Practical - 1

Aim : Basics of R software.

1.) R is a software for statistical analysis and data computing.

2.) It is an effective data handling software and outcome storage is possible.

3.) It is capable of graphical display.

4.) It is a free software.

Q1. Solve the following :-

1.) $4 + 6 + 8 \div 2 - 5$

> 4+6 + 8/2 -5

[1] 9.

2.) $2^2 + |-3| + \sqrt{45}$

> 2^2 + abs(-3) + sqrt(45)

[1] 13.7082.

3.) $5^3 + 7 \times 5 \times 8 + 46/5$

> 5^3 + 7*5*8 + 46/5

[1] 414.2.

a) $\sqrt{4^2 + 5\times3 + 7/6}$

> sqrt (4^2 + 5 * 3 + 7/6)

[1] 5.671567

b) round off

$46 \div 7 + 9\times8$

> round (46 + 7 + 9 *8)

[1] 79

Q2

> c (2,3,5,7) * 2

[1] 4 6 10 14

> c (2,3,5,7) * c(2,3,6,2)

[1] 4 9 30 14

> c(2,3,5,7)^ 2

[1] 4 9 25 49

> c(6,2,7,5) / c (4,5)

[1] 1.50 0.40 1.75 1.00

> c(2,3,5,7) * c(2,3)

[1] 4 9 10 21

> c(1,6,2,3) * c(-2,-3,-4,-1)

[1] -2 -18 -8 -3.

> c (4,6,8,9,4,5) ^ c(1,2,3)

[1] 4 36 512 9 16 15.

Q3

> x = 20 > y = 30 > z = 2

> x^2 + y^3 + z

> [1] 27402

> sqrt(x^2 + y)

[1] 20.73644

> x^2 + y^2

[1] 1300

Q4. > X <- matrix (nrow = 4, ncol = 2, data = c(1,2,3,4,5,6,7,8

> X

		[,1]	[,2]
[1]	[1,]	1	5
	[2,]	2	6
	[3,]	3	7
	[4,]	4	8

Q5. Find x+y and 2x+3y where $x = \begin{bmatrix} 4 & -2 & 6 \\ 7 & 0 & 7 \\ 9 & -5 & 8 \end{bmatrix}$

$Y = \begin{bmatrix} 10 & -5 & 7 \\ 12 & -4 & 9 \\ 15 & 6 & 5 \end{bmatrix}$

> X <- matrix (nrow = 3, ncol = 3, data = c(4,7,9,-2,0,-5,
6,7,8)]

> X

	[,1]	[,2]	[,3]
[1,]	4	-2	6
[2,]	7	0	7
[3,]	9	-5	8

> Y <- matrix [nrow = 3, ncol = 3, data = c(10,12,15,
-5, -4, -6, 7, 0, 5)]

> Y ~~<-matrix~~

	[,1]	[,2]	[,3]
[1,]	10	-5	7
[2,]	12	-4	9
[3,]	15	6	5

> X+Y

	[,1]	[,2]	[,3]
[1,]	14	-7	13
[2,]	19	-4	6
[3,]	24	-11	8

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```
> 2* X + 3 * Y.
      [,1]   [,2]   [,3]
[1,]   38    -19     33
[2,]   50    -12     41
[3,]   63    -28     21.
```

Q6. Marks of Statistics of CS Batch B.

x = c (58, 20, 35, 24, 46, 56, 55, 45, 27, 22, 47, 58, 54, 40, 50, 32, 36, 29, 35, 39)

