5

PROBABILITY

All business proceeds on beliefs, or judgments of probabilities, and not on certainty - CHARLES ELIOT

Main Targets

- To understand repeated experiments and observed frequency approach of Probability
- To understand Empirical Probability

Richard Von Mises
(1883-1953)

The statistical, or empirical, attitude toward probability has been developed mainly by R.F. Fisher and R. Von Mises. The notion of sample space comes from R.Von Mises. This notion made it possible to build up a strictly mathematical theory of probability based on measure theory. Such an approach emerged gradually in the last century under the influence of many authors. An axiomatic treatment representing the modern development was given by A. Kolmogorov.

5.1 Introduction

From dawn to dusk any individual makes decisions regarding the possible events that are governed at least in part by chance. Few examples are: "Should I carry an umbrella to work today?", "Will my cellphone battery last until tonight?", and "Should I buy a new brand of laptop?". Probability provides a way to make decisions when the person is uncertain about the things, quantities or actions involved in the decision. Though probability started with gambling, it has been used extensively, in the fields of Physical Sciences, Commerce, Biological Sciences, Medical Sciences, Insurance, Investments, Weather Forecasting and in various other emerging areas.

Consider the statements:

- ***Probably*** Kuzhalisai will stand first in the forth coming annual examination.
- ***Possibly*** Thamizhisai will catch the train today.
- The prices of essential commodities are ***likely*** to be stable.
- There is a ***chance*** that Leela will win today's Tennis match.

The words "***Probably***", "***Possibly***" , "***Likely***", "***Chance***" , etc., will mean "the lack of certainty" about the events mentioned above. To measure "the lack of certainty

Mathematics

or uncertainty", there is no perfect yardstick, i.e., uncertainty is not perfectly quantifiable one. But based on some assumptions uncertainty can be measured mathematically. This numerical measure is referred to as probability. It is a purposeful technique used in decision making depending on, and changing with, experience. Probability would be effective and useful even if it is not a single numerical value.

5.2 Basic Concepts and Definitions

Before we start the theory on Probability, let us define some of the basic terms required for it.

- Experiment
- Random Experiment
- Trial
- Sample Space
- Sample Point
- Events

Key Concept	**Experiment**
An ***experiment*** is defined as a process whose result is well defined	

Experiments are classified broadly into two ways:

EXPERIMENT

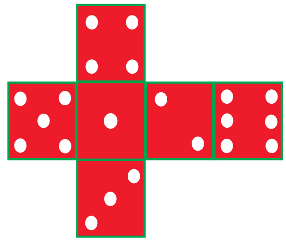
DETERMINISTIC

RANDOM

1. ***Deterministic Experiment*** : It is an experiment whose outcomes can be predicted with certainty, under identical conditions.

For example, in the cases-when we heat water it evaporates, when we keep a tray of water into the refrigerator it freezes into ice and while flipping an unusual coin with heads on both sides getting head - the outcomes of the experiments can be predicted well in advance. Hence these experiments are deterministic.

2. ***Random Experiment*** : It is an experiment whose all possible outcomes are known, but it is not possible to predict the exact outcome in advance.



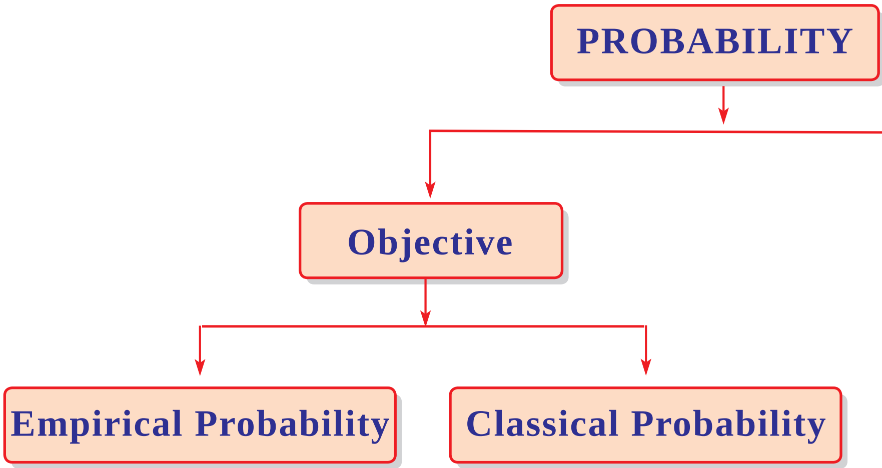
For example, consider the following experiments:

(i) A coin is flipped (tossed)

(ii) A die is rolled.

