$$P'_k = (1-\rho)\rho^k$$

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$$P_j(t+\Delta t) = \lambda_{j-1}\Delta t\, P_{j-1}(t) + (1 - \mu_j \Delta t - \lambda_j \Delta t)\, P_j(t) + \mu_{j+1}\Delta t\, P_{j+1}(t)$$

$$\lim_{\Delta t \to 0} \frac{P_j(t+\Delta t) - P_j(t)}{\Delta t} = \lambda_{j-1} P_{j-1}(t) - (\mu_j + \lambda_j) P_j(t) + \mu_{j+1} \lambda_{j+1}(t)$$

$$\frac{dP_j(t)}{dt} = \lambda_{j-1} P_{j-1}(t) -$$

$$P_{j+1} = \left\{ \frac{\lambda_j + \mu_j}{\mu_{j+1}} \right\} P_j - \frac{\lambda_{j-1}}{\mu_{j+1}} P_{j-1}$$

$$P_1 = \frac{\lambda_0}{\mu_1} P_0$$

On a network gateway measurements show that the packets arrive at a mean state

$$P\{n(t+\Delta t) = j+1 \,|$$

$$= \lambda_j \Delta t$$

$$P\{n(t+\Delta t) = j-1$$

$$= \mu_j \Delta t$$

$$P\{n(t+\Delta t) = j \,|\, n(t) = j$$

$$1 - \lambda_j \Delta t - \mu_j \Delta t$$

$$P_0(t+\Delta t) = (1-\lambda_0 \Delta t) P_0(t) +$$

$$\mu_1 \Delta t \, P_1(t)$$

$$P_1(t+\Delta t) = \lambda_0 \Delta t \, P_0(t) +$$

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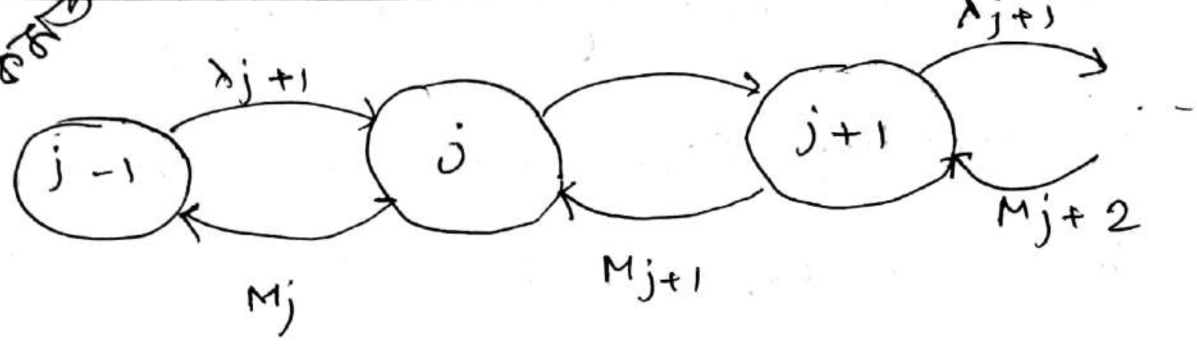
time P_j

$\Delta t \to 0$

** Steady state probability **

λ

lecture



When the system is in state n it has n jobs in it.

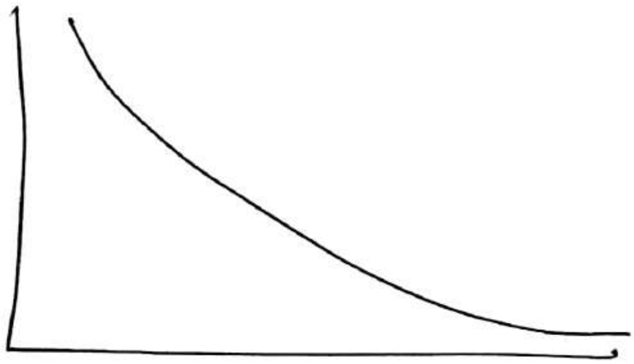
→ The new arrival take place a rate λ_n

→ The service rate is M_n

→ We assume that both the arrival times and service times are exponentially distributed suppose the system is in the state j at time t. There are j jobs in the system. In the next time system, both waiting and being serviced.

Time waiting (T_w) the average time each customers waits in the queue —

$$T_a = T_w + S$$



$$\begin{array}{r} 185 \\ \times \quad 2 \\ \hline 370 \end{array}$$

Service time (S) → The average time required to service one customer.

Number waiting (W) → The average no. of customer waiting.

Number in the system (Q) – The average total number of customers in the system.

Assumptions:

→ Independent arrivals.
→ Exponential distributions.
→ customers do not leave or change queues
→ large queues donot discourage customers.

Time in the system (T_2) the average time each customer is in the

$$\Rightarrow \quad N = \frac{\lambda}{\mu - \lambda}$$

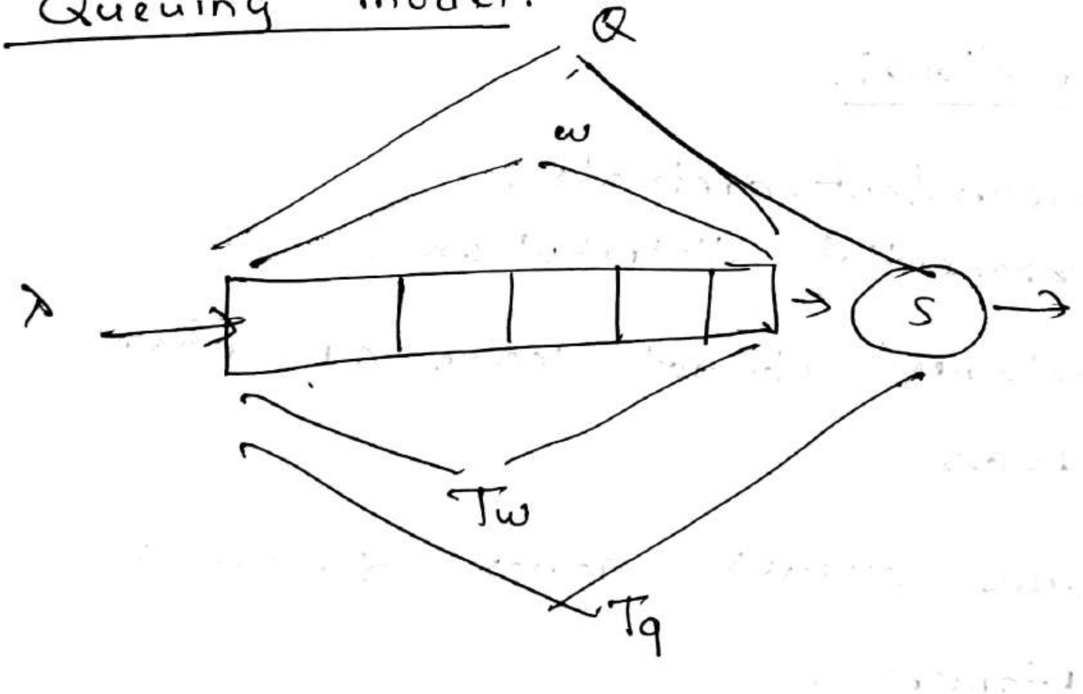
Average waiting time, $w = \dfrac{1}{\mu - \lambda} - \dfrac{1}{\mu}$

$$= \frac{\rho}{\mu - \lambda}$$

Average number of customer in queue.

$$N_Q = \lambda w = \frac{\rho^2}{1-\rho}$$

Queuing model:



Arrival rate(λ) = The average rate at which customer arrive.

So, we have,

$$\frac{1}{1-\rho} P_0 = 1$$

$\Rightarrow P_0 = 1 - \rho$

that is,

$$P_k = \rho^k (1-\rho)$$

ρ must be less than 1 or else the system is unstable.

Some formulas:

Average no. of customer -

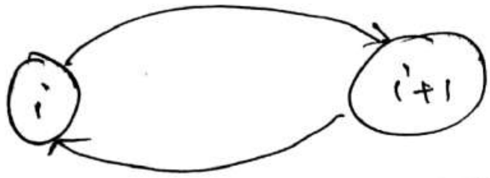
$$N = \sum_{k=0}^{\infty} k \cdot P_k = (1-\rho) \sum_{k=0}^{\infty} \rho^k$$

Average delay per customer (time in queue plus service time)

$$T = \frac{N}{\lambda}$$

$$\Rightarrow \frac{N}{\lambda} = \frac{1}{\mu - \lambda}$$

$$\Rightarrow N(\mu - \lambda) = \lambda$$



In equilibrium, the rate of movement in both directions should be equal.

let,

$$P_i = P\{\text{system in state } i\}$$

we have,

$$\lambda P_i = \mu P_{i+1}$$

From state transition diagram,

$$\lambda P_0 = \mu P_1$$

$$\lambda P_1 = \mu P_2$$

$$\lambda P_2 = \mu P_3$$

$$P_1 = \frac{\lambda}{\mu} P_0 = \rho P_0 \quad \left[\text{where } \rho = \frac{\lambda}{\mu}\right)$$

$$P_k = \rho^k P_0$$

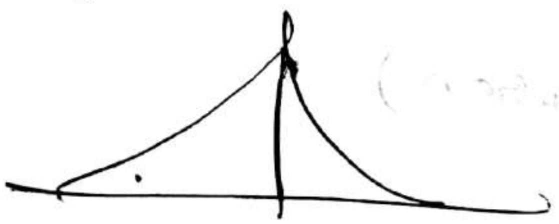
Since,

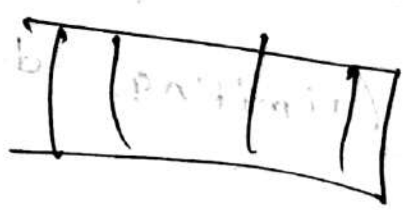
$$\sum_{k=0}^{\infty} P_k = \sum_{k=0}^{\infty} \rho^k P_0 = 1$$

concern of probabilistic analysis can be summerised by the number of customer in the system at i.

(The past history (how we get them) does not matter)

→ when a customer arrives or departs the system moves to an adjacent state (either i+1 or i-1)





iid = discrete distribution

We have a single server, an infinite
limiting line, the customer interarrival
times are iid and exponentially
distributed, λ and the customer service
times are also iid and we are
↓ कि एवन ~~[illegible]~~ स्थिरांक
mainly (in) in steady state
solution. i.e when the system after
a long running time tends to ~~reach~~
reach a state, where the distribution
of customers in the system does not
change (limiting distribution).

→ Due to memoryless property of
the exponential distribution the entire
state of a system as far as the

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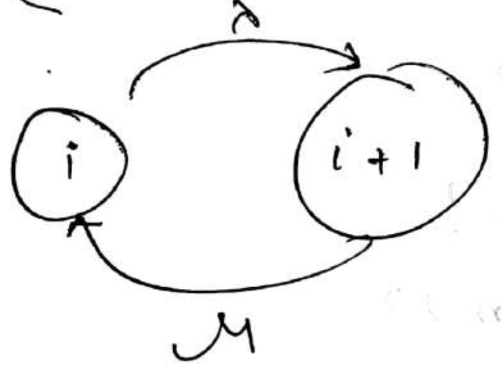
→ The buffer is assumed to be infinite.

→ The queuing discipline is FCFS.

