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1-12a

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Stats

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Unit - I

Q1 Explain Random Variable?

→ 1) Experiment is any process that generates outcomes. In an experiment we are interested in a particular outcome instead of that. if we concentrate on the process of assigning numerical values to experimental outcomes. Such a process is called random variable.

2) A random variable is a numerical description of the outcome of an experiment

3) A random variable from a sample space Ω into the real numbers

4) Ex - tossing of two coins, $\Omega = \{HH, HT, TH, TT\}$
range of random variable X is $\{0, 1, 2\}$

Q2. Explain standard deviation, Variance and expectation

→ a) Expectation - Let x be a discrete random variable with probability distribution (x_i, p_i) the expected value of X denoted by $E(X)$ is defined as $E(X) = \sum_{i=1}^{n} x_i p_i = X_1P_1 + X_2P_2 \cdots + X_nP_n$.

$\bar{X}$ - Suppose X is having a frequency distribution

E	X_1	X_2	...	X_n
$f(x)$	f_1	f_2	...	f_n

$$\bar{X} = \frac{\sum_{i=1}^{n} f_i x_i}{\sum_{i=1}^{n} f_i} = \frac{f_1 x_1}{N} + \frac{f_2 x_2}{N} \cdots \frac{f_n x_n}{N}$$

$$= \left(\frac{f_1}{N}\right)x_1 + \left(\frac{f_2}{N}\right)x_2 + \cdots + \left(\frac{f_n}{N}\right)x_n$$

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$E(x) = \sum_{i=1}^{n} x_i P_i = x_1 P_1 + x_2 P_2 \dots x_n P_n)$
(n is favourable outcome)

b) variance - Mathematical expectation of a random variable provide a description of its average behaviour but it tells nothing about how much it varies let x be a discrete random variable with probability description (x_i, P_i) the variance of x denoted by

$$V(x) = \sigma^2 = E(X - E(x))^2 = E(x)^2 - [E(x)]^2$$

c) Standard deviation - The square root of variance is called standard deviation

$$S.D = \sqrt{\sigma^2} = \sigma$$

3] Define and give properties of t distribution and Chi square distribution

:) The chi square distribution has a single parameter called degrees of freedom - This can be any positive integer the chi-square distributed with n degrees of freedom is denoted by X_n^2. The pdf of chi square distribution that is if x follows $X \sim X_n^2$ then p.d.f is given by

$$f(x) = \frac{1}{2^{n/2} \Gamma(\frac{n}{2})} x^{\frac{n}{2}-1} e^{-\frac{x}{2}}$$

Properties

1] If X has a gama distribution with parameter m and B then 2PX/B has a chi-square distribution with 2m degrees of freedom

2] If X has a Chi-square distribution with 2m

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degrees of freedom then mean of x is $\mu_2 = E(x)$ $= n$ & variance of $x = 2n$

3) If ~~y/c has~~ y/c has a chi-square distribution with n degrees of freedom then the variance of y is $\sigma_y^2 = 2n\sigma^2$

4) If X and Y are independant chi-square random variables with n and p degrees of freedom then $x+y$ is a chi-square random variable with $(n+p)$ degrees of freedom

5) let $x_1, x_2 \dots x_n$ be a ~~conto~~ independant normal random variable with mean 0 and standard deviation and let $= S = X_1^2 + X_2^2 \dots X_n^2$. Then S has a chi square distribution with n degrees of freedom

6) If X is chi-square distribution with n degrees of freedom then $Z = \frac{X - E(x)}{\sqrt{V}} = \frac{x-n}{\sqrt{2n}} \sim N(0,1)$ as $n \to \infty$

6) Suppose that we have two independant random variable such that y follows normal with $(0,1)$ and z follows chi-square with n degrees of freedom $(y \sim N(0,1)$ & $z \sim \chi_n^2)$ then random variable x defined by $X = \frac{y}{\sqrt{\frac{z}{n}}}$ has a t distribution with n degrees of freedom denoted by t_n

Its pdf is given by
$$f(t) = \frac{\gamma\left(\frac{n+1}{2}\right)}{\sqrt{\pi n}\,\gamma\left(\frac{n}{2}\right)}\left(1+\frac{t^2}{n}\right)^{-\frac{n+1}{2}} \quad -\infty < t < \infty$$

Properties of t distribution

1) It is a bell shaped curve

2) It is symmetric about the mean

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3) The mean, median and mode are located at the centre of distribution
4) The curve never touches the x-axis
5) The variance is greater than 1
6) The t is a family of curve based on the concept of degrees of freedom which is related to sample size.
7) As the sample size increases the t distribution approaches the standard normal curve.