These are random experiments, since we cannot predict the outcome of these experiments.

Key Concept		
Trial	A Trial is an action which results in one or several outcomes.	For example, " Flipping" a coin and "Rolling" a die are trials
Sample Space	A sample space S is the set of all possible outcomes of a random experiment.	For example, While flipping a coin the sample space, S = { Head, Tail} While rolling a die, sample space S = { 1, 2, 3, 4, 5, 6}
Sample Point	Each outcome of an experiment is called a sample point.	While flipping a coin each outcome {Head}, {Tail} are the sample points. While rolling a die each outcome, {1} {2} {3} {4} {5} and {6} are are corresponding sample points
Event	Any subset of a sample space is called an event.	For example, When a die is rolled some of the possible events are {1, 2, 3}, {1, 3}, {2, 3, 5, 6}



5.3 Classification of Probability

According to various concepts of probability, it can be classified mainly in to three types as given below:

(1) Subjective Probability

(2) Classical Probability

(3) Empirical Probability

5.3.1 Subjective Probability

Subjective probabilities express the strength of one's belief with regard to the uncertainties. It can be applied especially when there is a little or no direct evidence about the event desired, there is no choice but to consider indirect evidence, educated guesses and perhaps intuition and other subjective factors to calculate probability .

5.3.2 Classical Probability

Classical probability concept is originated in connection with games of chance. It applies when all possible outcomes are equally likely. If there are n equally likely possibilities of which one must occur and s of them are regarded as favorable or as a *success* then the probability of a *success* is given by (s/n).

5.3.3 Empirical Probability

It relies on actual experience to determine the likelihood of outcomes.

5.4 Probability - An Empirical Approach

In this chapter, we shall discuss only about empirical probability. The remaining two approaches would be discussed in higher classes. *Empirical* or *experimental* or *Relative frequency Probability* relies on actual experience to determine the likelihood of outcomes.

Empirical approach can be used whenever the experiment can be repeated many times and the results observed. Empirical probability is the most accurate scientific 'guess' based on the results of experiments about an event.

For example, the decision about people buying a certain brand of a soap, cannot be calculated using classical probability since the outcomes are not equally likely. To find the probability for such an event, we can perform an experiment such as you already have or conduct a survey. This is called collecting experimental data. The more data we collect the better the estimate is.

Key Concept **Empirical Probability**

Let m be the number of trials in which the event E happened (number of observations favourable to the event E) and n be the total number of trials (total number of observations) of an experiment. The empirical probability of happening of an event E, denoted by P(E), is given by

$$P(E) = \frac{\text{Number of trials in which the event happened}}{\text{Total number of trials}}$$

(or)

$$P(E) = \frac{\text{Number of favourable observations}}{\text{Total number of observations}}$$

$$\therefore\ P(E) = \frac{m}{n}$$

Clearly $0 \le m \le n \implies 0 \le \frac{m}{n} \le 1$, hence $0 \le P(E) \le 1$.

$$\boxed{0 \le P(E) \le 1}$$

i.e.the probability of happening of an event always lies from 0 to 1.

Probability is its most general use is a measure of our degree of confidence that a thing will happen. If the probability is 1.0, we know the thing happen certainly, and if probability is high say 0.9, we feel that the event is likely to happen. A probability of 0.5 denotes that the event is a equally likely to happen or not and one of 0 means that it certainly will not. This interpretation applied to statistical probabilities calculated from frequencies is the only way of expecting what we know of the individual from our knowledge of the populations.

Remark

If $P(E) = 1$ then E is called **Certain event** or **Sure event.**

If $P(E) = 0$ then E is known is an **Impossible event**.

If $P(E)$ is the probability of an event, then the probability of not happening of E is denoted by $P(E')$ or $P(\overline{E})$

We know, $P(E) + P(E') = 1; \Rightarrow P(E') = 1 - P(E)$

$$\boxed{P(E') = 1 - P(E)}$$

We shall calculate a few typical probabilities, but it should be kept in mind that numerical probabilities are not the principal object of the theory. Our aim is to learn axioms, laws, concepts and to understand the theory of probability easily in higher classes.

Illustration

A coin is flipped several times. The number of times head and tail appeared and their ratios to the number of flips are noted below.