(First come first serve).

Memoryless property (Markov system)

** (summerised in the current state)

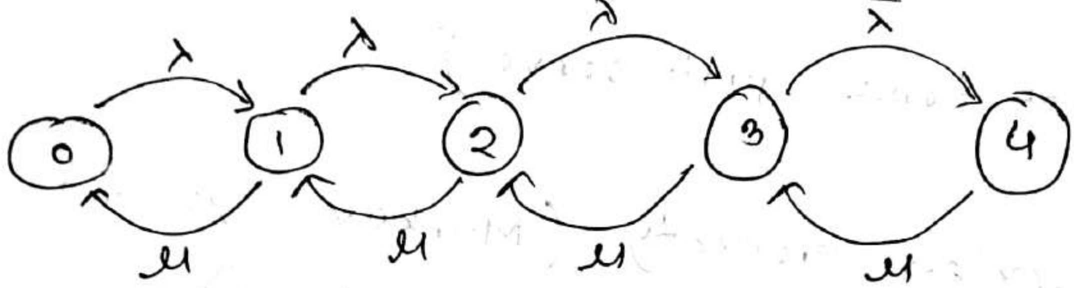


Taking the Markov system, the ~~st~~ most simple queuing system, the M/M/1 system (with FIFO ~~system~~ service) can then be described as follows:-

In equibrium, the rate of movement in both direction should be equal.

Basic queuing theory :

State transition diagram :



What is state ?

what is state function ?

What is memoryless property ?

what is Markov system ??

M/M/1 Queuing system:

(1) Interarrival times are exponentially distributed with average arrival rate λ.

(2) Service times are exponentially distributed, with average ~~distributed~~ service rate μ.

(3) There is only one server.

(iii) Number of servers

→ Queuing disciplines (how custome are taken from queue)

→ Number of buffers which customer use to wait for service.

Most common notation:

A/B/M, where m is the number of servers and A and B are chosen from ____

M :- Markov (exponential distribution)

D : Deterministic

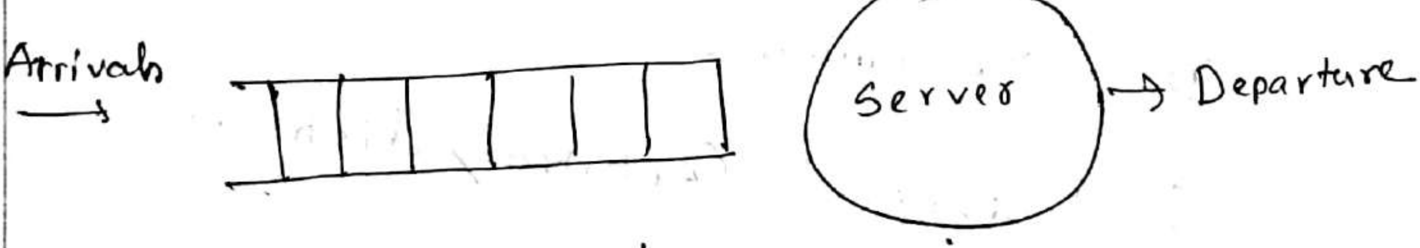
G : General (Arbitrary distribution)

Basic Queuing theory

Multithreading

Queuing theory is the mathematical basis for understanding and predicting any communication network.

Queuing system is a system consisting of a server or number of server that perform a specific task and a queue where the processes waits to be performed.



Major parameters:

(i) The inter arival time distribution
(ii) service time distribution.

Fig caption দিতে হবে।

~~এগ~~ ছোট ছোট ~~জিনিস~~ ভুলগুলো check করতে হবে।

Given below, ~~tab~~ Here is a table

এই type terms use করা যাবে না।

* Table এ unit দিতে হবে।

* Alogorithm comparison করার সময় অবশ্যই environment সবকিছু উল্লেখ করতে হবে।

in early part of the nineteenth century.

Problem আছে

property, mean, $\mu = \lambda$

varience, $\sigma^2 = \cancel{x}\ \cancel{\alpha}\ \lambda$

	Normal	Binomial	Poisson
Mean, μ	μ	Np	λ
std deviation	σ	$\sqrt{Npq}$	$\sqrt{\lambda}$
Varience	σ^2	Npq	λ

two ordinates $X = a$ and $X = b$, where $a < b$, represents the probability that X lies between a and b. This is denoted by $P_r\{a < X < b\}$

if $z = \frac{X - \mu}{\sigma}$

Then the standard form of the normal distribution is —

$$Y = \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2z^2}}$$

In each case we say that z is normally distributed with mean and varience 1.

The poisson distribution:

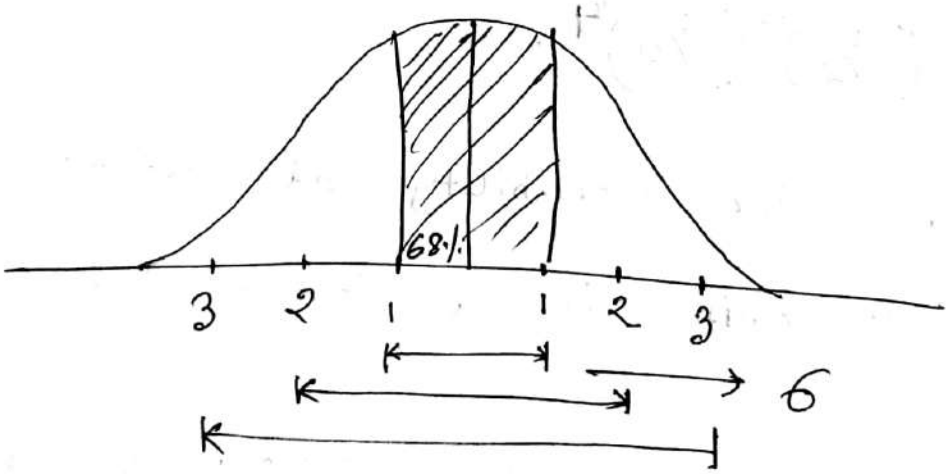
The discrete probability distribution

$$P(X) = \frac{\lambda^x e^{-1}}{x!}, \quad X = 0, 1, 2, \ldots$$ is called the poisson distribution after simean-denis poisson who discovered it

One of the most important examples of continuous probability distribution. is the normal distribution, normal curve or Guassian distribution it is defined by the equation:

$$y = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(x-\mu)^2/\sigma^2}$$

where,
μ = mean, σ = standard deviation



The total area bounded by this curve and the x axis is 1; hence the area under the curve between occur) is given by,

$$p(x) = \binom{N}{x} p^x q^{N-x} = \frac{N!}{x!\,(N-x)!} p^x q^{N-x}$$

The probability of getting exactly two ~~heds~~ heads in six tosses of a fair coin.

$$\binom{6}{2} \left(\tfrac{1}{2}\right)^2 \left(\tfrac{1}{4}\right)^4 =$$

Find out the probability of getting at least 4 heads in 6 tosses a fair coin?

$$\binom{6}{4} \left(\tfrac{1}{2}\right)^4 \left(\tfrac{1}{2}\right)^2 + \binom{6}{5} \left(\tfrac{1}{2}\right)^5 \left(\tfrac{1}{2}\right)^1$$

$$+ \binom{6}{6} \left(\tfrac{1}{2}\right)^6 \left(\tfrac{1}{6}\right)^0$$

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Binomial distribution

$$P(x) = \binom{N}{X} p^X q^{N-X} = \frac{N!}{X!\,(N-X)!} p^x q^{N-x}$$

where $X = 0, 1, 2, \ldots N$

$N! = N(N-1) \ldots 1$ and $0! = 1$

Binomial formula :-

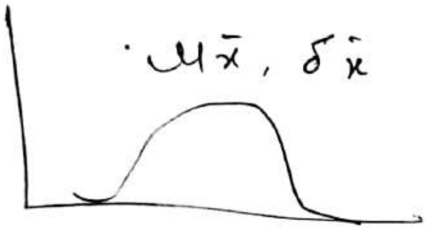
$$(q+p)^N = q^N + \binom{N}{1} q^{N-1} p + \binom{N}{2} q^{N-2} p^2 + \ldots + p^N$$

If p is the probability that ~~any~~ an event will happen (probability of success) and $q = 1 - p$ is the probability that it will fail to happen any single time (probability of a failure), then the probability that the event will happen exactly X times in N trials (i.e X successes and N - X failures will population parameter, the statistic is called and unbiased estimator of the parameter. Otherwise it is called a biased estimator. The corresponding values of such statistics are called unbiased or biased estimater respectively.

Efficient estimates:

If the sampling distribution of two statistics have the same mean or ~~va~~ expectation, then the statistics with smaller varience is called an efficient estimator of the mean, while the other statistics is called an inefficient estimators. The corresponding valuees of the or inefficient statistics are called efficient estimates respectively.

size $N_p > N$



Sampling distribution থেকে definition আসবে, Math আসবে না,

Statistical estimation theory

What is biased estimator?

" " unbiased estimator?

" " efficient estimates?

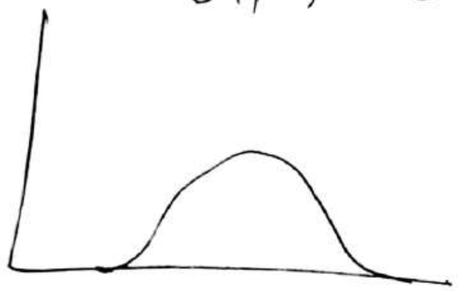
" " point estimates and interval estimates?

Definition:

If the mean of the sampling distribution of a statistics equals the corresponding

Sampling distribution :

$\mu_1, \mu_2, \mu_3, \ldots, \mu_{1000}$



যেকোন distribution হতে পারে।

Sample ন্যূন ৩০

Sampling distribution of mean.

The statistics ~~তা~~ like sample mean, varience etc will vary sample to sample. The distribution obtained of the statistics is called its sampling distribution.

Sampling distribution of mean;

$$\mu_{\bar{x}} = \mu \quad \text{and} \quad \delta_{\bar{x}} = \frac{\delta}{\sqrt{N}} \sqrt{\frac{N_p - N}{N_p - 1}}$$

All possible sample size N are drawn without replacement from a finite population of

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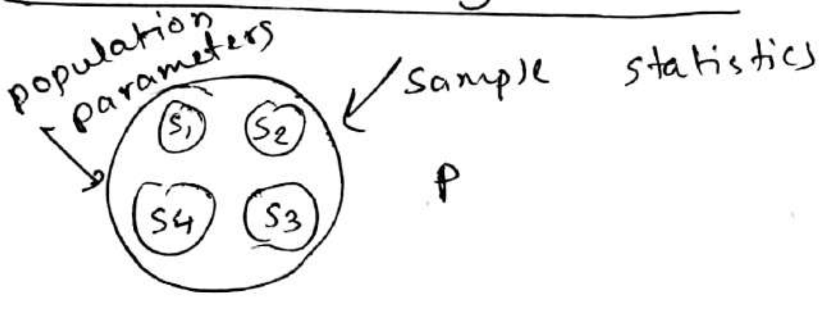
Elementary sampling theory



Sample is a subset of population, representative of whole population.

Sampling theory is a ~~stru~~ study of the relationship existing between population and sample drawn from the population.