4) Write a short note on C.D.F?
→ Let X be a continous random variable with pdf $f(x)$. The cumulative function of X or Distribution function of X denoted by $F(x)$ is defined as

$$F(X) = P(X \le x) = \int_{-\infty}^{x} f(y)\,dy$$

Also differentiating both sides we get

$$\frac{d}{dx} F(x) = f(x)$$

Hence, the density function is the derivative of cummulative distribution function

Properties of C.D.F
1) $F(x)$ is a non decreasing function of x, for $-\infty < x < \infty$ i.e if $a < b$ then $F(a) \le F(b)$
2) The cdf, $F(X)$, ranges from 0 to 1
3) $F(-\infty) = 0$ $F(\infty) = 1$
4) If X is continous random variable then $F(X)$ is continous function, it is smooth continous curve

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5] Write properties of expectation and variance

1) Expected value of constant is the constant itself $E(C) = C$

2) Effect of change of origin and scale of an expectation of x is given

$E(X+b) = E(X)+b$

$E(aX) = aE(X)$

$E\,a(X+b) = aE(X)+b$

1) $V(aX) = a^2V(X)$

2) $V(X+b) = V(X)$

3) $V(aX+b) = a^2V(X)$

4) If X and Y are independent then $V(X+Y) = V(X)+V(Y)$

5) $V(C) = 0$ (where C is constant)

6) $SD(X) = \sqrt{Var(X)}$

6] An Urn contains 6 red and 4 white balls 3 balls are drawn at random obtain the probability distribution of white balls

→ let X be number of white balls drawn
X is 0, 1, 2, 3

$$P(X=0) = \frac{\binom{4}{0}\binom{6}{3}}{\binom{10}{3}} = \frac{20}{120} = \frac{1}{6} = 0.1667$$

$$P(X=1) = \frac{\binom{4}{1}\binom{6}{2}}{\binom{10}{3}} = \frac{60}{120} = \frac{1}{2} = 0.5000$$

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$P(X=2) = \frac{\binom{4}{2}\binom{6}{1}}{\binom{10}{3}} = \frac{36}{120} = \frac{3}{10} = \cancel{0.2000} = 0.3000$

$P(X=3) = \frac{\binom{4}{3}\binom{6}{0}}{\binom{10}{3}} = \frac{4}{120} = \frac{1}{30} = 0.0333$

Probability distribution of X

X	0	1	2	3	Total
$P(X=x)$	0.1667	0.5000	0.3000	0.0333	1

Q7 Define normal distribution and give its properties

→ A random variable has a normal distribution with parameters μ and σ^2 if its density function f is given by

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}, x \in R$$

Properties

1) If $X \sim N(\mu, \sigma^2)$, then $\frac{X-\mu}{\sigma} \sim N(0,1)$

Thus by subtracting the mean and dividing by the standard deviation

2) If $X \sim N(\mu, \sigma^2)$, then $X = \mu + \sigma Z$, with $Z \sim N(0,1)$

3) $EX = \mu$, i.e mean of normal distribution is μ

4) $Var(X) = \sigma^2$

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$Var(x) = Var(\mu + \sigma z) = \sigma^2 Var(z)$

$$E z^2 = \left[z \frac{1}{\sqrt{2\pi}} e^{\frac{-z^2}{2}}\right]_{-\infty}^{\infty} + \int_{-\infty}^{\infty} z \times \frac{z}{\sqrt{2\pi}} e^{\frac{-z^2}{2}} dz$$

5) A bell shaped symmetric curve
6) Symmetric, arithmetic mean, median and ~~mod~~ mode coincide