Number of Tosses (n)	Number of Heads (m_1)	P(H) = $\frac{m_1}{n}$	Number of Tails (m_2)	P(T) = $\frac{m_2}{n}$
50	29	$\frac{29}{50}$	21	$\frac{21}{50}$
60	34	$\frac{34}{60}$	26	$\frac{26}{60}$
70	41	$\frac{41}{70}$	29	$\frac{29}{70}$
80	44	$\frac{44}{80}$	36	$\frac{36}{80}$
90	48	$\frac{48}{90}$	42	$\frac{42}{90}$
100	52	$\frac{52}{100}$	48	$\frac{48}{100}$

From the above table we observe that as we increase the number of flips more and more, the probability of getting of heads and the probability of getting of tails come closer and closer to each other.

Activity (1) Flipping a coin:

Each student is asked to flip a coin for 10 times and tabulate the number of heads and tails obtained in the following table.

Outcome	Tally Marks	Number of heads or tails for 10 flips.
Head		
Tail		

Repeat the experiment for 20, 30, 40, 50 times and tabulate the results in the same manner as shown in the above example. Write down the values of the following fractions.

$$\frac{\text{Number of times head turn up}}{\text{Total number of times the coin is flipped}} = \frac{\square}{\square}$$

$$\frac{\text{Number of times tail turn up}}{\text{Total number of times the coin is flipped}} = \frac{\square}{\square}$$

Activity (2) Rolling a die:

Roll a die 20 times and calculate the probability of obtaining each of six outcomes.

Outcome	Tally Marks	Number of outcome for 20 rolls.	$\frac{\text{No. of times corresponding outcomes come up}}{\text{Total no. of times the die is rolled}}$
1			
2			
3			
4			
5			
6			

Repeat the experiment for 50, 100 times and tabulate the results in the same manner.

Activity (3) Flipping two coins:

Flip two coins simultaneously 10 times and record your observations in the table.

Outcome	Tally	Number of outcomes for 10 times	$\frac{\text{No. of times corresponding outcomes comes up}}{\text{Total no. of times the two coins are flipped}}$
Two Heads			
One head and one tail			
No head			

In Activity (1) each flip of a coin is called a trial. Similarly in Activity (2) each roll of a die is called a trial and each simultaneous flip of two coins in Activity (3) is also a trial.

In Activity (1) the getting a head in a particular flip is an event with outcome “head”. Similarly, getting a tail is an event with outcome tail.

In Activity (2) the getting of a particular number say " 5" is an event with outcome 5.

The value $\frac{\text{Number of heads comes up}}{\text{Total number of times the coins fliped}}$ is called an experimental or empirical probability.

Example 5.1

A manufacturer tested 1000 cell phones at random and found that 25 of them were defective. If a cell phone is selected at random, what is the probability that the selected cellphone is a defective one.

Solution Total number of cell phones tested = 1000 i.e., $n = 1000$

Let E be the event of selecting a defective cell phone.

$n(E) = 25$ i.e., $m = 25$

$$P(E) = \frac{\textit{Number of defective cellphones}}{\textit{Total number of cellphones tested}}$$

$$= \frac{m}{n} = \frac{25}{1000} = \frac{1}{40}$$

Example 5.2

In T-20 cricket match, Raju hit a "Six" 10 times out of 50 balls he played. If a ball was selected at random find the probability that he would not have hit a "Six".

Solution Total Number of balls Raju faced = 50i.e., $n = 50$

Let E be the event of hit a "Six" by Raju

$n(E) = 10$ i.e., $m=10$

$$P(E) = \frac{\textit{Number of times Raju hits a "Six"}}{\textit{Total number of balls faced}}$$

$$= \frac{m}{n} = \frac{10}{50} = \frac{1}{5}$$

P (Raju does not hit a Six) = $P(E') = 1 - P(E)$

$$= 1 - \frac{1}{5} = \frac{4}{5}$$

Example 5.3

The selection committee of a cricket team has to select a team of players. If the selection is made by using the past records scoring more than 40 runs in a match, then find the probability of selecting these two players whose performance are given below?

The performance of their last 30 matches are

Name of the player	More than 40 runs
Kumar	20 times
Kiruba	12 times

Solution Total number of matches observed = 30 i.e., $n = 30$

Let E_1 be the event of Kumar scoring more than 40 runs.

$$n(E_1) = 20 \qquad \text{i.e., } m_1 = 20$$

Let E_2 be the event of Kiruba scoring more than 40 runs.

$$n(E_2) = 12 \qquad \text{i.e., } m_2 = 12$$

$$P(E_1) = \frac{m_1}{n} = \frac{20}{30}$$

$$P(E_2) = \frac{m_2}{n} = \frac{12}{30}$$

The probability of Kumar being selected is = $\frac{20}{30} = \frac{2}{3}$

The probability of Kiruba being selected is = $\frac{12}{30} = \frac{2}{5}$

Example 5.4

On a particular day a policeman observed vehicles for speed check. The frequency table shows the speed of 160 vehicles that pass a radar speed check on dual carriage way.