Sampling with and without replacement:

$^5C_2 \left(\frac{1}{6}\right)^2 \left(5/6\right)^3$ $\quad x \leq 1$

$= 10 \times \frac{1}{36} \times \frac{125}{216}$ $\quad n = 2$

$=$

$X \leq x$ $\quad \int_{-3}^{4}$

$1 - e^{-2x}$

$2e^{-2x}$

$2\int_{2}^{\infty} e^{-2x}$ $\quad e^{-2}$

$2\left[-e^{-4}\right]$

$q = \frac{5}{6}$

$^nC_r \, p^r q^{n-r}$ $\quad a = 0$

$=$

$^5C_2 (1/6)^2 \left(\frac{5}{6}\right)^{5-2}$

If E_1 and E_2 are two events, the probability that E_2 occurs ~~#~~ given that E_1 has occurred is denoted by $P_r\{E_2|E_1\}$, or $P_r\{E_2 \text{ given } E_1\}$ and is called the conditional property. of E_2 given that E_1 has occurred.

If the occurrence ~~an~~ or nonoccurrence of E_1 does not affect the probability of occurrence of E_2, then $P_r\{E_2|E_1\} = P_r\{E_2\}$ and we say that E_1 and E_2 are independent events; ~~a~~

$$P_r\{E_1E_2\} = P_r\{E_1\}\, P_r\{E_2|E_1\}$$

~~Ar~~ $P_r\{E_1E_2\} = P_r\{E_1\}\, P_r\{E_2|E_1\}$

$$= \frac{2}{5} \cdot \frac{1}{4} = \frac{1}{10}$$

If a variable X can assume a discrete set of values $X_1, X_2, \ldots, X_K$ with respective probabilities $P_1, P_2, \ldots, P_K$ where $P_1 + P_2 + \cdots + P_K = 1$

$$= \frac{1}{b-a}\left[\frac{b^2}{2} - \frac{a^2}{2}\right)$$

$$= \frac{1}{b-a} \cdot \frac{(b+a)(b-a)}{2}$$

$$= \frac{b+a}{2}$$

Suppose that, X is a discrete random variable which can take values -2, 0, 3 and is with probabilities $P[x=-2]=0.1$, $P[x=0]=0.3$, $P[x=3)=0.4$ and $P[x=5]=0.2$. Find the mean of X

$\mu = E(X) = ?$

$= -2 \times .1 + 0 \times .3 + .4 \times 3 + .2 \times 5$

Suppose, that, a continuous random variable follows density function as -

$$f(x) = \frac{1}{b-a}, \quad a \leq x \leq b$$

Find the mean of a

$$E(X) = \int_a^b x \frac{1}{b-a}\, dx$$

$$= \frac{1}{b-a} \left[\frac{x^2}{2}\right]_a^b$$

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$\cancel{x} f(x) = \frac{3}{4}(2x - x^2)\ dx$

$= \frac{3}{4}\cdot\cancel{2}\cdot\frac{x^2}{\cancel{2}} - \frac{3}{4}\cdot\frac{x^3}{3}$

$= \frac{3}{4}\int_{.5}^{1.5}$

$\frac{3}{4}\left\{(1.5)^2 - (.5)^2\right\} - \frac{1}{4}(1.5)^3 - (.5)^3$

$= \frac{3}{2} - \frac{13}{16}$

$= \frac{24 - 13}{16}$

$= \frac{11}{16} = .6875$

less than 1

$\int_0^1$

equal to 1

0

(iv) $P[x \leq 0.2] = \int_{-\infty}^{.2} f(x)\,dx$

$$= \int_{-\infty}^{.2} 0 = 0$$

(v) $P[x > 3] = \int_{3}^{\infty} f(x)\,dx$

$$= \int_{3}^{\infty} 0 \cdot dx = 0$$

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Let, x be a continuous random variable

~~that~~ fe with PDF

$$f(x) = \begin{cases} 2/3\, x & \text{if } 1 < x < 2 \\ 0 & \text{otherwise} \end{cases}$$

Find $P[x \leq 1.2]$, $P[x > 1.2]$, $P[1.2] < x < 1.6]$

$P[x \leq .2)$ and $P(x > 3)$

$\rightarrow P[x \leq 1.2] = \int_1^{1.2} f(x)\,dx = \int_1^{1.2} \frac{2}{3} x\, dx$

$$\left[\frac{x^2}{3}\right]_1^{1.2}$$

$= \frac{11}{75}$

(ii) $P[x > 1.2] = \int_{1.2}^{2} \frac{2}{3} x\, dx = ?$ $\frac{64}{75}$

$= \frac{2}{3} \cdot \left[\frac{x^2}{2}\right]_{1.2}^{2}$

(iii) $P[1.2 < x < 1.6] = \int_{1.2}^{1.6} \frac{2}{3} x\, dx$

$= \frac{1.6^2}{3} - \frac{1.2^2}{3}$

$= \frac{28}{75}$

Sol^n: find these probabilities values.

$F(x)$ for $x < -1 = P[x < -1] = 0$

$F(x)$ for $-1 \leq x < 2 = P[-1 \leq x < 2] = P[-1] = \frac{1}{4}$

$F(x)$ for $2 \leq x < 5 = P[2] = \frac{1}{2}$

$F(x)$ for $x \leq 5 = \frac{1}{4} + \frac{1}{2} + \frac{1}{4} = 1$

$$F(x) = \begin{cases} 0 & \text{for } x < -1 \\ 1/4 & \text{for } -1 \leq x < 2 \\ 3/4 & \text{for } 2 \leq x < 5 \\ 1 & \text{for } x \leq 5 \end{cases}$$

Rules to find the probabilities for a continuous variable:

i] $P[X = x] = 0$ for $-\infty < x < \infty$

ii] $P[X < x] = P[X \leq x]$

$$= \int_{-\infty}^{x} f(x)\,dx \quad \text{for } -\infty < X \leq x$$

iii) $P[a \leq X \leq b] = P[a \leq x \leq b]$

$$= [\int_a^b f(x)\,dx \quad \text{for } a < b$$

(iii) $P[x \le 4] = P(-2) + P(0) + P(4)$

$$= \frac{1}{10} + \frac{2}{10} + \frac{4}{10} = \frac{7}{10}$$

Another way :

$1 - P(11)$

$= 1 - \frac{3}{10}$

$= \frac{7}{10}$

~~Let~~ Let, X be a discrete random variable whose only possible values are $-1, 2$ and 3. Suppose that the probability function of X is

$$f(x) = \begin{cases} 1/4 & , \text{ for } x = -1 \\ 1/2 & , \text{ for } x = 2 \\ 1/4 & , \text{ for } x = 5 \end{cases}$$

Find the alternative ~~distributive~~ distribution function of x.

Let, x be a random variable with probability function defined by

$f(-2) = \frac{1}{10}$, $f(0) = \frac{2}{10}$, $f(4) = \frac{4}{10}$ and $f(11) = \frac{3}{10}$. Find (i) $P[-2 \leq x < 4]$

(ii) $P[x > 0]$

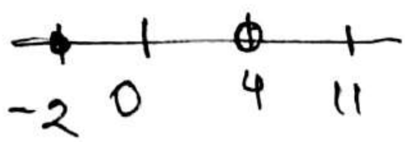
(iii) $P[x \leq 4]$

<u>Ans:</u> Here random variable x takes the values $-2, 0, 4$ and 11 with repulsive probabilities

Values of x	-2	0	4	11
$f(x)$	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{4}{10}$	$3/10$

(i) $P[-2 \leq x < 4] = P(-2) + P(0)$

$= \frac{1}{10} + \frac{2}{10}$



(ii) $P[x > 0] = P(4) + P(11)$

$P_r\{E_1+E_2\} = P_r\{E_1\} + P_r\{E_2\} - P_r\{E_1E_2\}$

If a variable X can assume a discrete set of values $x_1, x_2, \dots, x_k$ with respective probabilities $p_1, p_2, \dots, p_k$ where $p_1 + p_2 + \dots + p_k = 1$ we say that a discrete probability function for X has been defined. The function $p(x)$ which has the respective values $p_1, p_2, \dots, p_k$ is called the probability for $X = x_1, x_2, \dots, x_k$

Continuous :

1 $Y = p(x)$

The total area under this curve between lines $X = a$ and $x = b$ gives the probability that X lies between a and b, which can be denoted by $P_r\{a < X < b\}$

Rough

Suppose that, an event E can happen in h ways out of a total of n possible equally likely ways. Then the probability of occurrence of the event is denoted by

$$p = P_r\{E\} = \frac{h}{n}$$

If E_1 & E_2 are two events, the probability that E_2 occurs given that E_1 has occured is denoted by $P_r\{E_2|E_1\}$, or $P_r\{E_2 \text{ given } E_1\}$, and is called the conditional probability of E_2 given that E_1 has occurred

$$P_r\{E_1E_2\} = P_r\{E_1\}P_r\{E_2|E_1\}$$

$$P_r\{E_1E_2\} = P_r\{E_1\}P_r\{E_2\}$$

$$\frac{1}{2}\,\frac{1}{2} = \frac{1}{4}$$

is black $2/5$

first ball drawn " " $\frac{1}{4}$

second " "

$\frac{2}{5}$, $P_r\{E_1E_2\} = P_r\{E_1\}P_r\{E_2\} = \frac{1}{4}\cdot\frac{2}{5} = \frac{1}{10}$

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5 a) The distribution function of the random variable x is $f(x) = \begin{cases} 1 - e^{-2x} ; & x > 0 \\ 0 ; & x < 0 \end{cases}$

Find (i) The density function

(ii) The probability that $x > 2$

(iii) The probability that $-3 < x \le 4$

6. Find the probability that 5 tosses of fair dice, a 3 appear ~~in~~

(i) at no time.

(ii) once ~~is~~

(iii) Twice

(iv) three times

(v) four times

5

$\boxed{6} \to 5$

$\frac{5}{6}$

5 $\frac{1}{6}$

$1 - \frac{1}{6}$

$p(1) + p(2) = \frac{5}{6}$ $\frac{1}{6}$

$(1.5)^2 - 1$

$1 - \frac{5}{6}$

$a x \, dx$ $\frac{a}{2}$

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day in this region the rainfall is

(a) not more than 1 inch

(b) greater than 1.5 inches

(c) between .5 and 1.5 inches.

(d) equal to 1 inches

(e) less than 1 inches.

3) Let, x be a continuous random variable with PDF.

$$f(x) = \begin{cases} ax & \text{if } 0 \le x < 1 \\ a & \text{if } 1 \le x < 2 \\ -a + 3a & \text{if } 2 \le x \le 3 \\ 0 & \text{otherwi} \end{cases}$$

(i) determine the constant

(ii) compute $P[x \le 1.5]$

4. Find the expectation of continuous random variable X

$$f(x) = \frac{1}{\pi(1+x^2)} \quad -\infty < x < \infty$$

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$P(A \cup B) = P(A) + P(B) - P(A \cap B)$ ACTIVE

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(iii) $P[a \le X \le b] = P[a \le X < b] = P[a < X \le b]$

$= P[a < X < b] = \int_a^b f(x)\,dx$ for $a < b$

~~1.~~ A bag contain 4 red, 6 black and 7 white marbel. A marbel is chosen at random from the bag. If the marbel is not white, white is the probability that is red?