```
> x = c (data)
> breaks = seq (20, 60, 5)
> a = cut (x, breaks, right = FALSE)
> b = table (a)
> ~~c = transform (b)~~
> c = transform (b)
> c
         a        freq
1    [20, 25]     3
2    [25, 30]     2
3    [30, 35]     1
4    [35, 40]     4
5    [40, 45]     1
6    [45, 50]     3
7    [50, 55]     2
8    [55, 60]     4.
```

G

Practical - 2

Topic : Probability Distribution.

1.) Check whether the followings are p.m.f or not

x	$P(x)$
0	0.1
1	0.2
2	0.5
3	0.4
4	0.3
5	0.5

If the given data is p.m.f then $\Sigma P(x) = 1$.

$\therefore P(0) + P(1) + P(2) + P(3) + P(4) + P(5) = P(x)$

$= 0.1 + 0.2 \cancel{+} - 0.5 + 0.4 + 0.3 + 0.5$

$= 1.0$

$\because P(2) = -0.5$ it can be a probability mass function.

$\because P(x) \geq 0 \quad \forall, x.$

2)

x	$P(x)$
1	0.2
2	0.2
3	0.3
4	0.2
5	0.2

The condition for p.m.f. is $\Sigma P(x) = 1$.

So,

$\Sigma P(x) = P(1) + P(2) + P(3) + P(4) + P(5)$

$= 0.2 + 0.2 + 0.3 + 0.2 + 0.2$

$= 1.1$

$\therefore$ The given data is not a pmf because the $P(x) \neq 1$

3)

x	$P(x)$
10	0.2
20	0.2
30	0.35
40	0.15
50	0.1

The condition for pmf is $\forall x$ satisfy.

1) $P(x) \geq 0$

2) $\Sigma P(x) = 1$

$\Sigma P(x) = P(10) + P(20) + P(30) + P(40) + P(50)$

$= 0.2 + 0.2 + 0.35 + 0.15 + 0.1$

$= 1.$

$\therefore$ The given data is p.m.f

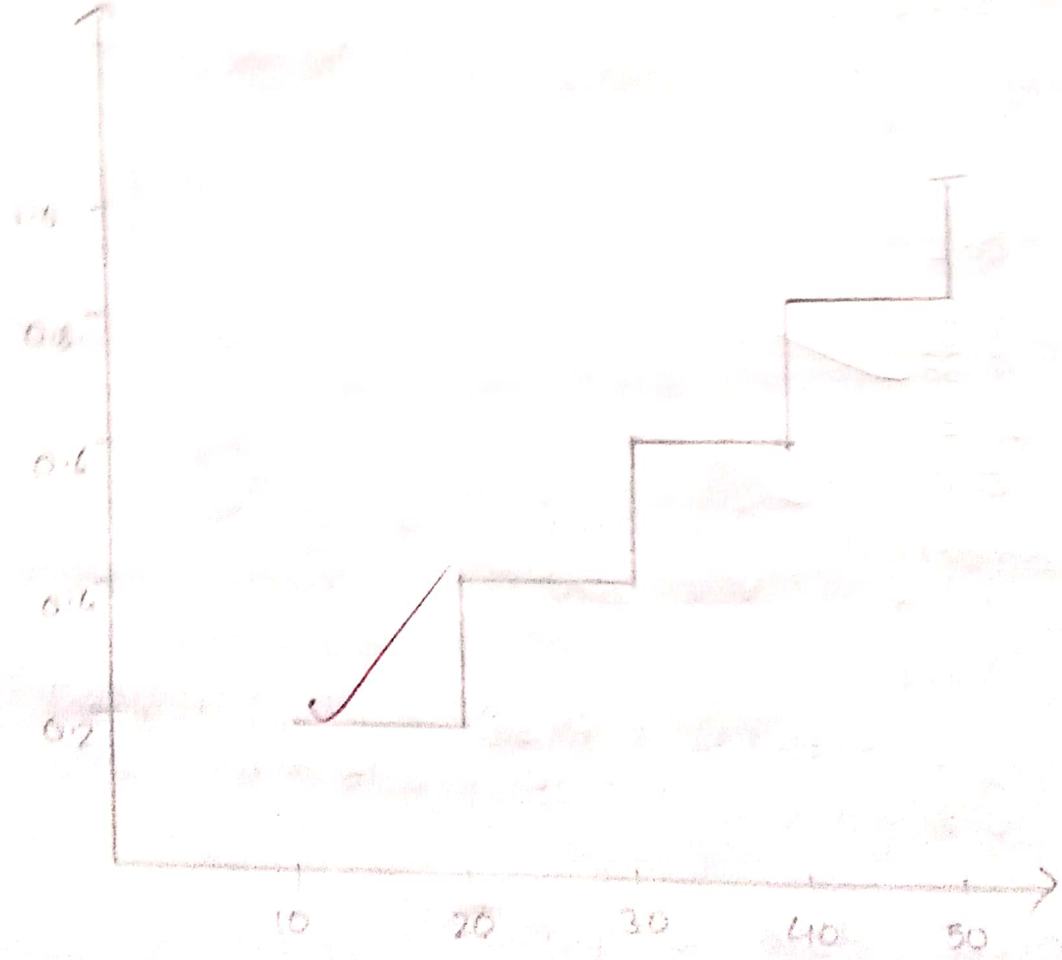
Code:

```
> Prob = c(0.2, 0.2, 0.35, 0.15, 0.1)
> Sum (Prob)
[1] 1
```

Q) Find the c.d.f for the following p.m.f and show the graph

x	10	20	30	40	50
$P(x)$	0.2	0.2	0.35	0.15	0.1

$$F(x) = \begin{cases} 0 & x < 10 \\ 0.2 & 10 \le x < 20 \\ 0.4 & 20 \le x < 30 \\ 0.75 & 30 \le x < 40 \\ 0.90 & 40 \le x < 50 \\ 0.1 & x \ge 50 \end{cases}$$