Speed (Km/h)	20-29	30-39	40-49	50-59	60-69	70 & above
No. of Vehicles	14	23	28	35	52	8

Find the probability that the speed of a vehicle selected at random is

(i) faster than 69 *km/h*. (ii) between 20 - 39 *km/h*.

(iii) less than 60 *km/h*. (iv) between 40 - 69 *km/h*.

Solution

(i) Let E_1 be the event of a vehicle travelling faster than 69 *km/h*.

$$n(E_1) = 8 \qquad \text{i.e. } m_1 = 8$$

Total number of vehicles = 160. i.e. $n = 160$

$$P(E_1) = \frac{m_1}{n} = \frac{8}{160} = \frac{1}{20}$$

(ii) Let E_2 be the event of a vehicle travelling the speed between 20 - 39 *km/h*.

$$n(E_2) = 14+23 = 37 \qquad \text{i.e. } m_2 = 37$$

$$P(E_2) = \frac{m_2}{n} = \frac{37}{160}$$

(iii) Let E_3 be the event of a vehicle travelling the speed less than 60 *km/h*.

$$n(E_3) = 14+23+28+35 = 100 \qquad \text{i.e. } m_3 = 100$$

$$P(E_3) = \frac{m_3}{n} = \frac{100}{160} = \frac{5}{8}$$

(iv) Let E_4 be the event of a vehicle travelling the speed between 40-69 *km/h*.

$$n(E_4) = 28+35+52 = 115 \qquad \text{i.e. } m_4 = 115$$

$$P(E_4) = \frac{m_4}{n} = \frac{115}{160} = \frac{23}{32}$$

Example 5.5

A researcher would like to determine whether there is a relationship between a student's interest in statistics and his or her ability in mathematics. A random sample of 200 students is selected and they are asked whether their ability in mathematics and interest in statistics is low, average or high. The results were as follows:

		Ability in mathematics		
		Low	Average	High
Interest in statistics	Low	60	15	15
	Average	15	45	10
	High	5	10	25

If a student is selected at random, what is the probability that he / she

(i) has a high ability in mathematics (ii) has an average interest in statistics

(iii) has a high interest in statistics (iv) has high ability in mathematics and high interest in statistics and (v) has average ability in mathematics and low interest in statistics.

Solution

Total number of students = 80+70+50=200. i.e. $n = 200$

(i) Let E_1 be the event that he/she has a high ability in mathematics .

$$n(E_1) = 15+10+25= 50 \qquad \text{i.e. } m_1 = 50$$

$$P(E_1) = \frac{m_1}{n} = \frac{50}{200} = \frac{1}{4}$$

(ii) Let E_2 be the event that he/she has an average interest in statistics.

$$n(E_2) = 15+45+10 = 70 \qquad \text{i.e. } m_2 = 70$$

$$P(E_2) = \frac{m_2}{n} = \frac{70}{200} = \frac{7}{20}$$

(iii) Let E_3 be the event that he/she has a high interest in statistics.

$$n(E_3) = 5+10+25 = 40 \qquad \text{i.e. } m_3 = 40$$

$$P(E_3) = \frac{m_3}{n} = \frac{40}{200} = \frac{1}{5}$$

(iv) Let E_4 be the event has high ability in mathematics and high interest in statistics.

$$n(E_4) = 25 \qquad \text{i.e. } m_4 = 25$$

$$P(E_4) = \frac{m_4}{n} = \frac{25}{200} = \frac{1}{8}$$

(v) Let E_5 be the event has has average ability in mathematics and low interest in statistics.

$$n(E_5) = 15 \qquad \text{i.e. } m_5 = 15$$

$$P(E_5) = \frac{m_5}{n} = \frac{15}{200} = \frac{3}{40}$$

Example 5.6

A Hospital records indicated that maternity patients stayed in the hospital for the number of days as shown in the following.