$\frac{4}{17}$ $1 - \frac{6}{17}$ $\frac{10}{17}$ ~~$\frac{10}{17} - \frac{9}{17} = \frac{1}{17}$ $\frac{10}{17} - \frac{3}{5}$~~ $1 - \frac{7}{17}$ $\boxed{\frac{10}{17}}$ $\times \frac{6}{10}$

$\frac{9}{17}$ 2. Suppose that in a certain region the daily rainfall (in inches) is a continuous random variable X with probability density function $f(x)$ given by

$$f(x) = \begin{cases} \frac{3}{4}(2x - x^2); & \text{if } 0 < x < 2 \\ 0 & ; \text{otherwise} \end{cases}$$

find the probability that on a given

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i) $\int_R f(x)\,dx = \int_{-\infty}^{\infty} f(x)\,dx = 1$

ii) The probability of any event A defined by $X < x$

$$P[A] = P[X < x]$$

$$= \int_{-\infty}^{x} f(x)\,dx$$

Moreover, if B is an event defined by $a \leq X \leq b$, then,

$$P[B] = P[a \leq X \leq b] = \int_a^b f(x)\,dx$$

Rules for finding probabilities for a continuous random variable:

(i) $P[X = x] = 0$ for $-\infty < x < \infty$

(ii) $[X < x] = P[X \leq x] = \int_{-\infty}^{x} f(x)\,dx$

for $-\infty < X \leq x$

Mathematical expectation :

~~M~~ The discrete random variable X can assume the values $x_1, x_2, \dots, x_n$ with respective probabilities $p_1, p_2, \dots, p_n$ where $p_1 + p_2 + \dots + p_n = 1$ then the mathematical ~~op~~ expectation of X denoted as $E(X)$ is defined as

3.75 / 2

$$E(x) = p_1 x_1 + p_2 x_2 + \dots + p_k x_k = \sum_{j=1}^{k} p_j x_j = \sum pX$$

A man's possibility to win \$10 is $\frac{1}{2}$

His expectation $E(x) = \frac{1}{2} \times \$10$

$= 5\$$

x. This makes events $\{X = x\}$ disjoint,

$$\sum_{x} p(x) = \sum_{x} P\{X = x\} = 1$$

$$\lim_{x \downarrow -\infty} F(x) = 0 \quad \text{and} \quad \lim_{x \uparrow +\infty} F(x) = 1$$

cdf $F(x)$ is a non decreasing function of x, always between 0 & 1.

The probability of an event can be calculated by adding, the probabilities of all the outcome of it.

Hence, for any set A,

$$P\{X \in A\} = \sum_{x \in A} P(x)$$

where A is an interval, its probability can be computed directly from the cdf, F(x),

$$P\{a < X \leq b\} = F(b) - F(a)$$

~~domain~~ $\mathbb{R}$

Domain of a variable is the sample space Ω.

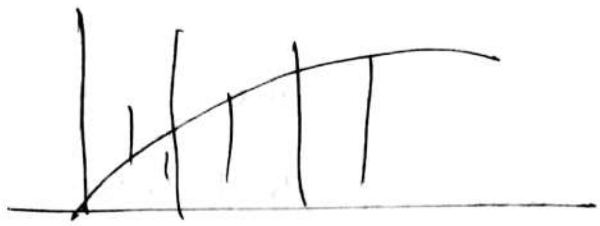
its range can be the set of all real number $\mathbb{R}$ or only the positive numbers $(0+\alpha)$ or the integars $\mathbb{Z}$ or the interval $(0,1)$ etc.

Collection of all the probabilities related to X is the distribution of X. Function

$P(x) = P\{X = x\}$ is the ~~proof~~ pmf (probability mass function). So the cdf (cumulative distribution function) is

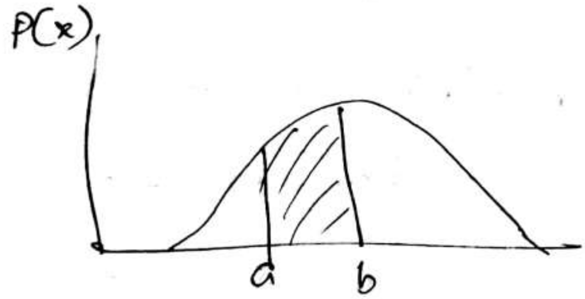
$$F(x) = P\{X \leq x\} = \sum_{y \leq x} P(y)$$

for every outcome ω, the variable X takes ~~t~~ one and only one ~~on~~ value



The area under the curve between line $x=a$ and $x=b$ gives the probability that x lies between a & b.

$$P_r\{a < x < b\}$$



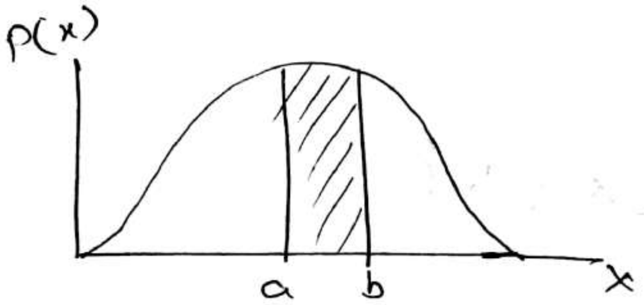
Random variable:

A random variable is a function of an outcome. It is a quantity that depends on chance. $X = f(\omega)$ ~~with~~ the

Discrete Probability distribution :

Variable X can assume the values $x_1, x_2 \ldots x_n$ with probabilities $P_1, P_2, \ldots \ldots P_k$ where $P_1 + P_2 + \ldots + P_k = 1$

The probability function or discrete probability distribution for X is shown as $p(x)$.



The idea can be extended when the variable X may assume a continuous ~~set~~ set of values. The relative frequency polygon of a sample becomes, in the theoritical or limiting case of a population, a continuous curve (given in figure) chose equation is $Y = P(X)$

$E_1 = \{\text{drawing an ace}\}$

$E_2 = \{\text{drawing an spade}\}$

If E_1 & E_2 are mutually exclusive

then $P(E_1 E_2) = 0$

$P_r\{E_1 + E_2\} = P_o\{E_1\} + P\{E_2\} - P\{E_1 E_2\}$

If mutually exclusive $P(E_1 + E_2) = P(E_1) + P(E_2)$

E_1 & E_2 thus are not mutually exclusive since the ace of spade can be drawn.

So the probability of drawing either an ace or a spade or both.

$$P\{E_1 + E_2\} = P\{E_1\} + P\{E_2\} - P\{E_1 E_2\}$$

$$= \frac{4}{52} + \frac{13}{53} - \frac{1}{13}$$

$$= \frac{16}{52} = \frac{4}{13}$$

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E_1 = drawing an ace

E_2 = drawing a king

$$P\{E_1\} = \frac{4}{52} = \frac{1}{13}$$

$$P\{E_2\} = \frac{4}{52} = \frac{1}{13}$$

Since both ace and king can not be drawn in a single draw, thus mutually exclusive events.

$$P(E_1 + E_2) = P(E_1) + P(E_2)$$

$$= \frac{1}{13} + \frac{1}{13}$$

Probability of drawing an ace or a king in a single draw.

The probability of drawing either an ace or a king in a single draw is

$$P\{E_1 + E_2\} = P\{E_1\} + P\{E_2\}$$

$$= \frac{1}{13} + \frac{1}{13}$$

$$= \frac{2}{13}$$

$$P\{E_1 + E_2\} = P\{E_1\} + P\{E_2\} - P\{E_1 E_2\}$$

Proof by yourself

$$P\{E_1 + E_2\} = P\{E_1\} + P\{E_2\}$$

[for mutually exclusive events]

$$P\{E_1 + E_2 + \dots + E_n\} = P\{E_1\} + P\{E_2\} + \dots + P\{E_n\}$$

" So here $E_1 + E_2$ denotes either E_1 or E_2 or both occur."

" $E_1 E_2$ denotes both E_1 & E_2 occur "

E_1 = drawing an ~~edge~~ ace from a deck of card.

E_2 = drawing an ~~key~~ king from a deck of card

Probability of $E_1 = \frac{4}{52} = \frac{1}{13}$

" of $E_2 = \frac{4}{52} = \frac{1}{13}$

The probability that the second ball drawn is black, given that the first ball drawn comes black $P\{E_2 | E_1\} = \frac{1}{4}$

$P\{E_1 E_2\} = \{\frac{1}{4} \times \frac{2}{5}\} = \frac{1}{10}$

Independent event example:

$E_1 = \{$ head on 5th toss $\}$

$E_2 = \{$ Head on 6th toss $\}$

$P\{E_1 E_2\} = \frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$

Mutually exclusive event:

Two or more events are called mutualy exclusive if the occurence of one of them excludes the occurrences of others.

$P\{E_1, E_2\} = 0$

Independent events:

Conditional probability

$$P\{E_1 E_2\} = P\{E_1\} \; P\{E_2 | E_1\}$$

$\downarrow$

compound event

$$P\{E_2 | E_1\} = \frac{P\{E_1 E_2\}}{P\{E_1\}}$$

Independent event:

$$P\{E_1 E_2\} = ?$$

Let's have 3 red balls and 2 black balls in a box.

E_1 = "1st black ball is picked up"

E_2 = "2ndly black ball is picked up"

$$P\{E_1\} = \frac{2}{5}$$

if ~~$P\{E_1, E_2\}$~~ $E_1 E_2$ is conditional combined event.

$$P_r\{E_1 E_2\} = P_r\{E_1\}\, P_r\{E_2 | E_1\}$$

$$P_r(E_2 | E_1) = \frac{P_r\{E_1 E_2\}}{P_r\{E_1\}}$$

Elementary Probability theory: (rps)

Probability is a measure of uncertainty.

~~Condi~~ Conditional probability:

Suppose that, an event E can occur in h ways out of a total of a possible likely ways. Then the probability of occurence of the event (called its success) is denoted by

$$P = P_r(E) = \frac{h}{n}$$

If E_1 and E_2 are two events, the probability that E_2 occurs ~~that~~ given that E_1 has occured. is denoted by $Pr\{E_2 | E_1\}$ or $\{E_2 \text{ given } E_1\}$ and is called the conditional probability of E_2 given that E_1 has occured.

Prediction:

In general, prediction is the process of determining the magnitude of statistical variates at some future point of time.

