$$= \frac{30 \times (5\times6 - 10\times9)^2}{14\times16\times15\times15}$$

$$= 2.142$$

Critical value : We have $\alpha = 0.05$ and degree of freedom (df) =

$$\therefore \chi^2_{tab} = \chi^2_{1,\,0.05} = 3.841$$

Decision : Since $\chi^2_{cal} < \chi^2_{tab}$, we do not reject H_0. Thus, the median lives of Neon and Helium tubes made by two manufacturers are same.

> KOLMOGOROV- SMIRNOV (K-S) TEST [ONE SAMPLE]

Q16. In a certain computer hardware manufacturing industry six different types of machines are working to cut pieces of wires. The number of wires of unequal length recorded in a day is as follows:

Machine	1	2	3	4	5	6
No of wire	2	0	4	8	5	11

H_0: The machines equally cut wires of unequal length

H_1: The machines do not equally cut wires of unequal length. (Two Tailed Test)

Test- statistic : Under H_0,

$$D_0 = \text{Maximum} \left| F_e(x) - F_0(x) \right|$$

Calculation

Machine	No. of wire	cf$_0$	$F_0(x)$	E = np	cfe	$F_e(x)$	$\lvert F_e(x) - F_0(x) \rvert$
1	2	2	2/30	5	5	5/30	3/30
2	0	2	2/30	5	10	10/30	8/30
3	4	6	6/30	5	15	15/30	9/30
4	8	14	14/30	5	20	20/30	6/30
5	5	19	19/30	5	25	25/30	6/30
6	11	30	30/30	5	30	30/30	0

$$\therefore D_0 = 9/30 = 0.3$$

Scanned with CamScanner

Critical value: We have $\alpha = 0.05$ and $n = 10$

$D_{n,\alpha}$ (Two-Tailed Test) : $D_{10,0.05}$ (Two ...

$= 0.242$

Decision: Since $D_0 > D_{n,\alpha}$, we reject H_0. Hence, the machines do not equally cut wires of unequal length.

Q18. A game consists of four pairs of color cards. Twenty chimpanzees of same age were taught the matching game of color cards for a specified period of time. At the end of the training 4 pairs of color cards were given to each chimpanzee for matching. The results were as follows:

Matched set	0	1	2	3	4
Frequency	1	0	5	7	7

Does chimpanzee recognize colors? Use Kolmogorov Smirnov test at 5% level of significance?

H_0: Chimpanzees recognize colors

H_1: Chimpanzees do not recognize colors (Two tailed test)

Test-statistic: Under H_0,

$D_0 = \text{Maximum } |F_e(x) - F_0(x)|$

Calculation

Matched set	Frequency	cfo	$F_0(x)$	E = np	cfe	$F_e(x)$	$\lvert F_e(x) - F_0(x) \rvert$
0	1	1	1/20	4	4	4/20	3/20
1	0	1	1/20	4	8	8/20	7/20
2	5	6	6/20	4	12	12/20	6/20
3	7	13	13/20	4	16	16/20	3/20
4	7	20	20/20	4	20	20/20	0

$\therefore D_0 = 7/20 = 0.35$

Scanned with CamScanner

Critical value: We have $\alpha = 0.05$ and $n = 20$

$\therefore D_{n,\alpha}$ (Two tailed test) $= D_{20, 0.05}$ (Two Tailed test)

$= 0.294$

Decision: Since $D_0 > D_{n,\alpha}$, we reject H_0. Thus, chimpanzees do not recognize colors.

Q. A random sample of 20 volume based internet have following speed of interconnection in mps:

2.7, 2.9, 3.0, 3.1, 2.8, 3.0, 2.9, 3.0, 2.6, 3.1, 3.2, 3.1, 3.0, 2.9, 3.3, 3.0, 2.8, 2.9, 3.0, 2.9.

Apply Kolmogorov-Smirnov test for testing that the internet speed are equally distributed. Use $\alpha = 5\%$.

Solution

Creating frequency table of above data

Internet Speed	Frequency	cf$_o$	$F_o(x)$	$E = np$	cf$_e$	$F_e(x)$	$\lvert F_e(x) - F_o(x) \rvert$
2.6	1	1	1/20	20/8	20/8		
2.7	1	2	2/20	20/8	20/4		
2.8	2	4	4/20	20/8	3*20/8		
2.9	5	9	9/20	20/8	20/2		
3.0	6	15	15/20	20/8	5*20/8		
3.1	3	18	18/20	20/8	6*20/8		
3.2	1	19	19/20	20/8	7*20/8		
3.3	1	20	20/20	20/8	20		

H_0: Internet speeds are equally distributed.

H_1: Internet speeds are not equally distributed.

