COIN TOSSING

Before moving to the practical lets see the basic terms and definition for proper understanding:

Macrostate:

It refers to a set of macroscopic properties that describe the system as a whole, such as temperature (T), volume (V), and total energy (E). It is the specification of the number of particles in each compartment of a system. It can be calculated by the following formula:

$$\Omega_{macro} = n + 1$$

Where:
- Ω_{macro} is the number of microstates.
- n is the number of particles.

For example, while tossing two coins, the total number of microstates will be two where we can arrange the outcomes such as head and tail.

Microstate:

A microstate refers to a specific microscopic configuration of the individual particles (atoms, molecules, etc.) that make up a system. It describes the precise arrangement of positions and momenta of all particles at a given instant for a particular macrostate. It helps us to calculate the entropy of the system as

$$S = k_B \ln \Omega$$

Where:
- S is the entropy of the system,
- k_B is the Boltzmann constant,
- Ω is the total number of microstates of the system.

Thermodynamic Probability:

It provides the likelihood of different microscopic configurations (microstates) within a given macroscopic state (macrostate) of a system. It helps predict how particles distribute themselves in terms of energy, position, and momentum. It can be calculated by the given formula

$$W = \frac{n!}{n_1! \cdot n_2! \cdot \ldots \cdot n_k!}$$

Where:
- n is the total number of particles,
- $n_1, n_2, \ldots, n_k$ are the number of particles in each microstate.

- k is the number of microstates.

Total Probability:

Total probability of a microstate is given by the formula

$$P = \frac{W}{k^n}$$

Where
- P is the total probability
- W is the thermodynamic probability
- k is the total number of microstate
- n is the total number of particles

Example:

Let we have to arrange **four particles** in **two compartments** so

Macrostates	Microstates Compartment 1	Microstates Compartment 2	Thermodynamic Probability	Total Probability
(0,4)	-	ABCD	$\frac{4!}{0!4!} = 1$	$\frac{1}{2^4} = 0.0625$
(1,3)	D A B C	ABC BCD CDA DAB	$\frac{4!}{1!3!} = 4$	$\frac{4}{2^4} = 0.25$
(2,2)	AB BC CD DA AC BD	CD DA AB BC BD AC	$\frac{4!}{2!2!} = 6$	$\frac{6}{2^4} = 0.375$
(3,1)	ABC BCD CDA DAB	D A B C	$\frac{4!}{3!1!} = 4$	$\frac{4}{2^4} = 0.25$
(4,0)	ABCD	-	$\frac{4!}{4!0!} = 1$	$\frac{1}{2^4} = 0.0625$

EXPERIMENT 4

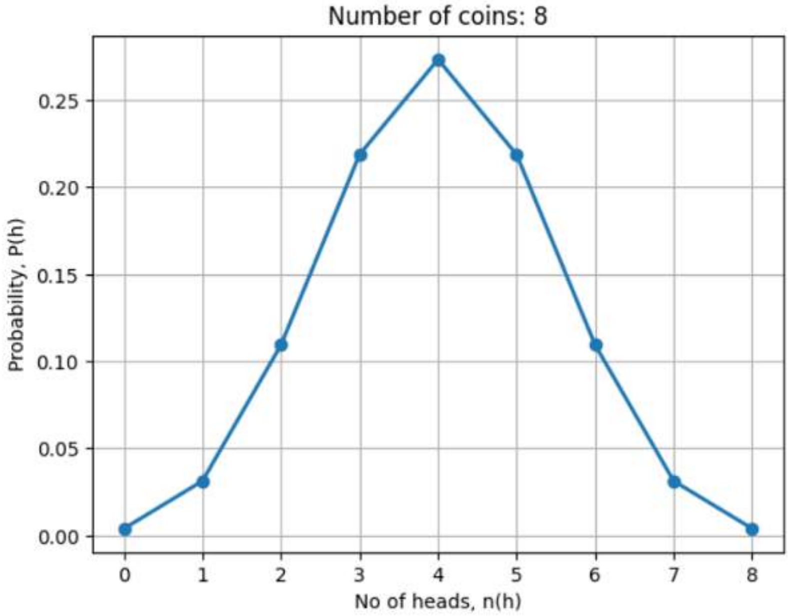
AIM: Find the probability of various macrostates of coin tossing of coin tossing (two level system) vs no heads for 4, 8, 16 coins.

CODE:

```
import numpy as np
import matplotlib.pyplot as plt
import math

n = int(input("Enter the number of coins: ")) # Input the number of coins
nm = 2**n # Calculate the number of microstates

# Arrays to store the number of heads and corresponding probabilities
h = []
P = []
print("n(h) P(h)")

# Calculate probability for each number of heads
for j in range(n + 1):
    ns = math.factorial(n) / (math.factorial(j) * math.factorial(n - j))
    prob = ns / nm
    h.append(j)
    P.append(prob)
    print(f"{j} {prob:.6f}")

# Plotting the graph
plt.plot(h, P, 'o-', linewidth=2)
plt.title(f"Number of coins: {n}", fontsize=12)
plt.xlabel("No of heads, n(h)", fontsize=10)
plt.ylabel("Probability, P(h)", fontsize=10)
plt.grid(True)
plt.show()
```


OUTPUT:

```
Enter the number of coins: 8
n(h) P(h)
0 0.003906
1 0.031250
2 0.109375
3 0.218750
4 0.273438
5 0.218750
6 0.109375
7 0.031250
8 0.003906
```


Number of coins: 8
Probability, P(h)
0.00
0.05
0.10
0.15
0.20
0.25
0
1
2
3
4
5
6
7
8
No of heads, n(h)