The researcher divides the population into separate groups, called clusters. Then a simple random sample of clusters is

Difference between

s

In statistical modeling, regression analysis is a statistial process for estimating the relationships among varlables. It includes many techniques for modeling and analyzing several variables,

s^2

$$s = \sqrt{\frac{\sum_{j=1}^{N} (x_j - a)^2}{N}}$$

68.27%

$\bar{x} - s$

$$s^2 = \frac{N_1 s_1^2 + N_2 s_2^2}{N_1 + N_2}$$

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{N}}$$

$$s^2 = \frac{\sum (x - \bar{x})^2}{N}$$

$$= \frac{\sum x^2 - 2\bar{x}x + \bar{x}^2}{N}$$

$$= \frac{\sum x^2}{N} - 2\frac{\bar{x}\sum x}{N} + \frac{N\bar{x}^2}{N}$$

$$= \frac{\sum x^2}{N} - 2\bar{x}^2 + \bar{x}^2$$

$$= \frac{\sum x^2}{N} - \bar{x}^2$$

$$\bar{x}^2 = \bar{x}^2$$

$=$

$$s = \sqrt{\frac{\sum x^2}{N} - \left(\frac{\sum x}{N}\right)^2} = \sqrt{\bar{x}^2 - \bar{x}^2}$$

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$$s = \sqrt{\frac{\sum_{j=1}^{N}(x_j - \bar{x})^2}{N}} = \frac{\sum f(x-\bar{x})^2}{N} = \sqrt{\frac{\sum f x^2}{N}}$$

$$\sqrt{(\overline{x-\bar{x}})^2}$$

$$s = \sqrt{\frac{\sum (x-\bar{x})^2}{N}}$$

$$s^2 = \frac{\sum (x-\bar{x})^2}{N}$$

$$= \frac{\sum (x^2 - 2\bar{x}x + \bar{x}^2)}{N}$$

$$= \frac{\sum x^2 - 2\bar{x}\sum x + N\bar{x}^2}{N}$$

$$= \frac{\sum x^2}{N} - 2\bar{x}\frac{\sum x}{N} + \bar{x}^2$$

$$= \cancel{\frac{\sum x^2}{N} - 2\bar{x}\frac{\sum x}{N} + \bar{x}^2}$$

$$= \frac{\sum x^2}{N} - 2\bar{x}^2 + \bar{x}^2 = \sqrt{\bar{x}^2 - \bar{x}^2}$$

$$= \frac{\sum x^2}{N} - \bar{x}^2$$

$$\bar{x}^2 = \bar{x}^2$$

$$= \frac{\sum \bar{x}^2}{N} - \left(\frac{\sum x}{N}\right)^2$$

$$\Rightarrow s = \sqrt{\frac{\sum x^2}{N} - \left(\frac{\sum x}{N}\right)^2}$$

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Thus is $\boxed{.75}$ $\boxed{1.5}$ $\boxed{.38}$

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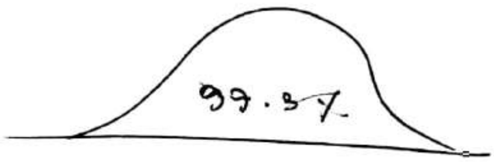
(i) List the data height & weight

~~(ii)~~ justify the normal behaviour



(ii) Verify the symmetric or not

symmetric properly.

Before we do anything with a data-
Look at it.

A quick look at a sample may
clearly suggest.

- A probability model i.e a family of distribution to be used.

- Statistical methods suitable for the given data.

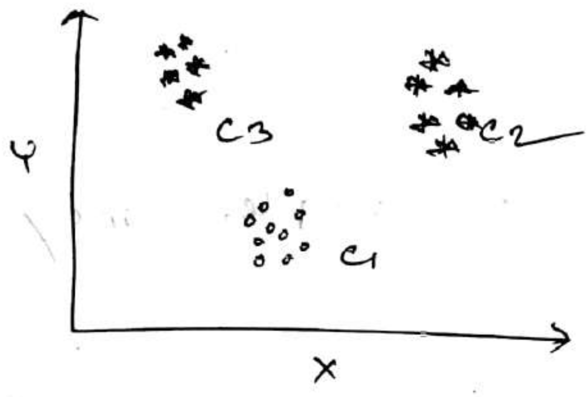
- Presence or absence of outliers.

- Existence of time trends ~~out~~ and other pattern.

- Relation between 2 or several values.

Histogram / box plot
stem & leaf plots
Scatter plots

Clusters & regression

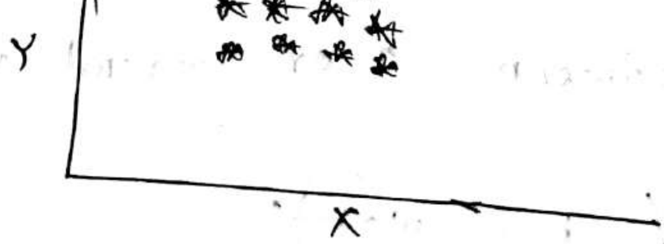


Σ sum square error
min

Clustering (process যদি random হয়)

~~Classifying~~
classification (process যদি supervised হলে)

Regression :



$$Y' = Ax^2 + Bx + C$$

Actually tells how two variables are related
to each other.

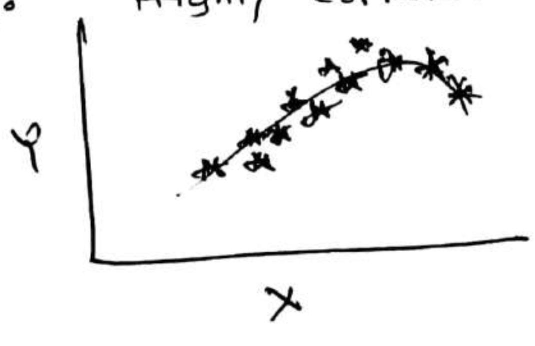
(iii) All the data points observe outside of this interval are assumed suspiciously far. They are the first candidate to be handed as outliers.

How to handle outlier :

Find out the history of outlier :

This rule ~~terms~~ comes from the assumption that the data are ~~normall~~ nearly normally distributed 99.3% population should appear within 1.3 f interquartile ranges from quartiles.

Corelation: Highly correlated



Lowly correlated

So we have to use those measures of variability to find defect outlier & which are not sensitive to outlier, i.e interquartile range.

Outlier detection :

(i) Find or measure the value 1.5 (interquartile range) 1.5 IQR

(ii) Then find out the limits by measuring 1.5 (IQR) from the both side quartiles.
$1.5(Q_3 - Q_1)$

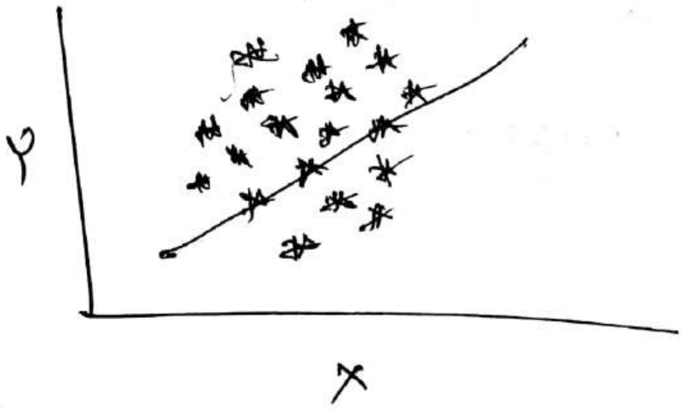
$$L_1 = Q_1 - 1.5\,(IQR)$$

$$L_2 = Q_3 + 1.5\,(IQR)$$

$$\text{Limit} = [L_1, L_2]$$

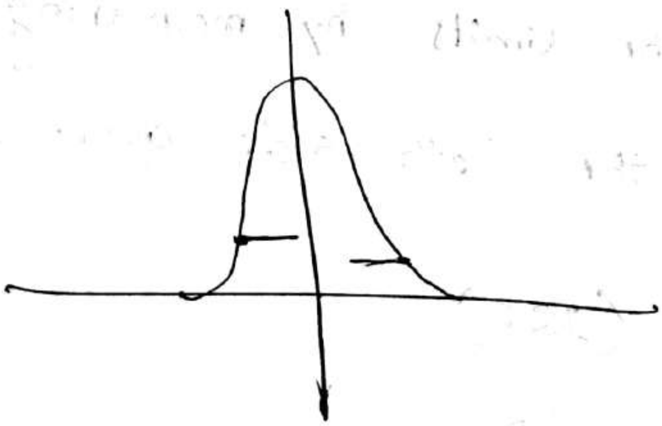
Prediction / Forecasting and outliers

abrupt



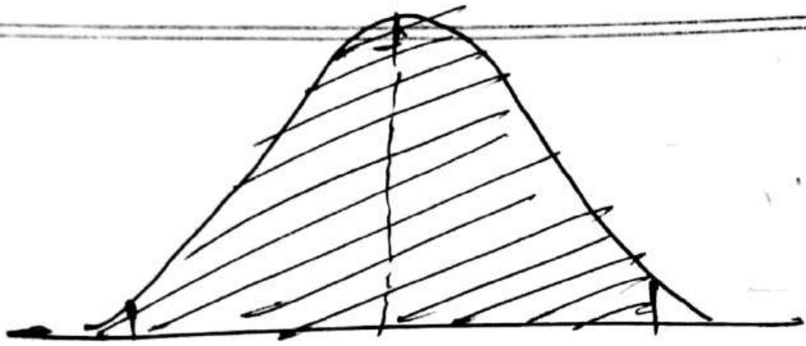
$Y = mx + c$

ব্যতিক্রম, extreme case গুলো হল outliers.



Standard deviation, variance

Some measure of variability are sensitive to outlier.



Combined variance

$$s^2 = \frac{N_1 s_1^2 + N_2 s_2^2}{N_1 + N_2}$$

$$s = \sqrt{\frac{\Sigma x^2}{N} - \left(\frac{\Sigma x}{N}\right)^2}$$

$$= \sqrt{\overline{x^2} - \bar{x}^2}$$

Standard deviation:

$$s = \sqrt{\frac{\left(\sum_{j=1}^{N} x_j - \bar{x}\right)^2}{N}}$$

$$= \sqrt{\left(\Sigma x - \bar{x}\right)^2}$$

Variance:

Standard deviation এর square ই হচ্ছে variance.

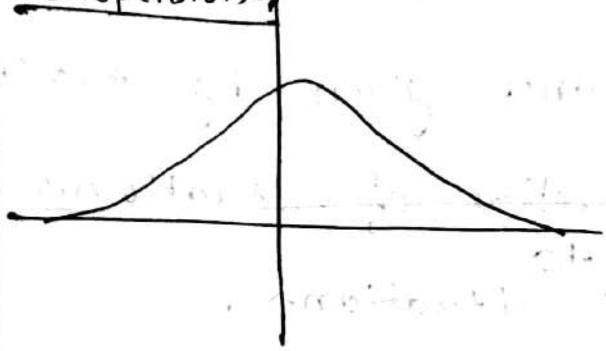
Properties of standard deviation:

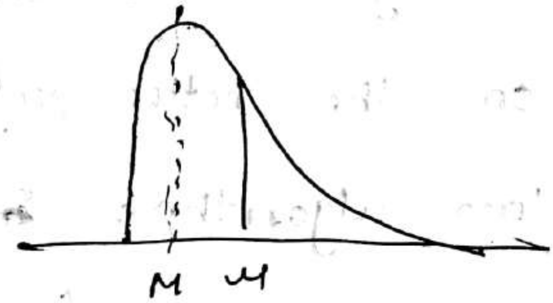
1. The SD can be defined as

$$s = \sqrt{\frac{\sum_{j=1}^{N} (x_j - a)^2}{N}}$$

of all such standard deviation, the minimum is that for which $a = \bar{x}$.

Dispersion:





Range:

Mean deviation

$x_1, x_2 \dots x_N$

$$MD = \sum^{N} \frac{|x_j - \bar{x}|}{N}$$

Interquartile range:

$$Q = \frac{Q_3 - Q_1}{2}$$

10-90 percentile range

$\longrightarrow P_{90} - P_{10}$

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Mainly. in the whole context we will focus on the better performance given by these two algorithms ~~irrespective of situations~~.

with ~~the~~ respect ~~of~~ to situations.

value is called the dispersion or variation of the data.

Example of
The measures of dispersion

range, mean deviation, semi interquartile range, 10–90 percentile range, standard deviation.

Mostly used → standard deviation.

Measures of variability actually measures how unstable the variable can be, and how much the actual value can differ from its expectation to assess reliability of our estimates and accuracy of our forecasts.

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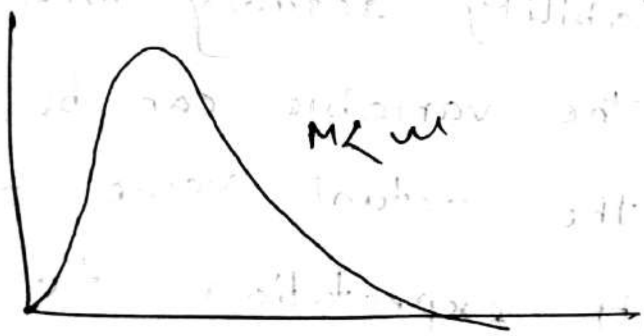
Population median M is a number that is exceeded with probability no greater than 0.5 and is preceeded with probability no greater than 0.5. That is, M is such that

$$P\{X > M\} \leq 0.5$$

$$P\{X < M\} \leq .5$$



Measures of central tendency
Measures of dispersion

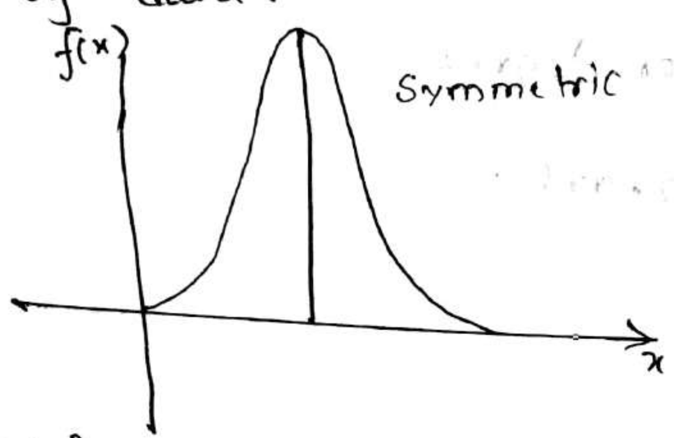
[illegible] difference with examples

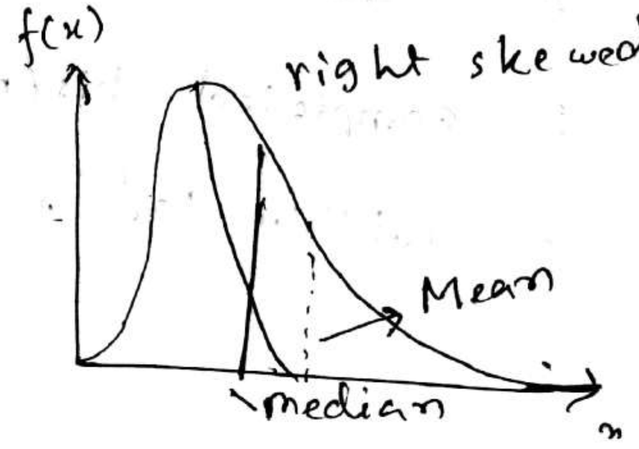
<u>dispersion:</u>

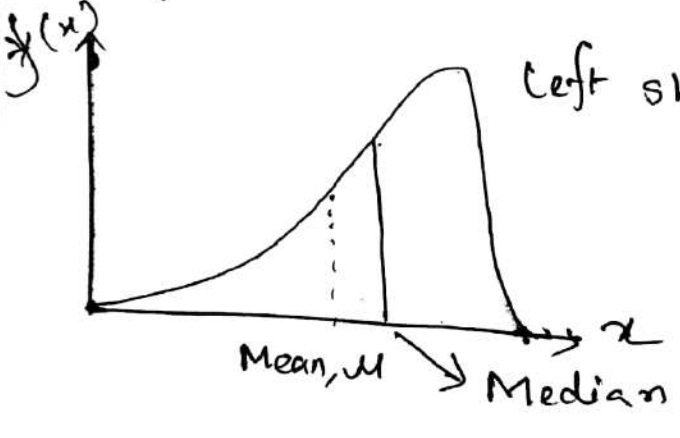
The degree to which numerical data tend to spread about an average

$\frac{5+b}{2}$

Varience, standard deviation or interquartile range measures the variability or spread of data.







Median means a 'central' value.
Sample median is a number that is ~~executed~~ exceeded by at most a half of observations and is preceeded by at most a half of observation.

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Population

= Bangladeshi students

= admitted into European university

= completed his/her degree.

= within last 5 years.

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$$= \frac{\Sigma A f_j + \Sigma f_j d_j}{N}$$

$$= \frac{A \Sigma f_j + \Sigma f_j d_j}{N}$$

$$= \frac{AN + \Sigma f_j d_j}{N}$$

$$= A + \frac{\Sigma f_j d_j}{N}$$

$$= A + \frac{\Sigma f d}{N}$$

$$\bar{x} = \frac{\Sigma x}{N} = \frac{\Sigma f x}{N}$$

Some problems from book HW

Disperssion.

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where we have used Σ in place of $\sum_{j=1}^{N}$ for briefly.

(b) In case $x_1, x_2, \dots x_k$ have respective frequencies, $f_1, f_2, \dots f_k$ and $d_1 = x_1 - A$, $d_2 = x_2 - A$, $d_k = x_k - A$

Show that the result in part A is replaced with,

$$\bar{x} = A + \frac{\sum_{j=1}^{k} f_j d_j}{\sum_{j=1}^{k} f_j}$$

$$= A + \frac{\Sigma f d}{N} \quad \text{where } \sum_{j=1}^{k} f_j = \Sigma f = N$$

Soln:
$$\bar{x} = \frac{\sum_{j=1}^{k} f_j x_j}{\sum_{j=1}^{k} f_j}$$

$$= \frac{\Sigma f_j x_j}{N}$$

$$= \frac{\Sigma f_j (A + d_j)}{N}$$

(a) If N numbers $x_1, x_2 \dots x_n$ have deviation from any number. A given by $d_1 = x_1 - A$, $d_2 = x_2 - A$ ... $d_N = x_N - A$ respresentively, then prove that,

$$\bar{x} = A + \frac{\sum_{j=1}^{N} dj}{N}$$

$$= A + \frac{\Sigma d}{N}$$

Solⁿ: Since $dj = x_j - A$ and $x_j = A + dj$ we have,

$$\bar{x} = \frac{\Sigma x_j}{N}$$

$$= \frac{\Sigma (A + dj)}{N}$$

$$= \frac{\Sigma A + \Sigma dj}{N}$$

$$= \frac{NA + \Sigma dj}{N}$$

$$= A + \frac{\Sigma dj}{N}$$

Here, $w = a$,

$$p = -2\frac{\sum x}{N}$$

$$q = \frac{\sum x^2}{N}$$

$$a = -\frac{1}{2}p$$

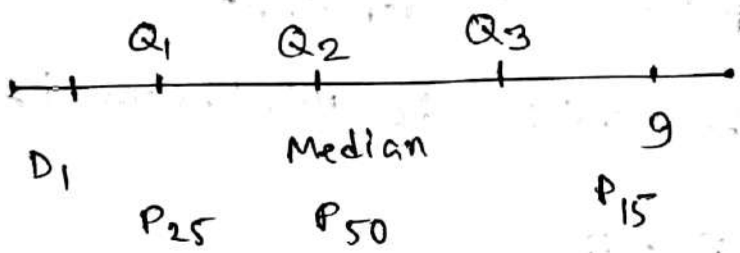
$$= \frac{\sum x}{N}$$

$$= \bar{x}$$

$\therefore \frac{\sum (x-a)^2}{N}$ it will be minimum if and only if

$$a = \bar{x}$$

Q = Quartiles



quartiles

Deciles = D

percentile = P1

Prove that sum of the squares of the derivation of a set of number x_j from any number a is minimum if and only if $a = \bar{x}$.

Lets take statement,

$$w^2 + pw + q$$

$$= w^2 + 2w \cdot \frac{1}{2}p + \left(\frac{1}{2}p\right)^2 + q - \frac{1}{4}p^2$$

$$= \left(w + \frac{1}{p}p\right)^2 + \underbrace{q - \frac{1}{4}p^2}_{\text{constant}}$$

The statement will be minimum if

$$w + \frac{1}{2}p = 0$$

$$\text{or, } w = -\frac{1}{2}p$$

$$\frac{\sum (x-a)^2}{N} = \frac{\sum (x^2 - 2ax + a^2)}{N}$$

$$= \frac{\sum x^2 - 2a \sum x + Na^2}{N}$$

$$= a^2 - 2a \sum \frac{x}{N} + \frac{\sum x^2}{N}$$

Prove that algebric sum of the derivations of a set of numbers from their arithmetic mean is zero.

Let, $x_1, x_2, \ldots, x_N$ is the set of numbers and mean is $\bar{x}$.

Then the derivations, deviations

$$d_1 = x_1 - \bar{x}$$

$$d_2 = x_2 - \bar{x}$$

$$d_N = x_N - \bar{x}$$

Sum of the derivations, $\sum d = \sum_{j=1}^{N} (x_j - \bar{x})$

$$\sum d = \sum_j x_j - \sum_j \bar{x}$$

$$= \sum_j x_j - N\bar{x}$$

$$= \sum_j x_j - N \sum \frac{x_j}{N}$$

$$= \sum_j x_j - \sum_j x_j$$

$$= 0$$

if and only if $a = \bar{x}$

→ If f_1 numbers have mean m_1, f_2 numbers have mean m_2, the number have mean n_k, the mean of all numbers is —

$$\bar{x} = \frac{f_1 m_1 + f_2 m_2 + \dots + f_k m_k}{f_1 + f_2 + \dots + f_k}$$ weighted AM of all the means.

10, 20, 30, 15, 25, 35

$$AM,\ x = \frac{10 + 20 + 30 + 15, 25, 35}{6} = \frac{135}{6}$$

$= 22.5$

(i) -12.5

(ii) -2.5

(iii) 7.5 Arithmetic mean of them are zero.

(iv) -7.5

(v) 2.5

(vi) 12.5

weight same ना रहना,

Weight arithmetic mean:

$x_1 - w_1$

$x_2 - w_2$

$x_N - w_N$

$$\bar{x} = \frac{x_1 w_1 + x_2 w_2 + \dots + x_N w_N}{w_1 + w_2 + \dots + w_N}$$

$$= \frac{\sum_{j=1}^{k} x_j w_j}{\sum_{j=1}^{k} w_j}$$

$$= \frac{\sum xw}{\sum w}$$

Properties:

→ Algebric sum of the derivation of a set of numbers from their arithmetic mean is zero.

→ The sum of the squares of the derivation of a set of numbers x_j from any number a is minimum

Bell shaped / symmetrical

→ Equidistance from the max will have same frequency

→ Normal distribution

Kurtosis

একটি distribution spike হতে পারে। একটি distribution flat হতে পারে।

Arithmatic mean (AM):

$$\bar{x} = \frac{x_1 + x_2 + \dots + x_n}{N}$$

$$= \frac{\sum_{j=1}^{k} x_j}{N}$$

$$= \frac{\sum x}{N}$$

$x_1 - f_1$

$x_2 - f_2$

$\vdots$

$x_n - f_n$

$$= \frac{x_1 f_1 + x_2 f_2 + \dots + x_N f_N}{f_1 + f_2 + \dots + f_n}$$

$$= \sum_{j=1}^{k} \frac{f_j x_j}{f_j} = \frac{\sum f x}{N}$$

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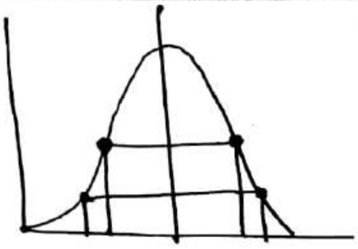
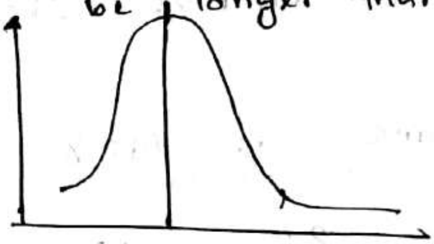
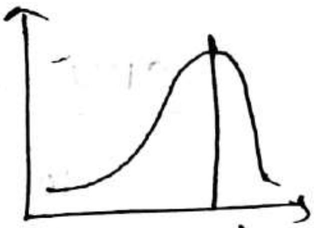
tail in one side of the maximum will be longer than other side



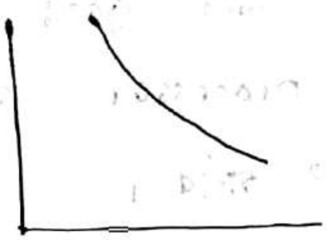
Bell shaped
symmetrical

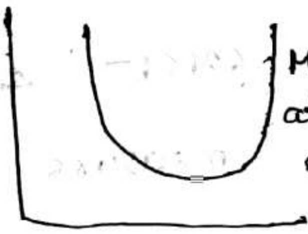


Right skewed
(positive skewed)



left skewed
(negetive





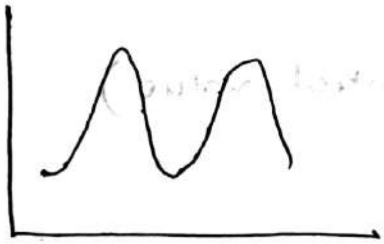
Maximum at both end

maximum at one end

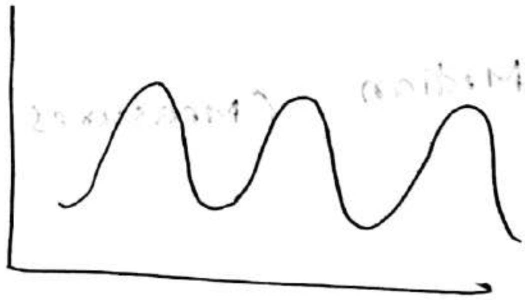
J shaped

Reverse J shape

U shaped (minimum থেকে count করলে symmetric বলা যায়)



bimodal



~~multi~~ trimodal.

Simple descriptive statistics

CPU time of N = 8 jobs

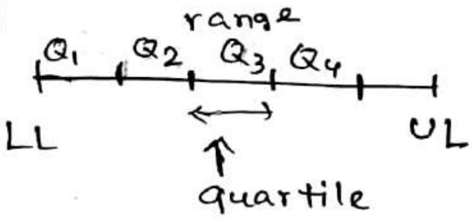
10	20	15	16
17	20	21	17

← Good sample

random sample যদি good sample হয় তাহলে তা থেকে আমরা processor এর performance measure করতে পারি।

Distribution

Knowledge ~~of~~ or information



→ Mean (Find out the average of a sample set)

→ Median (Measures the central value)

আছে

68 84 75 82 68 90 62 88 76 93

73 79 88 73 60 93 71 59 85 75

61 65 75 87 74 62 95 78 63 72

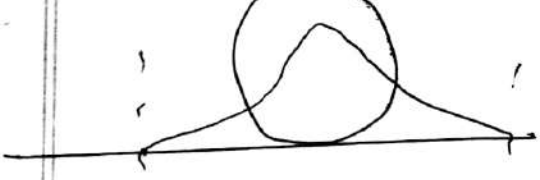
66 78 82 75 94 77 69

→ Find highest & lowest

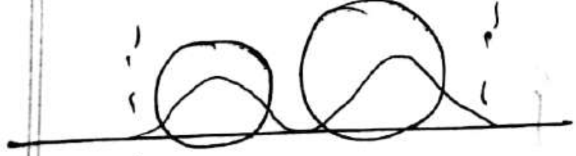
→ divide into intervals

→ Make histogram

→ Again find mean, median etc using equation and compare with histogram.



-single mode



bi model

tri model

if the graph is like that then the object এ কোনটার background আছে কোনটার object আছে। দুই জায়গায় Data prominent আছে।

Mean: Measures the average value of a sample.

Median: Measures the central value.

Quartile/Quantile: actually shows where certain portion of a sample are located.

Variance, standard deviation, interquartile range: measures the variability or spread of data.

X is a sample.

$S = \{x_1, x_2, \ldots, x_n\}$

Mean:

$$\text{Mean}, M = E(X) = \frac{x_1 + x_2 + \ldots + x_n}{n}$$

Sorted data : $x_1, x_2, \ldots x_n$

→ odd : x_i

→ even : $\frac{x_i + x_{i+1}}{2}$

Simple descriptive Statistics :

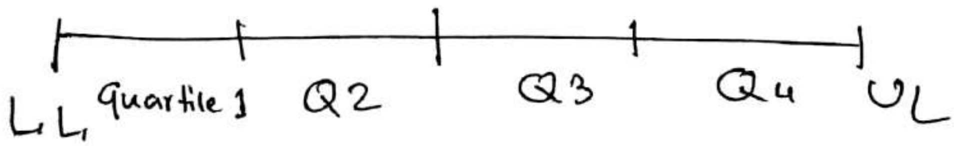
CPU time of N = 8 jobs

10 20 15 16

17 20 21 17

knowledge
or
information

→ Mean
→ Median
→ Quantiles/Quartiles
→ Variants, standard deviation
→ Interquartile range



wrong

choose করার হয়েছিল, Biased হওয়ার থাকে না।

Sales	10
Admin	5
~~Marketing~~ HR	30

Notebook

A

B

C

Collection of data ভুল হলে prediction ভুল হবে।

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of a population is observed. For most of reasonable statistical procedures, sampling errors decrease as the sample size increases.

Non sampling errors:

Non sampling errors are caused by inappropriate sampling ~~skills~~ schemes or wrong statistical techniques.

Literary digest magazine

1920
1924
1928
1932 prediction
USA presidential election prediction

1936 এ Prediction fail করেছে।

Because The Literary digest subscribers were mostly republicans. Wrong sample

POPULATION → Parameters : μ, σ, σ^2 and others

↓ ↓ ↓ ↓

data collection (sampling)

↓↓↓

sample → statistics $\bar{x}, s, s^2$ and others

statistical inference About the population

- Estimation
- Hypothesis testing
- Modeling
- etc

Population → parameters

Sample → statistics

A properly collected sample of data can provide rather sufficient information about the parameters of the observe system.

Sampling errors :

Sampling errors are cost by the mere fact that only a sample a proportion

Algorithm

1. Input the ranges.
2. Select the intervals.
3. Check the frequency of each interval and find out the number
4. Repeat the process 3.

H [1:n]

```
for (i = 1:n)
    if (m == i)
        H[i] + = 1;
```

Central tendency

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Data representation

→ Write down the algorithm to find out the histogram from array of table.

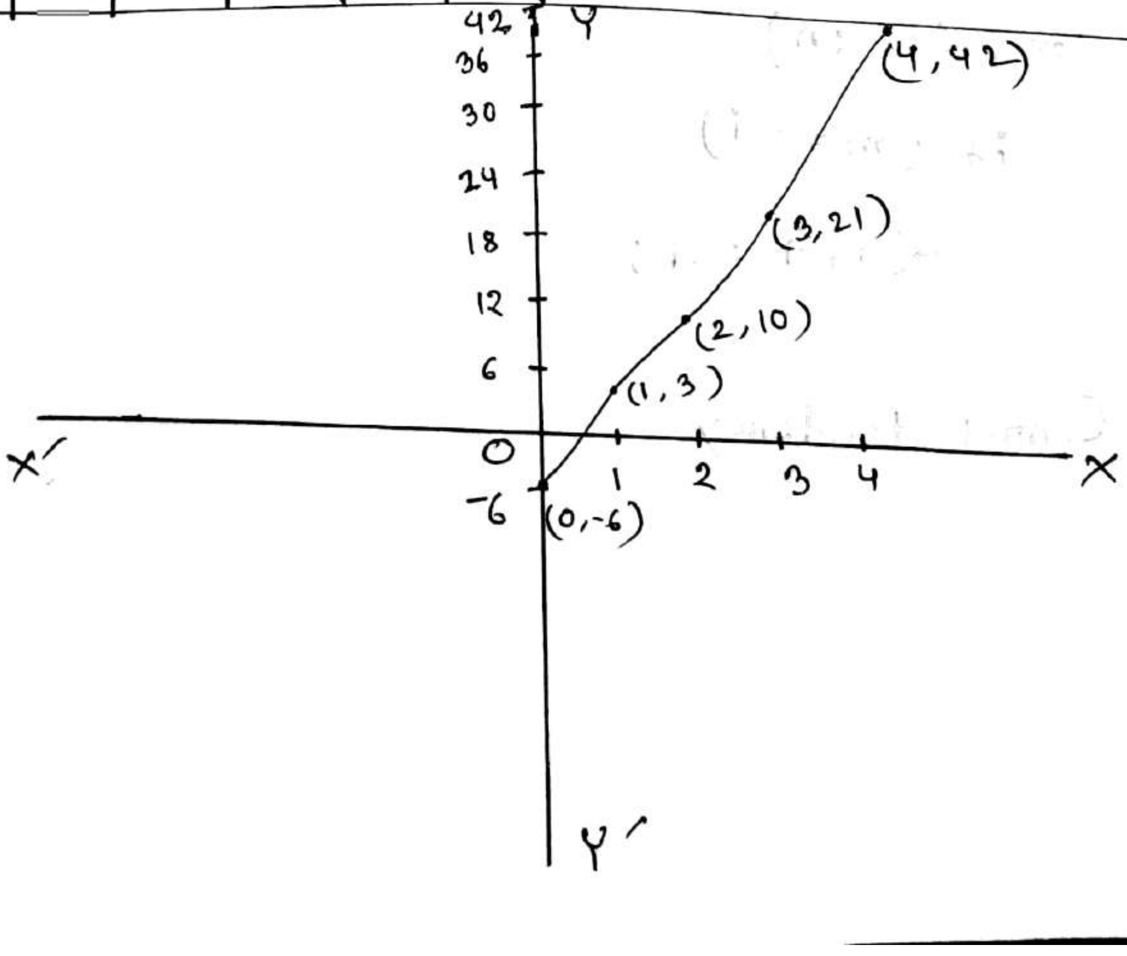
→ Graph the equation $Y = X^3 - 4X^2 + 12X - 6$