```
> X = c(10, 20, 30, 40, 50)
> plot (x, cumsum (Prob), "s")
```

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Q3. Find

x	1	2	3	4	5	6
$p(x)$	0.15	0.25	0.1	0.2	0.2	0.1

$F(x) = 0 \quad x < 1$

$= 0.15 \quad 1 \le x < 2$

$= 0.40 \quad 2 \le x < 3$

$= 0.50 \quad 3 \le x < 4$

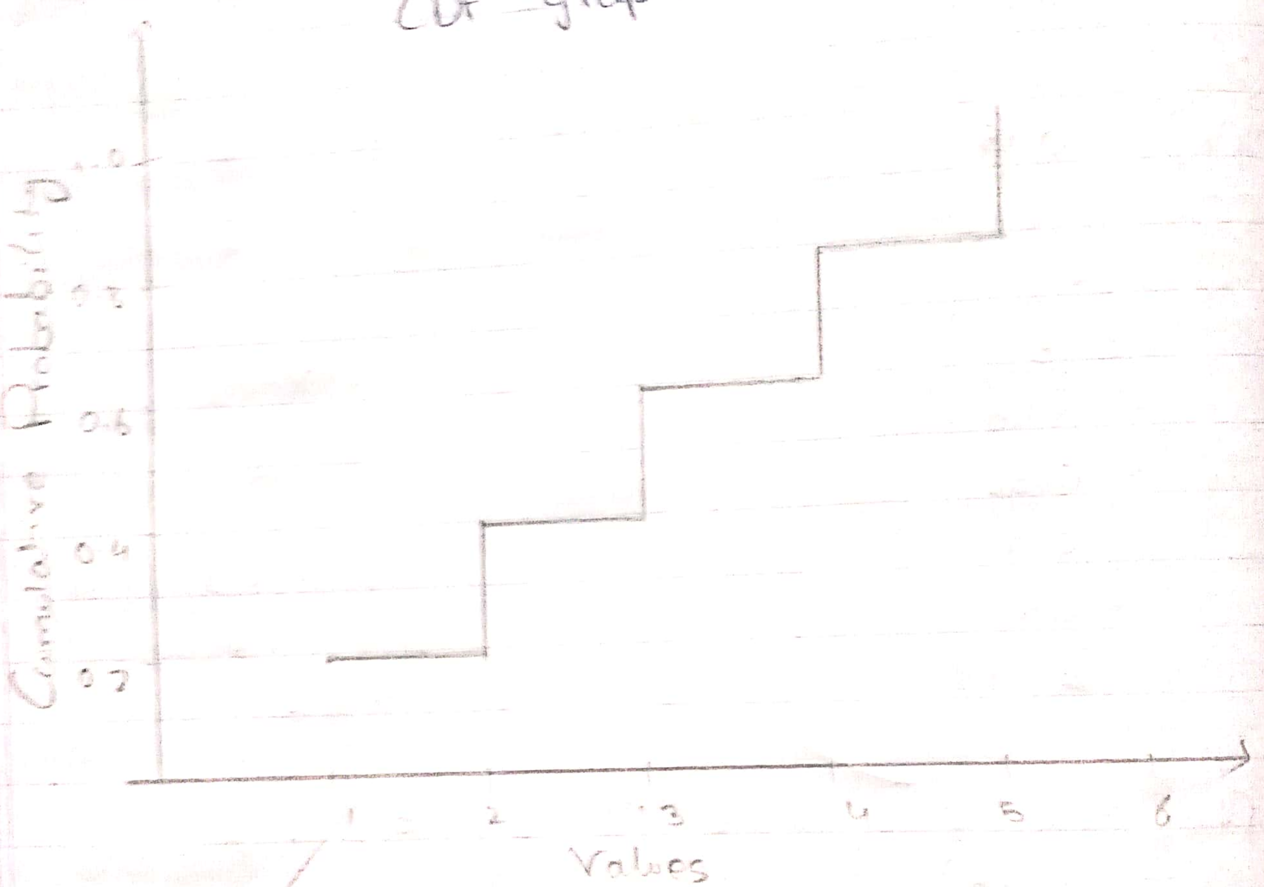
$= 0.70 \quad 4 \le x < 5$

$= 0.90 \quad 5 \le x < 6$

$= 1.00 \quad x \ge 6.$