No. of days stayed	3	4	5	6	more than 6
No. of patients	15	32	56	19	5

If a patient was selected at random find the probability that the patient stayed

(i) exactly 5 days (ii) less than 6 days

(iii) at most 4 days (iv) at least 5 days

Solution

Total number of patients of observed = 127 i.e., $n = 127$

(i) Let E_1 be the event of patients stayed exactly 5 days.

$$n(E_1) = 56 \qquad \text{i.e., } m_1 = 56$$

$$P(E_1) = \frac{m_1}{n} = \frac{56}{127}$$

(ii) Let E_2 be the event of patients stayed less than 6 days.

$$n(E_2) = 15 + 32 + 56 = 103 \quad \text{i.e., } m_2 = 103$$

$$P(E_2) = \frac{m_2}{n} = \frac{103}{127}$$

(iii) Let E_3 be the event of patients stayed atmost 4 days (3 and 4 days only).

$$n(E_3) = 15 + 32 = 47 \qquad \text{i.e., } m_3 = 47$$

$$P(E_3) = \frac{m_3}{n} = \frac{47}{127}$$

(iv) Let E_4 be the event of patients stayed atleast 5 days (5, 6 and 7 days only).

$$n(E_4) = 56 + 19 + 5 = 80 \qquad \text{i.e., } m_4 = 80$$

$$P(E_4) = \frac{m_4}{n} = \frac{80}{127}$$

Exercise 5.1

1. A probability experiment was conducted. Which of these cannot be considered as a probability of an outcome?

   i) 1/3 ii) – 1/5 iii) 0.80 iv) – 0.78 v) 0

   vi) 1.45 vii) 1 viii) 33% ix) 112%

2. Define: i) experiment ii) deterministic experiment iii) random experiment iv) sample space v) event vi) trial

3. Define empirical probability.

4. During the last 20 basket ball games, Sangeeth has made 65 and missed 35 free throws. What is the empirical probability if a ball was selected at random that Sangeeth make a foul shot?

5. The record of a weather station shows that out of the past 300 consecutive days, its weather was forecasted correctly 195 times. What is the probability that on a given day selected at random, (i) it was correct (ii) it was not correct.

6. Gowri asked 25 people if they liked the taste of a new health drink. The responses are,

Responses	Like	Dislike	Undecided
No. of people	15	8	2

   Find the probability that a person selected at random

   (i) likes the taste (ii) dislikes the taste (iii) undecided about the taste

7. In the sample of 50 people, 21 has type “O” blood, 22 has type “A” blood, 5 has type “B” blood and 2 has type “AB” blood. If a person is selected at random find the probability that

Mathematics

(i) the person has type "O" blood (ii) the person does not have type "B" blood
(iii) the person has type "A" blood (iv) the person does not have type "AB" blood.

8. A die is rolled 500 times. The following table shows that the outcomes of the die.

Outcomes	1	2	3	4	5	6
Frequencies	80	75	90	75	85	95

Find the probability of getting an outcome (i) less than 4 (ii) less than 2
(iii) greater than 2 (iv) getting 6 (v) not getting 6.

9. 2000 families with 2 children were selected randomly, and the following data were recorded.

Number of girls in a family	2	1	0
Number of families	624	900	476

Find the probability of a family, chosen at random, having (i) 2 girls (ii) 1 girl (iii) no girl

10. The follwing table gives the lifetime of 500 CFL lamps.

Life time (months)	9	10	11	12	13	14	more than 14
Number of Lamps	26	71	82	102	89	77	53

A bulb is selected at random. Find the probability that the life time of the selected bulb is
(i) less than 12 months (ii) more than 14 months
(iii) at most 12 months (iv) at least 13 months

11. On a busy road in a city the number of persons sitting in the cars passing by were observed during a particular interval of time. Data of 60 such cars is given in the following table.

No. of persons in the car	1	2	3	4	5
No. of Cars	22	16	12	6	4

Suppose another car passes by after this time interval. Find the probability that it has
(i) only 2 persons sitting in it (ii) less than 3 persons in it
(iii) more than 2 persons in it (iv) at least 4 persons in it

12. Marks obtained by Insuvai in Mathematics in ten unit tests are listed below.

Unit Test	I	II	III	IV	V	VI	VII	VIII	IX	X
Marks obtained (%)	89	93	98	99	98	97	96	90	98	99

Based on this data find the probability that in a unit test Insuvai get

(i) more than 95% (ii) less than 95% (iii) more than 98%

13. The table below shows the status of twenty residents in an apartment

Gender \ Status	College Students	Employees
Male	5	3
Female	4	8

If one of the residents is chosen at random, find the probability that the chosen resident will be (i) a female (ii) a college student (iii) a female student (iv) a male employee

14. The following table shows the results of a survey of thousand customers who bought a new or used cars of a certain model

Type \ Satisfaction level	Satisfied	Not Satisfied
New	300	100
Used	450	150

If a customer is selected at random, what is the probability that the customer

(i) bought a new car (ii) was satisfied (iii) bought an used car but not satisfied

15. A randomly selected sample of 1,000 individuals were asked whether they were planning to buy a new cellphone in the next 12 months. A year later the same persons were interviewed again to find out whether they actually bought a new cellphone. The response of both interviews is given below

	Buyers	Non-buyers
Plan to buy	200	50
No plan to buy	100	650

If a person was selected at random, what is the probability that he/she (i) had a plan to buy (ii) had a plan to buy but a non-buyer (iii) had no plan to buy but a buyer.