$1 - 4 + 12 - 6$

$27 - 4 \cdot 9 + 36 - 6$ $\quad$ $8 - 4 \cdot 4 + 24 - 6$

From different values of X we find the corresponding values of Y $\quad$ $64 - 64 + 48 - 6$

X	0	1	2	3	4
Y	-6	~~4~~ 3	10	21	42



Attendence – 10

Article – 30 [4–6] page

How to write an article

3.25
.75
1625
22750
2.4375

~~Co~~ Algorithm

Next class এ Title ঠিক করে আনতে হবে।

Review report
(Opposition report)
} (1-2) (1.5-3) page 20

Slide + Presentation (5+10)

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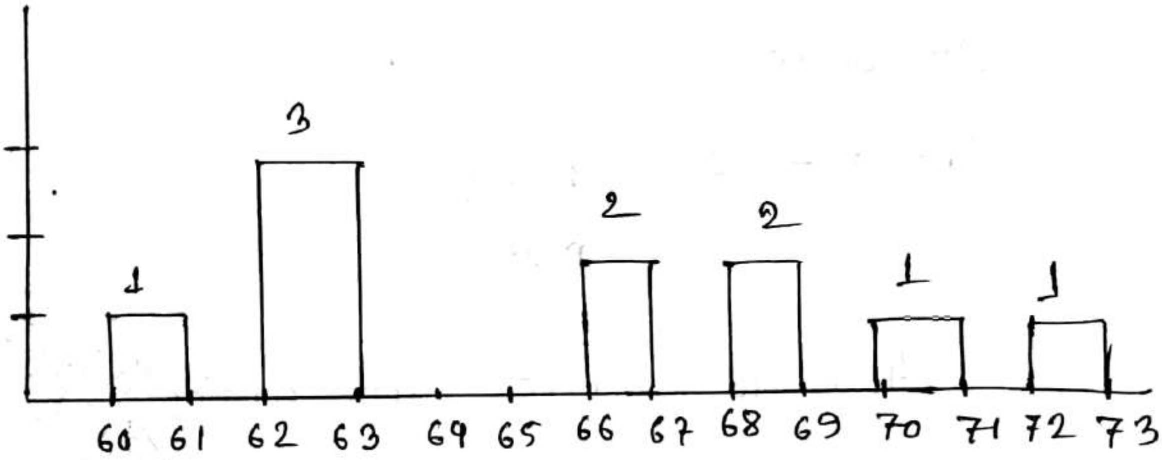

~~Histogram~~ representation

Q. What is relation between st

Q. Describe the role of statistics in computer science. Find out a real life problem with algorithm to show the relation.

Assignment

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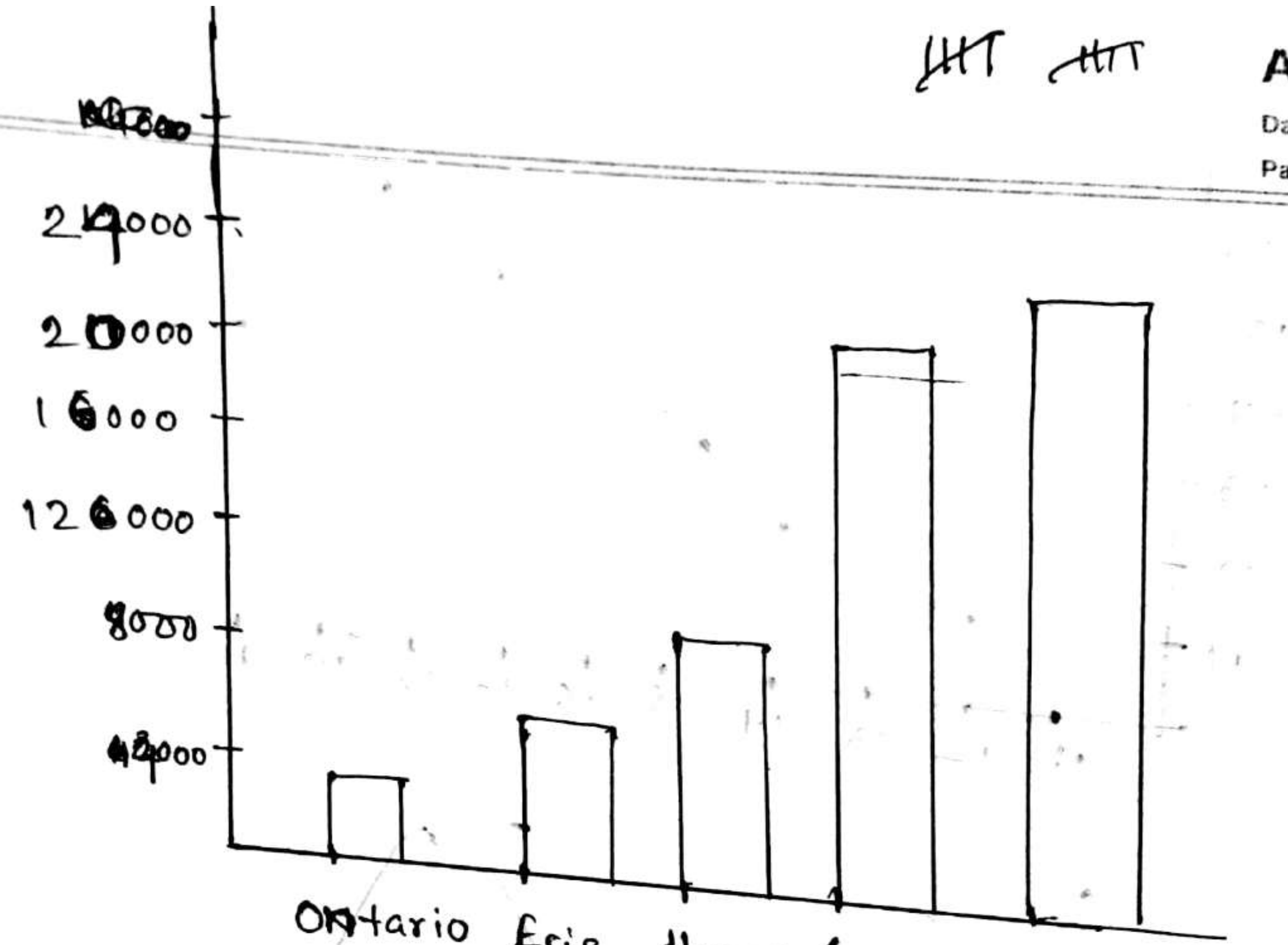
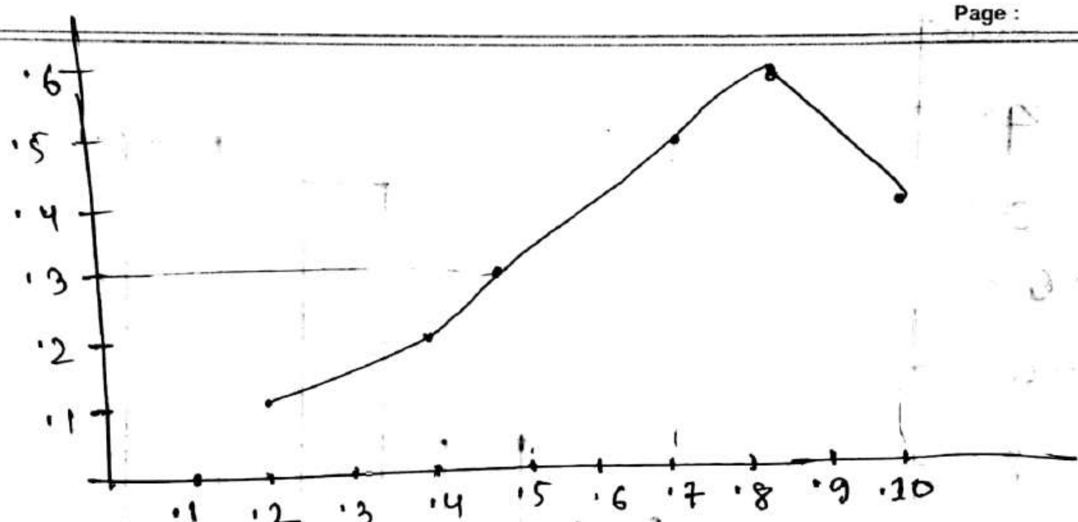
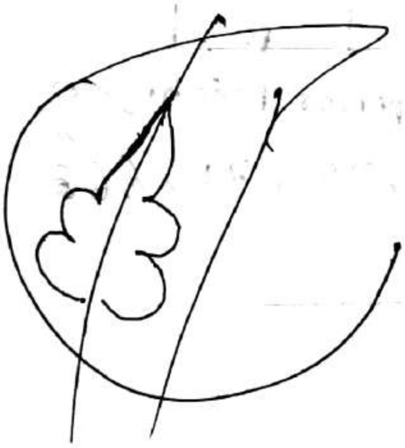
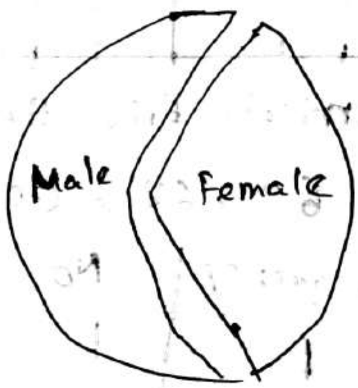


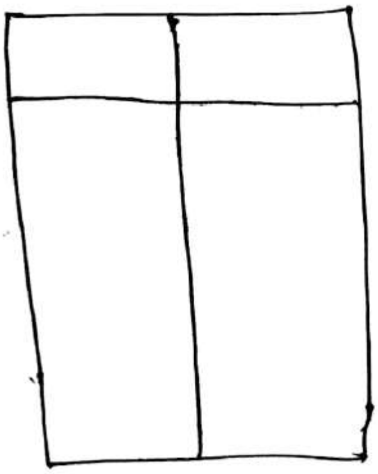
67, 63, 62, 62, 60, 68, 72, 71, 66

Interval	Frequency	No
60-61	I	1
62-63	III	3
64-65		
66-67	II	2
68-69	II	2
70-71	I	1
72-73	I	1


·6
·5
·4
·3
·2
·1
·1 ·2 ·3 ·4 ·5 ·6 ·7 ·8 ·9 ·10




Male
Female



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→ Descriptive Statistics / Deductive statistics

→ Inductive statistics / Inference

↳ deals with the condition ~~that~~ ~~to~~ make a conclusion valid.

কোন একটি interval এ যদি অসংখ্য number ~~continuous~~ ~~variable~~ দিয়ে represent করা যায় তাকে continuous variable

Discrete variable : (can be represented by finite no)

Male	0.1	.3	.5	.4	.6	.2
Female	.2	.5	.7	.10	.8	.4

* Statistics is gathering information out of data.
* Statistics is operation on data to infer something.

Statistics is the ~~summaryze of~~ summerized representation of information from ~~big~~ data.

Sample:
Sample should be a good representative of ~~a~~ the population.

Statistics

Population & Sample

What is statistics?

What do you mean by population & samples?

→ Data collection

→ Data representation

→ Data Analysis

→ Inference (Draw some conclusions)

Definition:
Statistics is concerned with scientific methods for collecting, organising, summarising, presenting and analyzing data as well as drawing valid conclusions. and making reasonable decisions on the basis of such analysis.