```
> Prob = c(0.15, 0.25, 0.1, 0.2, 0.2, 0.1)
> sum (prob)
> [1]
> cumsum (prob)
[1] 0.15, 0.40, 0.50, 0.10, 0.90, 1.00
> x = c (1,2,3,4,5,6)
> plot (x, cumsum (prob)), "S" xlab = " value ".
    ylab = " cumulative probability ",
    main = " CDF graph ", col = " brown ").
```

CDF graph



3// Check that whether the following is p.d.f or not.

i) $F(x) = 3-2x; \quad 0 \leq x \leq 1$

ii) $F(x) = 3x^2 \quad ; \quad 0 < x < 1$

i) $F(x) = 3-2x$

$= \int_0^1 F(x)$

$= \int_0^1 (3-2x)\, dx$

$= \int_0^1 3dx - \int_0^1 2x\, dx$

$= [3x - x^2]_0^1 = 2$

$\because$ The $\int_0^1 f(x) = 1$ $\therefore$ It is not a pdf.

2.) $f(x) = 3x^2 ; 0 < x < 1$

$\int_0^1 f(x)$

$= \int_0^1 3x^2$

$= 3\int_0^1 x^2$

$= \left[3 \frac{x^3}{3}\right]_0^1$ $\because x^n = \frac{x^{n+1}}{n+1}$

$= x^3$

$= 1,$

The $\int_0^1 F(x) = 1$ $\therefore$ It is a pdf.

GR

1.) > x = dbinom(10, 100, 0.1)

> x

[1] 0.1318653

2// 1.) dbinom (4, 12, 0.2)

[1] 0.1328756

2.) pbinom (4, 12, 0.2)

[1] 0.4274445

3.) 1 - pbinom(5, 12, 0.2)

[1] 0.01940528.

3// dbinom (0:5, 5, 0.1)

0 - 0.59049

1 - 0.32805

2 - 0.07290

3 - 0.00810

4 - 0.00045

5 - 0.00001

4// 1.) dbinom (5, 12, 0.25)

[1] 0.1032414.

2.) pbinom (5, 12, 0.25)

[1] 0.9455978

3.) 1 - pbinom(7, 12, 0.25)

[1] 0.0027815,

4.) dbinom (6, 12, 0.25)

[1] 0.04014945

Practical - 3

Topic : Binomial Distribution.

$p(x = x)$ = dbinom (x, n, p).

$p(x \leq x)$ = pbinom (x, n, p)

$p(X > x)$ = 1- pbinom (x, n, p)

If x is unknown

$P1 = p(X \leq x)$ = qbinom (P_1, n, p)

1) Find the probability of exactly 10 success in hundred trials with $p = 0.1$.

2) Suppose there are 12 mcq, each question has 5 options out of which 1 is correct. Find the probability of having exactly 4 correct answers
ii) atmost 4 correct answers
iii) More than 5 correct answers.

3) Find the complete distribution when $n = 5$ and $p = 0.1$.

4) $n = 12$, $p = 0.25$. Find the following probabilities