16. The survey has been undertaken to determine whether there is a relationship between the place of residence and ownership of an automobile. A random sample of car owners, 200 from large cities, 150 from suburbs and 150 from rural areas were selected and tabulated as follow

Car ownership \ Type of Area	Large city	Suburb	Rural
Own a foreign car	90	60	25
Do not own a foreign car	110	90	125

If a car owner was selected at random, what is the probability that he/she

(i) owns a foreign car.

(ii) owns a foreign car and lives in a suburb.

(iii) lives in a large city and does not own a foreign car.

(iv) lives in large city and owns a foreign car.

(v) neither lives in a rural area nor owns a foreign car.

17. The educational qualifications of 100 teachers of a Government higher secondary school are tabulated below

Age \ Education	M.Phil	Master Degree Only	Bachelor Degree Only
below 30	5	10	10
30 - 40	15	20	15
above 40	5	5	15

If a teacher is selected at random what is the probability that the chosen teacher has (i) master degree only (ii) M.Phil and age below 30 (iii) only a bachelor degree and age above 40 (iv) only a master degree and in age 30-40 (v) M.Phil and age above 40

18. A random sample of 1,000 men was selected and each individual was asked to indicate his age and his favorite sport. The results were as follows.

Age \ Sports	Volleyball	Basket ball	Hockey	Football
Below 20	26	47	41	36
20 - 29	38	84	80	48
30 - 39	72	68	38	22
40 - 49	96	48	30	26
50 and above	134	44	18	4

If a respondent is selected at random, what is the probability that

(i) he prefers Volleyball (ii) he is between 20 - 29 years old

(iii) he is between 20 and 29 years old and prefers Basketball

(iv) he doesn't prefer Hockey (v) he is at most 49 of age and prefers Football.

19. On one Sunday Muhil observed the vehicles at a Tollgate in the NH-45 for his science project about air pollution from 7 am. to 7 pm. The number of vehicles crossed are tabulated below.

Vehicles \ Time interval	7 a.m. to 11 a.m.	11 a.m. to 3 p.m.	3 p.m. to 7 p.m.
Bus	300	120	400
Car	200	130	250
Two Wheeler	500	250	350

A vehicle is selected at random. Find the probability that the vehicle chosen is a

(i) a bus at the time interval 7 a.m. to 11 a.m. (ii) a car at the time interval 11 a.m. to 7 p.m.

(iii) a bus at the time interval 7 a.m. to 3 p.m. (iv) a car at the time interval 7 a.m. to 7 p. m.

(v) not a two wheeler at the time interval 7 a.m. to 7 p.m.

Exercise 5.2

Multiple Choice Questions.

1. Probability of sure event is

(A) 1 (B) 0 (C) $\frac{1}{2}$ (D) 2

2. Which one can represent a probability of an event

(A) $\frac{7}{4}$ (B) -1 (C) $-\frac{2}{3}$ (D) $\frac{2}{3}$

3. Probability of impossible event is

(A) 1 (B) 0 (C) $\frac{1}{2}$ (D) -1

4. Probability of any event x lies

(A) $0 < x < 1$ (B) $0 \le x < 1$ (C) $0 \le x \le 1$ (D) $1 < x < 2$

5. $P(E')$ is

(A) $1 - P(E)$ (B) $P(E) - 1$ (C) 1 (D) 0

Mathematics

Points to Remember

- Uncertainty or probability can be measured numerically.
- Experiment is defined as a process whose result is well defined.
- Deterministic Experiment : It is an experiment whose outcomes can be predicted with certainty, under identical conditions.
- Random Experiment is an experiment whose all possible outcomes are known, but it is not possible to predict the exact outcome in advance.
- A trial is an action which results in one or several outcomes.
- A sample space S is a set of all possible outcomes of a random experiment.
- Each outcome of an experiment is called a sample point.
- Any subset of a sample space is called an event.
- Classification of probability

  (1) Subjective probability (2) Classical probability (3) Empirical probability
- The empirical probability of happening of an event E, denoted by P(E), is given by

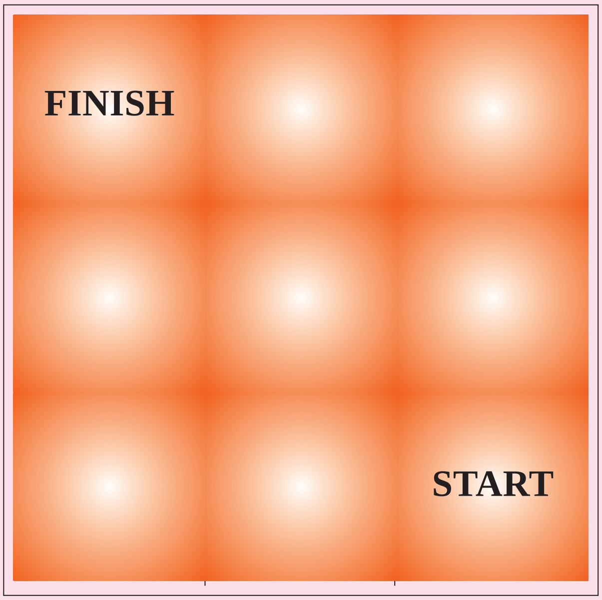
$$P(E) = \frac{\text{Number of trials in which the event happened}}{\text{Total number of trials}}$$

$$\text{(or)} \quad P(E) = \frac{\text{Number of favourable observations}}{\text{Total number of observations}} \qquad \text{(or)} \quad P(E) = \frac{m}{n}$$

- $0 \le P(E) \le 1$
- $P(E') = 1 - P(E)$, where E' is the complementary event of E.

Activity 1

This is a simple game, where you throw a dice which controls the position of your counter on a 3×3 board.



Place your counter at the START square. Throw a dice.

If you get an EVEN number, you move your counter one square upwards.

If you get an ODD number, you move your counter one square left.

If your counter moves off any side of the board, you lose!

If your counter reaches the FINISH square, you have won.

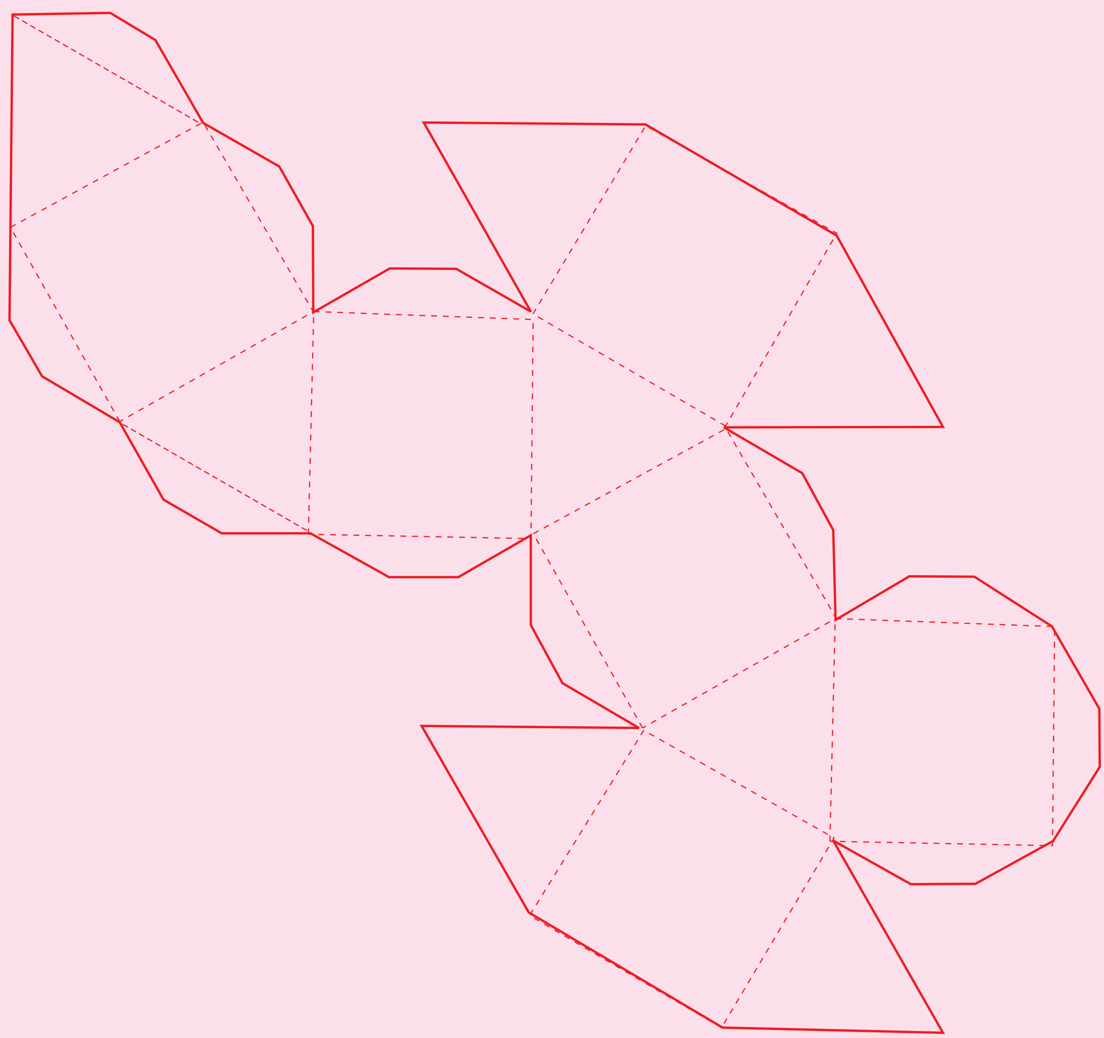
Play the game a few times and see if you win.

How many ‘odds’ and how many ‘evens’ do you need to get to win?

What is the probability of winning?

Activity 2

The net of a cuboctahedron is given below. It consists of 6 squares and 8 triangles. Make this 3-dimentsional object using card.



If this object is thrown, what do you think will be to probability of it landing on

(i) one of its square faces

(ii) one of its triangular faces?

Throw the object (at least 100 times) and estimate these probabilities.

How close are they to your original estimates?

Exercise 5.1

1. (ii) $\frac{-1}{5}$ (iv) -0.78 (vi) 1.45 (ix) 112% **4.** $\frac{13}{20}$ **5.** (i) $\frac{13}{20}$ (ii) $\frac{7}{20}$

6. (i) $\frac{3}{5}$ (ii) $\frac{8}{25}$ (iii) $\frac{2}{25}$ **7.** (i) $\frac{21}{50}$ (ii) $\frac{9}{10}$ (iii) $\frac{11}{25}$ (iv) $\frac{24}{25}$

8. (i) $\frac{49}{100}$ (ii) $\frac{4}{25}$ (iii) $\frac{69}{100}$ (iv) $\frac{19}{100}$ (v) $\frac{81}{100}$ **9.** (i) $\frac{39}{125}$ (ii) $\frac{9}{20}$ (iii) $\frac{119}{500}$

10. (i) $\frac{179}{500}$ (ii) $\frac{53}{500}$ (iii) $\frac{281}{500}$ (iv) $\frac{219}{500}$

11. (i) $\frac{4}{15}$ (ii) $\frac{19}{30}$ (iii) $\frac{11}{30}$ (iv) $\frac{1}{6}$

12. (i) $\frac{7}{10}$ (ii) $\frac{3}{10}$ (iii) $\frac{1}{5}$ **13.** (i) $\frac{3}{5}$ (ii) $\frac{9}{20}$ (iii) $\frac{1}{5}$ (iv) $\frac{3}{20}$

14. (i) $\frac{2}{5}$ (ii) $\frac{3}{4}$ (iii) $\frac{3}{20}$ **15.** (i) $\frac{1}{4}$ (ii) $\frac{1}{20}$ (iii) $\frac{1}{10}$

16. (i) $\frac{7}{20}$ (ii) $\frac{3}{25}$ (iii) $\frac{11}{50}$ (iv) $\frac{9}{50}$ (v) $\frac{3}{4}$

17. (i) $\frac{7}{20}$ (ii) $\frac{1}{20}$ (iii) $\frac{3}{20}$ (iv) $\frac{1}{5}$ (v) $\frac{1}{20}$

18. (i) $\frac{183}{500}$ (ii) $\frac{1}{4}$ (iii) $\frac{21}{250}$ (iv) $\frac{793}{1000}$ (v) $\frac{33}{250}$

19. (i) $\frac{3}{25}$ (ii) $\frac{19}{125}$ (iii) $\frac{21}{125}$ (iv) $\frac{29}{125}$ (v) $\frac{14}{25}$

Exercise 5.2

1. A **2.** D **3.** B **4.** C **5.** A