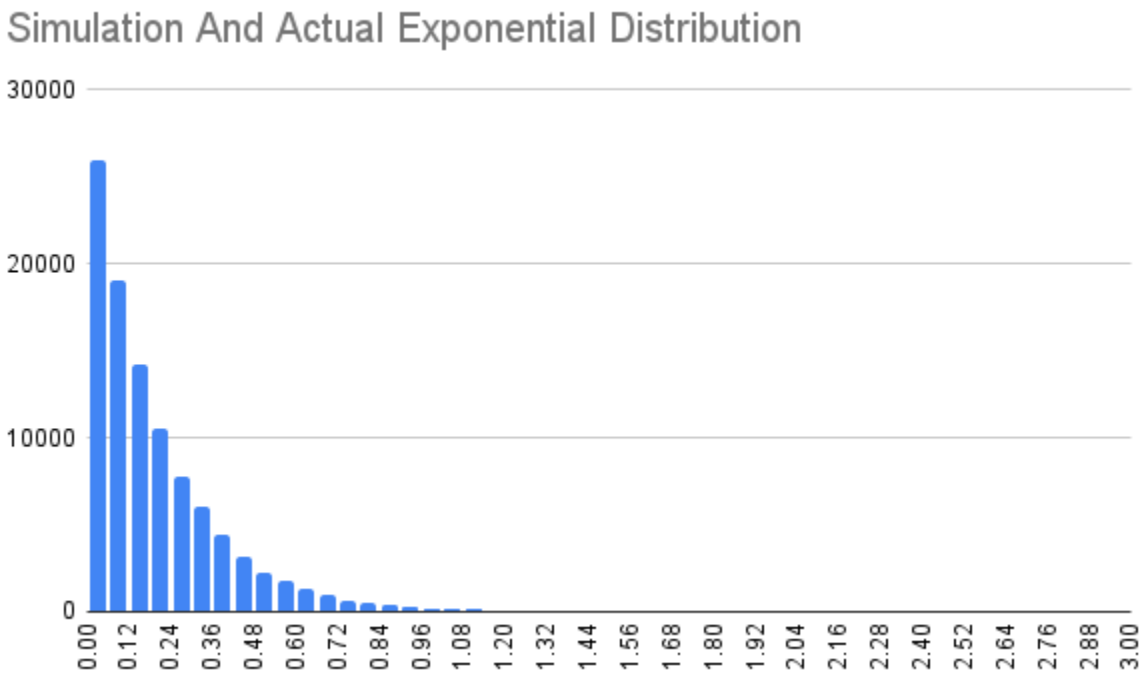
ASSIGNMENT_1_B
ASSIGNMENT_1_B.csv
ASSIGNMENT_1_B.f90
graph.py
99985 0.620864809 , 9.53283906E-02
99986 0.971126378 , 5.85973263E-03
99987 0.942285776 , 1.18893385E-02
99988 0.278270006 , 0.255832672
99989 0.854785442 , 3.13809514E-02
99990 0.635744810 , 9.05916095E-02
99991 0.813670933 , 4.12398577E-02
99992 0.544909298 , 0.121427178
99993 0.183082134 , 0.339564085
99994 0.737520039 , 6.08924031E-02
99995 0.819727778 , 3.97565961E-02
99996 0.698252439 , 7.18349218E-02
99997 0.363718092 , 0.202275217
99998 0.343646944 , 0.213628113
99999 0.152802318 , 0.375722051
100000 0.139011532 , 0.394639671
100001
PROBLEMS
OUTPUT
DEBUG CONSOLE
TERMINAL
(gautcd "/home/gautamop/Desktop/Fortran/" && gfortran ASSIGNMENT_1_B.f90 -o
NMENT_1_B && "/home/gautamop/Desktop/Fortran/"ASSIGNMENT_1_B
(gautamop㉿gautamop)-[~/Desktop/Fortran]
$
OUTLINE

The simulated graph is shown here -



Part C

Calculate the average energy of the system.

We will now use our distribution to get the average momentum, averaging the momenta of all the particles as illustrated below:

$$E = \frac{\sum Ep}{10000}$$

Ep - Energy of each individual particle

$$E = \frac{20013.2}{10000} = 0.20013$$

Thank You