i) $P(X = 6)$
ii) $P(X \leq 5)$
iii) $P(X \geq 7)$
iv) $P(5 < x < 7)$.

5.) The probability of a salesman making a sale to customer 0.15 Find the probability of

i) No sales out of 10 customer.

2.) More than 3 sales out of 20 customer

6.) A salesman has 20 % probability of making a sale to customer out of 30 customers what minimum number of sales has can make with 88 % of probability.

7.) X follows binomial distribution with $n=10$, $p=0.3$. plot the graph of p.m.f and c.d.f.

1) > x = dbinom (10, 100, 0.1)

> x

[1] 0.1318653

2) dbinom (4, 12, 0.2)

0.1328756

pbinom (4, 12, 0.2)

0.4274445

1 - pbinom (5, 12, 0.2)

0.01940528

3) dbinom (0:5, 5, 0.1)

0 - 0.59049

1 - 0.32805

2 - 0.07290

3 - 0.00810

4 - 0.00045

5 - 0.00001

4) dbinom (5, 12, 0.25)

0.1032414

pbinom (5, 12, 0.25)

0.9455978

1 - pbinom (7, 12, 0.25)

0.00278151

dbinom (6, 12, 0.25)

0.04014945

5.] dbinom (0, 10, 0.15)

0.1968744

1 - pbinom (3, 20, 0.15)

0.3522748

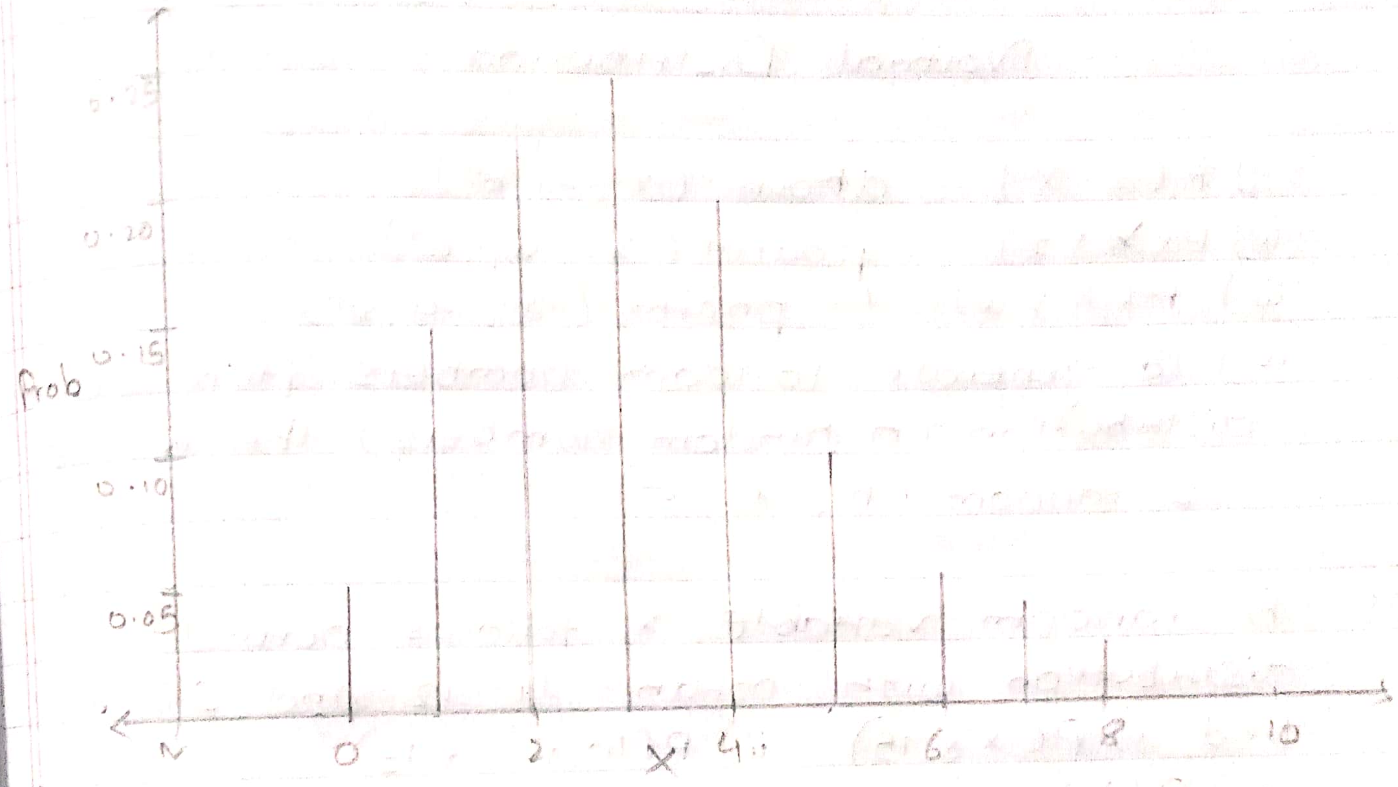
6.] qbinom (0.88, 30, 0.2)

9

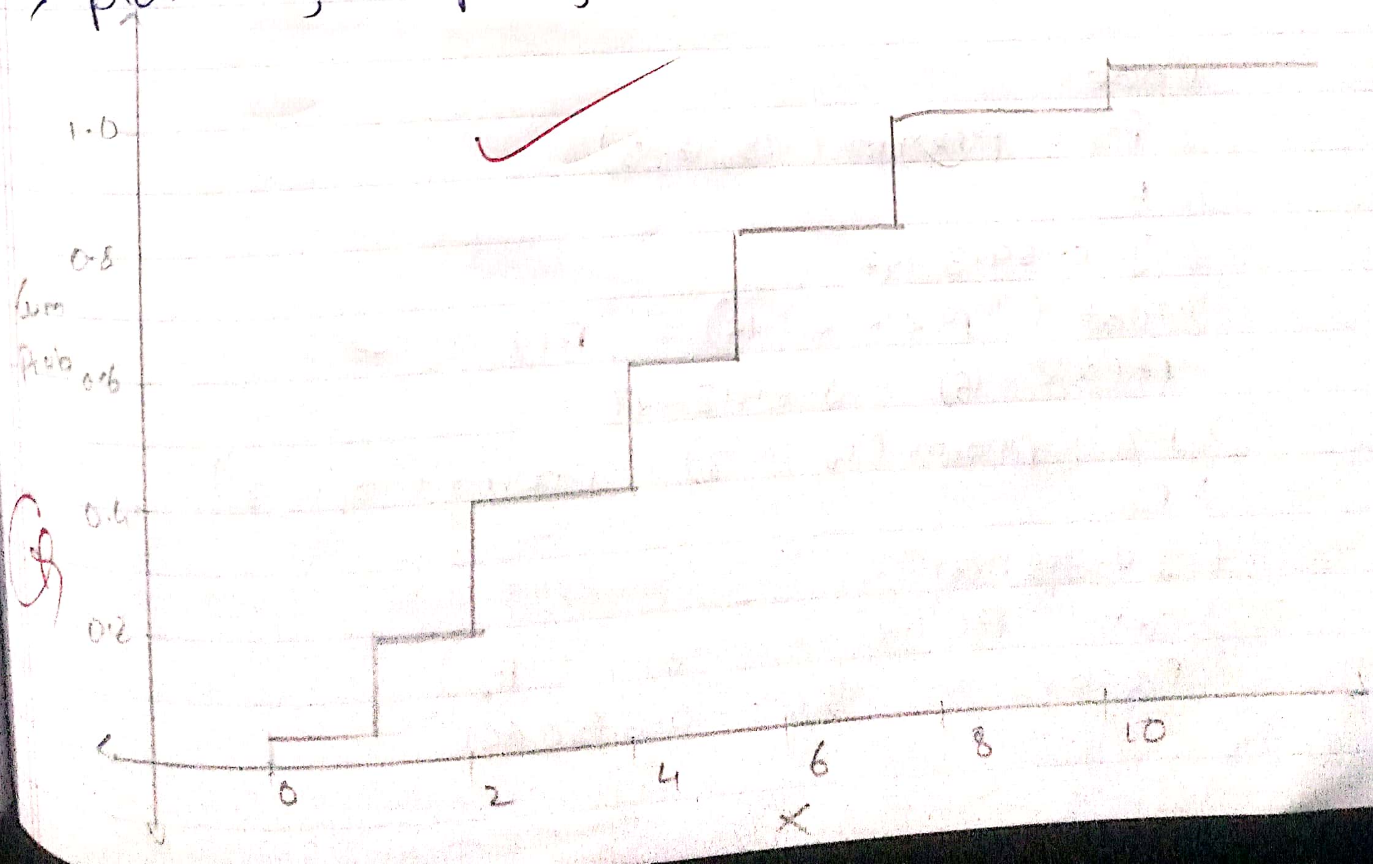
7.]
```
n = 10
p = 0.3
x = 0:n
prob = dbinom(x, n, p)
cumprob = pbinom(x, n, p)
d = data.frame("X values", = x, "Probability" = prob)
print (d)
```

	X values	Probability
1	0	0.0282
2	1	0.1210
3	2	0.2334
4	3	0.2668
5	4	0.2001
6	5	0.1029
7	6	0.0367
8	7	0.0090
9	8	0.0014
10	9	0.0001
4	10	0.0000

> plot (x, prob, "h")



> plot (x, cumprob, "s")



Practical - 4

Normal Distribution

i) $P(x = X)$ = dnorm (x, μ, σ)

ii) $P(X \leq x)$ = pnorm (x, μ, σ)

iii) $P(X > x)$ = 1 - pnorm (x, μ, σ)

iv) To generate random numbers from a normal distribution (n random numbers) the R code is random (n, μ, σ)

Q1. A random variable x follows normal distribution with mean = μ = 12 and S.D = σ = 3
Find i) $P(x \leq 15)$ ii) $P(10 \leq x \leq 13)$
iii) $P(x > 14)$
iv) Generate 5 observations (random numbers)

Code:

```
> P1 = pnorm (15, 12, 3)
> p1
[1] 0.8413447
> cat ("P<x <= 15) =", P1)
P (x <= 15) = 0.8413447
> P2 = pnorm (13, 12, 3) - pnorm (10, 12, 3)
> P2
[1] 0.378 0661
> cat ("P(10<= x <=13) = ", P2)
P(10<= x <= 13) = 0.3780661
```

```
> P3 = 1 - pnorm(14, 12, 3)
> P3
[1] 0.2524925
> cat("P(X>14) = ", P3)
P(X>14) = 0.2524925
> P4 = rnorm(5, 12, 3)
> P4
[1] 15.254723    16.548505    11.280515    6.419944    12.27246
```


2.) X follows normal distribution with $\mu = 10$, $\sigma = 2$,
Find i.) $P(X \leq 7)$ ii.) $P(5 < x < 12)$ iii.) $P(X > 12)$
iv.) Generate 10 observations. v.) Find k such that $P(X < k) = 0.4$.

code :

```
> a1 = pnorm(7, 10, 2)
> a1
[1] 0.668072
> a2 = pnorm(5, 10, 2) - pnorm(12, 10, 2)
> a2
[1] - 0.835135)
> a3 = 1 - pnorm(12, 10, 2)
> a3
[1] 0.1586553
> a4 = rnorm(10, 10, 2)
> a4
[1]
```

Practical - 5

Aim :- Normal and T- test.

Q1. Test the hypothesis $H_0; \mu = 15$, $H_1 : \mu \neq 15$. it is Random sample of size 400 is drawnand And the calculated the sample mean is 14. And the standard deviation is 3. Test the hypothe at 5% level of significance ?

m → mean   0 → population

σ → s.d.   n → sample size

Soln:

```
> mo = 15
> mx = 14
> sd = 3
> n = 400
> zcal = (mx - mo) /(sd / (sqrt(n)))
> zcal
[1] -6.666667
> cat ("Calculate value at 2 is = ,")
Calculate value at 2 is = ,
> cat ("Calculate value at 2 is = , ", zcal)
Calculate value at 2 is =-6.666667
> pvalue = 2 * (1 - pnorm (abs (zcal)))
> pvalue
[1] 2.616796e-11
```

Since p value is less than 0.05 we Reject

no. μ = 15

2.) Test the hypothesis $H_0 : \mu = 10$, $H_1 : \mu \neq 10$. Random sample of size 400 is drawn with sample mean 10.2 and standard deviation 2.25. Test the hypothesis at 5% level of significance.

```
> mo = 10
> mx = 10.2
> sd = 2.25
> n = 400
> zcal = (mx-mo)/(sd/(sqrt(n)))
> zcal
[1]  1.777778
> cat ("Calalate value at z is = ", zcal).
Complete value at z is = 1.777778
> pvalue = 2 * (1 - pnorm (abs (zcal)))
> pvalue
[1]  0.07544036
```

3.)

3.) Test the hypothesis to proportion of smoke[rs] in a college is 0.2. A sample is collect[ed] and sample proportion is calculated as 0.125. Test the hypothesis at 5% level of significance. (sample size = 400)

⇒ P -> population

p -> sample

Sol^n:

```
> P = 0.2
> p = 0.125
> n = 400
> Q = 1-P
> zcal = (p-P) / (sqrt(P* Q/n))
> zcal
[1] -3.75
```

4) Last year farmer's lost 20 % of their crops a random sample of 60 fields are collected. It will found that 9 field crops are insect populated. Test the hypothesis at 1 % level of significance.

P - 0.2 (capital)

p - 9/60

Sol^n:

```
> P = 0.2
> p = 9/60
> n = 66
> zcal = (p-P) / (sqrt(P*Q/n))
> zcal.
[1] -0.9682458.
> pvalue = 2*(1-pnorm(abs(zcal)))
> pvalue
[1] 0.3329216.
```

∴ The value is 0.1 so value is accepted.

Practical-6

Aim:- Large Sample Test

Q1. Let the population mean (the amount spent by customer in a Restaurant is 250. A sample of 100 customers selected. Sample mean is calculated as 275th and SD as 30th. Test the hypothes that population mean is significance

Q2. In a Random Sample of 1000 students it is found that 750 use blue pen. Test the hypothesis that population proportion is 0.8 at 1% level of significance.

1.) $H_0 : \mu = 275$ against $H_1 : \mu \neq 275$

```
> m0 = 256
> mx = 275
> n = 100
> sd = 30
> zcal = (mx - m0) /(sd / sqrt(n))
> zcal
> [1] 8.333333
> Pvalue = 2 * (1 - pnorm (abs(zcal)))
> pvalue
[1] 0
```

Value is less than 0.05 we will reject the value of $H_0 = \mu = 250$.

2) >p = 0.8
>Q = 1-P
>p = 750 / 1000
>n = 1000
>zcal (p-P) / (sqrt (p * Q/n))
>cat (" Value of z is : ", zcal)
value of z is -3.952847.
> pvalue = 2 * (1-pnorm (abs (zcal)))
> pvalue
7.72268 e-05.

3) To random sample of size 1000 & 2000 are drawn from two population with some 502.5. The sample means are 67.5 & 68. Test the hypothesis $\mu_1 = \mu_2$ at 5% < of significance.

→

n1 = 1000
n2 = 2000
mx1 = 67.5
sd1 = 2.5
sd2 = 2.5
zcal = (~~mx~~ mx1 - mx2) / sqrt((sd1^2 / n1) + (sd2^2/n2))
zcal
-5.163978

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1

pvalue = 2 * (1 - pnorm (abs (zcal)))
pvalue
2.~~80~~ 4117564 e -08
: Rejected

Practical - 7

Topic : Small Sample Test.

1) The marks of 10 students are given by 63, 63, 66, 67, 68, 69, 70, 71, 72 test the hypothesis that the sample comes from the population with average 66.

→ Ho : $\mu = 66$

```
> x = c(66, 63, 66, 67, 68, 69, 70, 70, 71)
> t.test(x)
```

One sample t test

data : x

t= 68.319 , dF = 9 , pvalue = $1.558e^{-13}$

alternative hypothesis

True mean is not equal to 0

95 percent confidence interval

865.65171 70.14829

sample estimate

mean of x

67.9

∵ The pvalue is less than 0.05 we reject the hypothesis at 5% level of significance.

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2.) Two groups of students scored the following marks. Test the hypothesis that there is no significant difference between the 2 groups.

Gr1 - 18, 22, 21, 17, 20, 17, 23, 20, 22, 21.

Gr2 - 16, 20, 14, 21, 20, 18, 13, 15, 17, 21.

H_0 : There is no difference between the 2 groups.

```
> x=c(18, 22, 21, 17, 20, 17, 23, 20, 22, 21)
> y=c(16,20, 14, 21, 20, 18, 13, 15, 17, 21)
> t.test (x,y)
```

With Two Sample T-test

data: X and Y

t= 2.2573 df= 16.376 p-value = 0.03798

alternative hypothesis:

True difference in means is not equal to 0

95 percent confidence interval:

0.1628205 5.0371795

sample estimates:

mean of x mean of y

20.1 17.5

```
> p-value = 0.03798
> if (pvalue > 0.05) {cat ("accept ho")}
else {cat ("reject Ho")}
reject Ho.
```

(Paired T-test)

1) The sales data of 6 shops before & after a special campaign are given below.

Before : 53, 28, 31, 48, 50, 42.

After : 58, 29, 30, 55, 56, 45.

Test the hypothesis as that the campaign is affective or not.

H_0: There is no significance difference of sales before & after campaign.

> x = c (Before)

> x = c (After)

> t.test (x, y, paired = T, alternative = "greater")

paired t-test.

data: x & Y

t = -2.7815, df = 5 ; pvalue = 0.9806

alternative hypothesis:

True difference in means is greater than

95 percent confidence interval:

-6.035647 inf

Sample estimates

mean of the difference

-3.5

pvalue is greater than 0.05, we accept the hypothesis at 5% level of significance

Practical - 8

Topic : Large and Small Test.

$H_0 : \mu = 55$, $H_1 : \mu \neq 55$.