Test-statistic: Under H_0,

D_0 = Maximum $\lvert F_e(x) - F_o(x) \rvert$

PTO

Scanned with CamScanner

Calculation

Tabulating above data as follows:

Internet speed	Frequency	cfo	$F_o(x)$	E = np	cfe	$F_e(x)$	$\lvert F_e(x) - F_o(x) \rvert$
2.6	1	1	1/20	2.5	2.5	2.5/20	1.5/20
2.7	1	2	2/20	2.5	5	5/20	3/20
2.8	2	4	4/20	2.5	7.5	7.5/20	3.5/20
2.9	5	9	9/20	2.5	10.0	10/20	1/20
3.0	6	15	15/20	2.5	12.5	12.5/20	2.5/20
3.1	3	18	18/20	2.5	15.0	15/20	3/20
3.2	1	19	19/20	2.5	17.5	17.5/20	1.5/20
3.3	1	20	20/20	2.5	20.0	20/20	0

$\therefore D_o = \frac{3.5}{20} = 0.175$

Critical value: We have, $\alpha = 0.05$ and $n = 20$.

$\therefore D_{n,\alpha}$ (Two tailed test) $= D_{20, 0.05}$ (Two tailed test)

$= 0.294$

Decision: Since $D_o < D_{n,\alpha}$, we accept H_0. Thus, internet speeds are equally distributed.

[TWO SAMPLES]

[EQUAL CASE]

Q12. Amount of time required to design website by software developers A and B are found as follows:

Time (hrs)	0-4	4-8	8-12	12→16	16-20
No. of websites designed by A	2	7	12	5	4
No. of websites designed by B	6	9	8	4	3

Does A take more time than B to design website? Use Kolmogorov-Smirnov test at 5% level of significance.

Solution

H_0: A doesn't take more time than B to design website

H_1: A takes more time than B to design website (One Tailed Test)

Test-statistic: Under H_0,

D_o = Maximum $\lvert F(x) - F(y) \rvert$

Scanned with CamScanner

Calculation

Time (hrs)	f_x	f_y	cf_x	$F(x)$	cf_y	$F(y)$	$\lvert F(x) - F(y) \rvert$
0-4	2	6	2	2/30	6	6/30	4/30
4-8	7	9	9	9/30	15	15/30	6/30
8-12	12	8	21	21/30	23	23/30	2/30
12-16	5	4	26	26/30	27	27/30	1/30
16-20	4	3	30	30/30	30	30/30	0
	$n_1 = 30$	$n_2 = 30$					

$\therefore D_0 = 6/30 = 0.2$

Critical value : We have $\alpha = 0.05$, $n_1 = 30$, $n_2 = 30$

$\therefore D_{(n_1, n_2), \alpha}$ (One Tailed Test) $= D_{(30, 30), 0.05}$ (One Tailed Test)

$= 9/30 = 0.3$

Decision :- Since $D_0 < D_{(n_1, n_2), \alpha}$, we do not reject H_0. Thus, A doesn't take more time than B to design website.

[UNEQUAL CASE]
(LARGE SAMPLE)

Q13. Two independent samples of 26 junior programming and 25 senior programming smokers selected from a software company used to smoke following number of cigarettes per day.

Number of cigarettes	0-2	2-4	4-6	6-8	8-10	10-12	12-14
Number of junior programmer	7	6	4	2	2	3	2
Number of senior programmer	5	4	6	3	4	2	1

Using Kolmogorov Smirnov test identify if there is any significance between junior and senior programmer. Use 0.05 level of significance.

Solution

H_0 : There is no significance between junior and senior programmer.

H_1 : There is a significance between junior and senior programmer. (Two tailed test)

Test-statistic : Under H_0,

$D_0 = \text{Maximum} \lvert F(x) - F(y) \rvert$

Scanned with CamScanner

Calculation

No. of cigarettes	f_x	f_y	cf_x	$F(x)$	cf_y	$F(y)$	$\lvert F(x) - F(y) \rvert$
0-2	7	5	7	7/26	5	5/25	0.069
2-4	6	4	13	13/26	9	9/25	0.14
4-6	4	6	17	17/26	15	15/25	0.053
6-8	2	3	19	19/26	18	18/25	0.010
8-10	2	4	21	21/26	22	22/25	0.072
10-12	3	2	24	24/26	24	24/25	0.036
12-14	2	1	26	26/26	25	25/25	0
	$n_1 = 26$	$n_2 = 25$					

$D_0 = 0.14$

Critical value: We have, $\alpha = 0.05$, $n_1 = 26$, $n_2 = 25$

$\therefore D_{(n_1, n_2), \alpha}$ (Two tailed test) $= D_{(26, 25), 0.05}$ (Two tailed test)

$= 1.36 \sqrt{\frac{n_1 + n_2}{n_1 n_2}}$

$= 1.36 \sqrt{\frac{26+25}{26*25}}$

$= 1.36 \sqrt{\frac{51}{26*25}}$

$= 0.380$

Decision: Since $D_0 < D_{(n_1, n_2), \alpha}$, we do not reject H_0.

Thus, there is no significance between junior and senior programmer.