Q8 Find $E(x)$ and $V(x)$ for the following probability distribution

X	0	1	2	3	Total
$P(x)$	1/6	1/2	3/10	1/30	1
$xP(x)$	0	1/2	~~6/10~~ 3/5	~~3/30~~ 1/10	6/5
$x^2 P(x)$	0	1/2	~~2/10~~ 6/5	3/10	20/10

$E(x) = \sum x P(x) = 0 + 1/2 + 3/5 + \frac{1}{10} = 6/5 = 1.2$

$V(x) = E(x)^2 - [E(x)]^2$

$= 2 - (1.2)^2$

$= 2 - 1.44$

$= 0.56$

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Q9. An unbaised coin is tossed 5 times find probability of getting a) All heads b) 3 heads. & c. No heads

→ n : number of coins = 5
p = head = 0.5
q = 1 - p = 1 - 0.5
= 0.5

a) All heads

$P(X=5) = {}^5C_5 \, p^5 \, q^{5-5}$
$= \frac{5}{5} (0.5)^5 (0.5)^0$
$= 1 \times 0.03125 \times 1$
$= 0.03125$

b) 3 heads

$P(X=3) = {}^5C_3 \, p^3 \, q^{5-3}$
$= \frac{5 \times 4 \times 3}{3 \times 2 \times 1} \times (0.5)^3 \times (0.5)^2$
$= 10 \times 0.125 \times 0.25$
$= 0.3125$

c) No heads
$P(X=0) = {}^5C_0 \, p^0 \, q^{5-0}$
$= 1 \times 1 \times 0.03125$
$= 0.03125$

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10) Define binomial distribution and give its properties.

-> Bi means two, when any experiment results into two possible outcomes it is called as Binomial
Consider an example of tossing of n coin. If X is the random variable defined on this experiment which counts the total numbers of heads and the probability of head is p then we say X has a binomial distribution with parameters n and p and write X ~ B in (n, p)

Properties

1) If X ~ B (n, p), mean of X is np
2) Variance of X is npq
3) Additive property: If X ~ B(n1, p) and Y ~ B (n2, p) are independent random variable then X + Y ~ B (n1 + n2, p)

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Unit II

3) What do you understand by One tailed and two tailed test
~~3) Define different types of Hypothesis~~

-> One Sided Hypothesis :- A statistical test in which the population parameter lies entirely above or below the value specified in H_0 is a one-sided (or one-tailed) test
eg. $H_0 : \mu > 165$ or $H_0 : \mu < 165$

Two sided Hypothesis : An alternative hypothesis that specified that the parameter can lie on either side of the value specified by H_0 is called a two sided (or two-tailed test)
eg $H_1 : \mu = 165$

~~The null hypothesis is the null condition : no difference means or no relationship between variables.~~
~~The alternate hypothesis will be statement involving the same population parameters in which H_1 and H_0 cannot be true~~

2) Explain different types of Errors

-> 1) Type I error occurs when rejecting the null hypothesis when it is actually true. Fke (α)

2) Type II error occurs when failing to reject the null hypothesis, when it is actually false. (β)

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	Null Hypothesis is true	Alternative Hypothesis is true
Accept Null Hypothesis	No Error	Type II Error
Reject Null Hypothesis	Type I Error	No Error

Q1) Define different types of hypothesis

1) a) null hypothesis, denotes H_0, states that some parameter is equal to a specific value

b) The null hypothesis is the null condition: no difference between means or no relationship between variables. The null hypothesis denoted H_0, is claim about a population parameter that is assumed to be true until declared false

2) a). Alternate hypothesis H_1 will be a statement involving the same population parameters in such a way that H_1 and H_0 cannot be true

b) An alternative hypothesis denoted H_1 states that the value of parameter differs from that specified by the null hypothesis.

4) The mean height of 100 individuals from a population is 160. The S.D is 10. Will it be reasonable to suppose that the mean height of population is 65

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$H_0: \mu = 65$

6) Difference between large sample size and small sample size

Sr No	Large Sample	Small sample
1	The sample size is greater than 30	The sample size is 30 or less
2	Normal distribution is used for testing	Sampling distribution like t, F etc are used for testing

8) Explain the procedure for testing ~~statistic~~ anova?
=> ~~State the null and alternative hypothesis~~
~~The null~~
Analysis of variance is a hypothesis testing technique used to test the equality of two or more population (or treatment) means by examining the variance of sample that are ~~talking~~ taking. it allows one to determine whether the difference between the sample are simply due to random error (sampling error) or whether there are sysmatic treatment effects that causes the mean in one group to differ from the mean in other group.

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4) The mean height of 100 individual from a population is 160. The S.D is 10 will it be reasonable to suppose that the mean height of population is 65

→ let x be the random variable that represents the height of the individual
mean = 160 and S.D = 10
~~find mean height~~ u
$\therefore$ for $x = 65$, $z = \frac{65}{10} = 16$ $\qquad \frac{x - u}{\frac{\sigma}{\sqrt{n}}}$

Now ~~x_1~~ $x = \frac{160}{10} = 16$

$\therefore$ probability when mean = 65
= $P(x_1 - z)$
= $P(16 - 65)$
= 9.5

$\therefore$ The probability that the mean height of population is 65 is 9.5

Q5. Test made breaking strenght of 10 pieces of a metal wire are as follows 578, 572, 570, 568, 572, 570, 570, 572, 596, 584 in kgs. Test the breaking strenght of ~~wire~~ at 577 kg)
→ let $\bar{x}$ be sample mean & SD (ie sample SD then test if $\bar{x}$ differs significantly from the population mean $u = 577$

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we take the assumed mean $A = \frac{568 + 596}{2} = 582$

$d_i = x_i - A$

$x_i = d_i + A$

$\bar{x} = \frac{1}{n} \Sigma x_i = \frac{1}{n} \Sigma d_i + A$

$= \frac{1}{10} \times (-68) + 582 = 575.2$ (from table below)

$S^2 = \frac{1}{n} \Sigma d_i^2 - \left[\frac{1}{n} \Sigma d_i\right]^2$ (from table below)

$= \frac{1}{10} \times 1144 + \left(\frac{1}{10} \times (-68)\right)^2$

$= 68.16$

$S = 868.16$

Now $t = \frac{\bar{x} - u}{S/\sqrt{n-1}} = \frac{575.2 - 577}{8.26/\sqrt{9}}$

$A = -0.65$ & $v = n - 1$
$= 9$

x_i	$d_i = x_i - A$	d_i^2
578	-4	16
572	-10	100
570	-12	144
568	-14	196
572	-10	100
570	-12	144
570	-12	1844
572	-10	100
596	14	106
584	2	4

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$H_0: \bar{x} = \mu$ & $H_1: \bar{x} \neq \mu$

* Two tailed test is be used let LOS be 5%
: $v = 9$, $t_{0.05} = 2.26$
since $|t| < t_{0.0}$
Since $|t| < t_{0.05}$
Therefore the mean breaking strenght of the wire can be assumed as 577 kg at 5%

3) H_0 - student are benefited by coaching w.o
H_1 - student are not not benefited by coaching w.o

x_1	x	d	d^2
70	68	2	4
68	70	-2	4
56	52	4	16
75	73	2	4
80	75	5	25
90	78	12	144
68	80	-12	144
75	92	-17	289
56	54	2	4
58	55	3	9
		$\Sigma d_i = -1$	$\Sigma d^2 = 643$

$\bar{d} = \frac{\Sigma d_i}{n} = \frac{-1}{10} = -0.1$

$\frac{\bar{d}\ Sd}{\sqrt{n}}$

Test statistics
$t = \bar{d}\sqrt{n}$

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$$S_d^2 = \frac{\Sigma d^2 - n\bar{d}^2}{n-1} = \frac{643-10}{9} = \frac{633}{9} = 70.333$$

$$t = \frac{-1\sqrt{10}}{\sqrt{70.333}} \qquad \frac{S_d}{\sqrt{n}}$$

$$= \frac{-1 \times 3.1627}{8.3864}$$

$$= \frac{-3.1627}{8.3864} = -0.3771$$

Critical region

Reject H_0 if $|t_{cal}| > t_{\alpha/2}$

$t_{0.01,9} = 3.250$

$\therefore$ we accept H_0 as $|t_{cal}| < t_{\alpha/2}$

$\therefore$ The student are helped by coaching

3)

	A	B	C	D	Total
P	6	4	8	6	24
Q	7	6	6	9	28
R	8	5	10	9	32
Total	21	15	24	24	84.

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P $24/4 = 6$ $\bar{Y}_1$

Q $28/4 = 7 = \bar{Y}_2$

R $32/4 = 8 = \bar{Y}_3$

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$A : 2113 = 7 : \bar{Y}_1$
$B = 1513 = 5 = \bar{Y}_2$
$C : 2413 = 8 = \bar{Y}_3$
$D = 2413 = 8 = \bar{Y}_4$

$\bar{Y} = \frac{P+Q+R+A+B+C+B}{n} = \frac{168}{12} = 14$

$\alpha = \bar{y}_i - \bar{y}$ $\quad$ $B_i = y_i - \bar{y}$
$\alpha_1 = 6 - 14 = -8$ $\quad$ $B_2 = 5 - 14 = -9$
$\alpha_2 = 7 - 14 = -7$ $\quad$ $B_3 = 8 - 14 = -6$
$\alpha_3 = 8 - 14 = -16$ $\quad$ $B_4 = 8 - 14 = -6$

$SSA = (6-14) + (7-14) + (8-14) + (4-14) + (6-14) + (5-14)$
$+ (8-14) + (6-14) + (10-14) + (6-14) + (8-14) + (9-14)$
$= (8) + (-7) + (-6) + (-10) + (-8) + (-9) + (-0) + (-8) + (-4)$
$+ (-8) + (-5) + (-5) = -84$

$SSE = (6-24) + (4-24) + (8-24) + (6-24) + (7-28) + (0-28)$
$+ (6-28) + (9-28) + (8-32) + (5-32) + (110-32) + (98-32)$
$(6-21) + (7-21) + (8-27) + (4-18) + (6-14) + (5-14)$
$(8-44) + (6-24) + (10-24) + (6-24) + (9-24) + (9-24)$
$= (-18) + (-20) + (-16) + (-18) + (2-21) + (-22) + (-23) + (-19)$
$+ (-24) + (-29) + (-22) + (-23) + (-18) + (-14) + (-13) + (-12)$
$+ (-11) + (-9) + (-10) + (+6) + (-18) + (-18) + (-1) + (-1)$
$= -43)$

SSt = SSA + SSB + SSE
(·8421(-84+(-435)
= -603

2 way anova

	SOS	Dof	mean	F
A	-84	3	-27	4.28
B	-84	3	-42	6.58
Error	-435	68	-6.390	
Total	-603	71		

(14) Construct a Anova form:

A	B	C
14	14	6
14	8	12
12	10	14
2	8	16
8	$\bar{x}=10$	$\bar{x}=12$

$\bar{x} = \frac{\Sigma x_{ij}}{N} = \frac{14+14+12+2+14+8+10+8+6+12+14+16}{12}$

$= 10$

SSTR $= \Sigma x_{ij}(x_{ij}-\bar{x})^2 = [3x(8-10)^2 + 3x(10-10)^2 + 3x(12-10)^2]$
$= 12+0+12$
$= 24$

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SSE = ΣΣ $(x_{ij} - \bar{x}_j)^2$ = $(14-8)^2 + (4-8)^2 + (12-8)^2 + (2-8)^2$
$+ (4-10)^2 + (8-10)^2 + (10-10)^2 + (2-10)^2 + (6-12)^2$
$+ (12-12)^2 + (14-12)^2 + (16-12)^2$
= 36 + 16 + 16 + 36 + 16 + 4 + 0 + 0 + 36 + 0 + 4 + 16
= 184

SST = SSTR + SSE = 24 + 184 = 208

$MSTR = \frac{SSTR}{C-1} = \frac{24}{2} = 12$

$MSE = \frac{SSE}{n-1} = \frac{184}{4-3} = 184$

$F = \frac{MSTR}{MSE} = \frac{12}{184} = 0.0521$

Source	SOS	DoF	Mean	F value
Between Group	24	2	12	
Within group	184	1	184	0.0521
Total group	208	2		

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Statistics - Unit II

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Q1) When do we use Non-parametric test?
-> 1) ~~State use~~ Generally one need to use parametric test unless and until clear idintification of non parametric test
2) It is used for small sample size
3) ~~Non~~ It is used when we ~~have~~ have nominal or ordial data
4) It is used for qualitative or ranked data

Q3. Write a difference between parametric and non parametric test?
->

Non-parametric tests	Parametric tests
1) Generally one need to use parametric test unless and until clear identification of non parametric test	1) Parametric follows standard distribution
2) Non parametric test are less acurate with compare to parametric test	2) Parametric test are more accurate than non parametric test
3 Non parametric test are used for small samples size	3) Parametric test used for large sample size
4) Non parametric methods are used when we have nominal or ordinal data	4) Parametric method are generally used for ratio or interval data
5) Non parametric test are used for qualitative or ranked data	5) Parametric test are used for quantitave data

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~~Q2 F~~

Q2) Explain Wilcoxon sign test and Sign test procedure.

-) 1) This is an extension of sign test takes into account magnitude and direction also

2) It is powerful and more accurate than sign test

3) We assign rank for ordinal data

4) Steps

a) We need to compute the difference scores

b) Next step is to rank the difference scores

c) We order the absolute value of difference scores and assign rank from 1 to n

d) Add + or - to Ranks

e) We use $\frac{n(n+1)}{2}$

f) We find critical by using Table of critical values of T

g) By critical value we determine whether to reject or accept Ho

Q4) A study is run to evaluate the effectiveness of an exercise program in reducing systolic blood pressure in patients with pre hypertension. A total of 15 patients were enrolled

-) Ho : The difference is zero

H1 : The difference is not zero $\alpha = 0.05$

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Patient	Befor	After	Difference	Rank	Value signed	Ranks
1	125	118	7	1	1	1
2	132	134	-2	2.5	2	-2.5
3	138	130	8	2.5	2	-2.5
4	120	124	-4	4	3	-4
5	125	105	20	6	4	-6
6	127	130	-3	6	4	-6
7	136	136	6	6	4	6
8	139	132	7	8	6	8
9	131	123	8	10	7	-10
10	132	128	4	10	7	10
11	135	126	9	10	7	10
12	136	140	-4	12.5	8	13.5
13	128	135	-7	12.5	8	13.5
14	127	126	1	14	9	14
15	130	132	2	15	20	15

$W+ = 89$, and $W- = 31$

$W = 89 + 31 = 120$, $\frac{n(n+1)}{2} = \frac{15(16)}{2} = 120$

Test Statistic

W, Min $(+W, -W)$ = Min $(89, 31) = 31$

$31 > 25$

at $n = 15$ and $\alpha = 0.05$

we do not reject null hypothesis

∴ There is no difference the difference is zero

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5) Explain the RUN test with an example.
→ 1) The runs test is used to determine the serial randomness: whether or not observations occurs in a sequence in time or over space
2) In geographic studies, the run test is most often used to determine whether observations are random.
~~1) A BBAAB~~
Ex
AA BB AA BBBB AAA BBBB AA BBB

H_0 : The distribution of success is random
H_1 : The distribution of success is not random

$n_1 = 9$ ← there 9 occurences of the value A
$n_2 = 14$ ← there 14 occurences of the value B
$u = 8$ ← there are 8 runs
$\alpha = 0.05$
~~whe~~ there are two critical value using table upper and lower value

$U_{critical} = 6, 17$
Since $6 < 8 < 17$ accept Null ~~a~~ Hypothesis H_0

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6) In Mumbai University a student appeared for an examination in 12 paper result is given below. Does students performed well or no PPPPFFFFFPFP

$\underbrace{1\,2\,3\,4}_{1}$ $\underbrace{1\,2\,3\,4\,5}_{2}$ $\frac{5}{3}$ $\frac{6}{5}$ $\frac{6}{5}$

H0: Students have performed well
H1: Students have not performed well

$n_1 \to 6 = (P)$
$n_2 \to 6 = F$
$u = 5$
$\alpha = 0.05$

There are two critical value using runs test table
~~U critical~~ Ucritical = 3, 11
3 < 5 < 11
Thus accept Null hypothesis H0

7) The Kruskal Wallis test us if the difference between the groups are so large that they are unlikely to have occurred by chance
⇒ ~~Sample~~
~~No 20 60~~
23
In This outcome $n_1 = 8$ $n_2 = 8$ $n_3 = 7$
Null hypothesis: There is difference (H0)
Alternative hypothesis: There is no difference (H1)

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Sample			Ordered		
No	20min	60min	No	20min	60min
~~23~~	~~22~~	~~59~~		22	
~~26~~	~~27~~	66	23		
~~51~~	~~39~~	~~38~~	26		
~~49~~	~~29~~	~~49~~		27	
~~58~~	~~46~~	~~56~~	37		~~38~~
~~37~~	~~48~~	~~60~~			38
~~29~~	~~49~~	65		39	
~~44~~	65	~~62~~	44		
				46	
			49	49	49

Sample			Ordered			Ranks		
No	20min	60min	No	20min	60min	No	20min	60min
23	22	59		22			1	
26	27	66	23			2		
51	39	38	26			3		
49	29	49		27			4	
58	46	56	29	29		5.5	5.5	
37	48	60	37			7		
29	49	65			38			8
24	65	62		39			9	
			44			10		
				46			11	
				48			12	
			49	49	49	14	14	14
			51			16		
					56			17
			58	~~58~~		18	~~18~~	
			~~58~~		59	~~19~~		19
					60			~~20~~ 20

22+23
45/2
22.5

13+14+15
14
+15
42
/3
14

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	65	62		22.5	21
		65			22.5
		66			24.5

$R_1 = \cancel{76.5}$, $R_2 = 79$, $R_3 = \cancel{126.5} = 145.5$

$R_1 = \cancel{76.5}$
75.5

$\frac{n(n+1)}{2} = \frac{\cancel{25(26)}}{2} = \cancel{325}$

$= \frac{24(25)}{2} = 300$ — ①

$\therefore R_1 + R_2 + R_3 = 75.5 + 79 + 145.5$
$= 300$ — ②

① = ②

$$H = \left(\frac{12}{24(25)}\right)\left[\frac{(75.5)^2}{8} + \frac{(79)^2}{8} + \frac{(145.5)^2}{8}\right] - 3(24+1)$$

~~8) Define Duncans test and Mann Whitney~~

$= 0.02\,(712.53 + 780.12 + 2646.28) - 3(25)$
$= 0.02(4{,}138.93) - 75$
$= 82.7786 - 75$
$= 7.7786$

K=3 (number of groups)

$H = K-1 = 3-1 = 2$

Critical value

$H = 7.7786 > 5.66$ therefore we reject null hypothesis

Thus there is difference.

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8) Define Duncan's test and Mann whitney U test

-> a) Duncan's multiple range test for multiple comparision where error rate is reitor on an experimentwise basis nor on a per-comparision basis

$$W = q(pr, N-g) \times \sqrt{\frac{WMMS}{n}}$$

where as before, n is the number of observation per treatment groups: N is total number of observation from g treatment groups; WMMS is with (residual) mean square derived from ANOVA Table

b) Mann whitney test U test is used to compare two independant sample like unpaired t test it is parametic test. A popular non-parametric test to compare outcomes between two independent group is the Mann Whitney U test..

9) ~~The distribution of kruskal-wallis test st~~ Explain the procedure and limitation of kruskal wallis test?

-> 1) The distribution of the Krusal-wallis test static approximates a chi-square distribution with K-1 degree of freedom

2) If the calculated value of the krusal-wallis test is less than critical chi-square value, then the null hypothesis cannot be rejected.

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3) The procedure for the test involves pooling the observation from k samples into one combined sample, keeping track of which sample each observation comes from, and then ranking lowest to highest from 1 to N, where $N = n_1 + n_2 + \ldots n_k$

Q10) What are the advantages of Non-parametric test?
→ 1) If the sample size is very small, there may be non-parametric statistical test unlesss the nature of the ~~popu~~ population distribution is known exactly
2) Non parametric test typically make fewer assumption about the data and may be more relevant to a particular situation
3) Non parametric test ~~typically make fewer~~ care methods are available to treat data which are simply categorical i.e are measured in nominal scale
4) Non-parametric statistical tests typically are much easier to learn and to apply than are parametric tests. In addition, their interpretation often is more direct than the interpretation of parametric tests