```
> n = 100
> mx = 52
> mo = 55
> sd = 7
> zcal = (mx - mo) / (sd / (sqrt (n)))
> zcal
[1]    -4.285714
> pvalue = 2 * (1 - pnorm (abs (zcal)))
> pvalue
[1]  1.82153e-05
```

As pvalue is less than 0.05 we reject Ho at 5% level of significance

$H_0 : P = 0.5$ against $H_0 : P \neq 0.5$

```
> P = 0.5
> q = 1-P
> n = 700
> zcal = (p- P) / (sqrt (P*q/n))
> zcal.
[1] 0.
> pvalue = 2 * (1 - pnorm (abs (zcal)))
> pvalue
[1] 1.
```

AS pvalue is greater than 0.05 we accept H_0 at 1% level of significance.

3.) $H_0 = P_1 = P_2$ against $H_1 : P_1 \neq P_2$

\>n1 = 1000

\>n2 = 1500

\>p1 = 2/1000

\>p2 = 1/1500

\>p = (n1 * p1 + n2 * p2) / (n1 + n2)

\>p

[1] 0.0012

\>q = 1 - p

[1] 0.9988

\>zcal = (p1 - p2) / ~~sqrt~~ (p * q * (1/n1 + 1/n2))

\>zcal

[1] 0.9433752

\>pvalue = 2 * (1 - pnorm(abs(zcal)))

\>pvalue

[1] 0.345489

∵ pvalue is greater than 0.05 we accept H_0 and 5% level of significance.

4) $H_o : \mu = 100$ against $H_1 : \mu \neq 100$

```
> var = 64
> n = 400
> mo = 100
> mx = 99
> sd = sqrt(var)
> sd
[1] 8
> zcal = (mx - mo) / (sd / (sqrt(n)))
> zcal
> zcal = (mx - mo) / (sd / (sqrt(n)))
> zcal
[1] 2.5
> pvalue = 2 * (1 - pnorm (abs(zcal)))
> pvalue
[1] 0.01241933
```

Since pvalue is less than 0.05 we reject H_o at 5% level of significance.

5) $H_o : \mu = 66$ against $H_1 : \mu \neq 66$

```
> x = c(63, 63, 68, 69, 71, 71, 72)
> t.test(x)
```

One Sample test

data: x

t = 47.94, dF = 6, p-value = 5.522e-09

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alternative hypothesis:
True mean is not equal to 0
95 percent confidence interval:
64.66479 71.62092
Sample estimates:
mean of x
68.14286

Since, p value is less than 0.05 we reject Ho at 1% level of significance

Practical

Chi - Square test & ANOVA (Analysis of Variance)

Q1] Using the following data, test whether the condition of home & the condition of child are independent or not

→ Condition of home

	Clean	Dirty
Clean	70	50
Fairly clean	80	20
Dirty	35	45

→ H_0: condition of Home & child are independent

```
x = c(70, 80, 35, 50, 20, 45)
m = 3
n = 2
y = matrix(x, nrow = m, ncol = n)
y
      [,1]  [,2]
[1,]   70    50
[2,]   80    20
[3,]   35    45

pv = chisq.test(y)
pv

Pearson's chi squared test
data  y
X-squared = 25.646, df = 2, pvalue = 2.698e-06
```

∴ Ho is rejected, Since pv is less than 0.05

2) Test the hypothesis the vaccination & disease are independent or not.

Vaccine Disease	Affected	Not Affected.
Affected	70	46
Not Affected	35	37.

→ Ho: condition of disease & vaccination are independent

x = c (70, 46, 35, 37)

m = 2

n = 2

y = matrix(x, ~~nrow~~ = m, ncol = n).

y.

	[,1]	[,2]
[1,]	70	46
[2,]	35	37.

PV = chisq.test (Y)

PV

X-squared = 2.0275, df = 1, PV = 0.1545

Ho: is accepted, Since PV is more than 0.05.

∴ H_0 is rejected, Since PV is less than 0.05

2) Test the hypothesis the vaccination & disease are independent or not.

Vaccine

Disease	Affected	Not Affected.
Affected	70	46
Not Affected	35	37

→ H_0: condition of disease & vaccination are independent

```
x = c (70, 46, 35, 37)
m = 2
n = 2
y = matrix(x, nrow = m, ncol = n)
y.
```

	[,1]	[,2]
[1,]	70	46
[2,]	35	37.

```
PV = chisq.test(Y)
PV
```

X-squared = 2.0275, df = 1, PV = 0.1545

H_0 : is accepted, Since PV is more than 0.05

3.) Perform a ANOVA for the following data.

Type	Observations
A	50, 52
B	53, 55, 53
C	60, 58, 57, 56
D	52, 54, 54, 55

→ Ho: The means are equal for A, B, C, D

```
x1 = c(50, 52)
x2 = c(53, 55, 53)
x3 = c(60, 58, 57, 56)
x4 = c(52, 54, 54, 55).
d = stack(list(b1 = x1, b2 = x2, b3 = x3, b4 = x4))
names(d)
[1] values   "ind"

> oneway.test(values ~ ind, data = d, varequal = T)
        One-way analysis of means
data: values & ind.
F = 11.735, num df = 3, denom df = 9, p-value = 0

> anova = aov(values ~ ind, data = d)
summary(anova)
```

	DF	Sum sq	Mean sq	F-value	Pr(>F)
ind	3	71.06	23.688	11.73	0.0018
Residuals	9	18.17	2.019		

Signif codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '