

1ª Lista de Exercícios de Instrumentação – FEMEC 41070 – 1º Semestre 2020

- 1) Montar um Histograma para os dados coletados abaixo.

28.68 28.66 28.70 28.57 28.61 28.59 28.71 28.59 28.69 28.58
28.73 28.55 28.71 28.70 28.57 28.56 28.58 28.50 28.68 28.69

HISTOGRAMA: CONSIDERAÇÕES SOBRE O NÚMERO DE CLASSES (n_k):

1. Se $N \leq 20 \rightarrow n_k = 5$
2. Se $20 < N < 40 \rightarrow$ número de OCORRÊNCIAS em cada classe ≥ 5
3. Se $N > 40 \rightarrow$ critério de KENDAL & STUART: $n_k = 1.87 \cdot (N-1)^{0.4}$

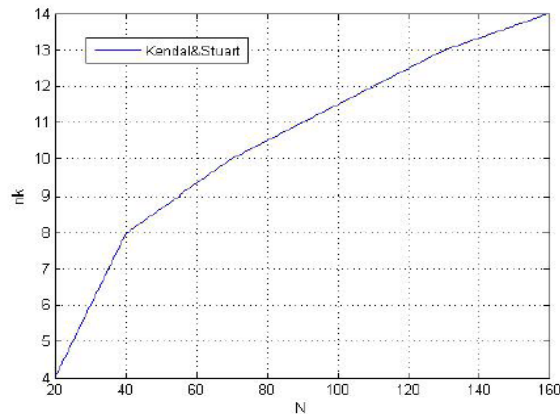


Figura 1: Número de Ocorrências em classes com $N \geq 20$

- 2) Para o exemplo do item 1, adotando um o valor da média da população de 28,58 com desvio padrão de 0,10, pede-se o intervalo de confiança para $\alpha = 95\%$.

$$\alpha = 2 \cdot \Phi(z) - 1 \quad (1)$$

$$D = \frac{Z \cdot x \cdot \sigma}{\sqrt{N}} \quad (2)$$

$$\text{IC: } \text{média} - D \leq \mu \leq \text{média} + D \quad (3)$$

- 3) Refazer o exercício 2 só que desconhecendo o valor da média e do desvio da população. Sugestão: adote a média e desvio da amostra.

$$D = t(1-\alpha/2, d) \cdot \sigma / (N)^{0.5} \quad (4)$$

- 4) Dado as medidas a seguir de comprimento de uma barra. Calcule o valor médio e desvio padrão. Aplique o critério de Chauvenet para verificar se há inconsistências. Caso exista inconsistência(s), refaça o cálculo da média e desvio sem a(s) mesma(s).

Leitura	1	2	3	4	5	6	7	8	9	10
x [cm]	5,42	5,71	5,82	5,45	5,87	5,40	5,73	5,64	5,83	5,75

$$x_{\text{média}} = \frac{1}{n} \sum_{i=1}^n x_i \quad (5)$$

$$d_i = x_i - x_{\text{média}} \quad (6)$$

$$\sigma = \sqrt{\frac{1}{n} \sum_{i=1}^n (d_i^2)} \quad (7)$$

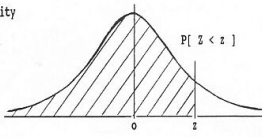
$$\Delta R = \frac{d_i}{\sigma} \quad (8)$$

Tabela 1: Tabela da Área da Função Normal em Função de Z

STANDARD STATISTICAL TABLES

1. Areas under the Normal Distribution

The table gives the cumulative probability up to the standardised normal value z i.e.

$$P[Z < z] = \int_{-\infty}^z \frac{1}{\sqrt{2\pi}} \exp(-\frac{1}{2}z^2) dz$$


z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5159	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7854
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8804	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9773	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9865	0.9868	0.9871	0.9874	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9924	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9980	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
z	3.00	3.10	3.20	3.30	3.40	3.50	3.60	3.70	3.80	3.90
P	0.9986	0.9990	0.9993	0.9995	0.9997	0.9998	0.9998	0.9999	0.9999	1.0000

Tabela 2: Distribuição tstudent

TABLE A 4
DISTRIBUTION OF t (TWO-TAILED TESTS)

Degrees of Freedom	Probability of a Larger Value, Sign Ignored									
	0.500	0.400	0.200	0.100	0.050	0.025	0.010	0.005	0.001	
1	1.000	1.376	3.078	6.314	12.706	25.452	63.657			
2	0.816	1.061	1.886	2.920	4.303	6.205	9.925	14.089	31.598	
3	.765	0.978	1.638	2.353	3.182	4.176	5.841	7.453	12.941	
4	.741	.941	1.533	2.132	2.776	3.495	4.604	5.598	8.610	
5	.727	.920	1.476	2.015	2.571	3.163	4.032	4.773	6.859	
6	.718	.906	1.440	1.943	2.447	2.969	3.707	4.317	5.959	
7	.711	.896	1.415	1.895	2.368	2.841	3.499	4.029	5.405	
8	.706	.889	1.397	1.860	2.306	2.752	3.355	3.832	5.041	
9	.703	.883	1.383	1.833	2.262	2.685	3.250	3.690	4.781	
10	.700	.879	1.372	1.812	2.228	2.634	3.169	3.581	4.587	
11	.697	.876	1.363	1.796	2.201	2.593	3.106	3.497	4.437	
12	.695	.873	1.356	1.782	2.179	2.560	3.055	3.428	4.318	
13	.694	.870	1.350	1.771	2.160	2.533	3.012	3.372	4.221	
14	.692	.868	1.345	1.761	2.145	2.510	2.977	3.326	4.140	
15	.691	.866	1.341	1.753	2.131	2.490	2.947	3.286	4.073	
16	.690	.865	1.337	1.746	2.120	2.473	2.921	3.252	4.015	
17	.689	.863	1.333	1.740	2.110	2.458	2.898	3.222	3.965	
18	.688	.862	1.330	1.734	2.101	2.445	2.878	3.197	3.922	
19	.688	.861	1.328	1.729	2.093	2.433	2.861	3.174	3.883	
20	.687	.860	1.325	1.725	2.086	2.423	2.845	3.153	3.850	
21	.686	.859	1.323	1.721	2.080	2.414	2.831	3.135	3.819	
22	.686	.858	1.321	1.717	2.074	2.406	2.819	3.119	3.792	
23	.685	.858	1.319	1.714	2.069	2.398	2.807	3.104	3.767	
24	.685	.857	1.318	1.711	2.064	2.391	2.797	3.090	3.745	
25	.684	.856	1.316	1.708	2.060	2.385	2.787	3.078	3.725	
26	.684	.856	1.315	1.706	2.056	2.379	2.779	3.067	3.707	
27	.684	.855	1.313	1.703	2.052	2.373	2.771	3.056	3.690	
28	.683	.855	1.313	1.701	2.048	2.368	2.763	3.047	3.674	
29	.683	.854	1.311	1.699	2.045	2.364	2.756	3.038	3.659	
30	.683	.854	1.310	1.697	2.042	2.360	2.750	3.030	3.646	
35	.682	.852	1.306	1.689	2.030	2.342	2.724	2.996	3.591	
40	.681	.851	1.303	1.684	2.021	2.329	2.704	2.971	3.551	
45	.680	.850	1.301	1.680	2.014	2.319	2.690	2.952	3.520	
50	.680	.849	1.299	1.676	2.008	2.310	2.678	2.937	3.496	
55	.679	.849	1.297	1.673	2.004	2.304	2.669	2.925	3.476	
60	.679	.848	1.296	1.671	2.000	2.299	2.660	2.915	3.460	
70	.678	.847	1.294	1.667	1.994	2.290	2.648	2.899	3.435	
80	.678	.847	1.293	1.665	1.989	2.284	2.638	2.887	3.416	
90	.678	.846	1.291	1.662	1.986	2.279	2.631	2.878	3.402	
100	.677	.846	1.290	1.661	1.982	2.276	2.625	2.871	3.390	
120	.677	.845	1.289	1.658	1.980	2.270	2.617	2.860	3.373	
∞	.6745	.8416	1.2816	1.6448	1.9600	2.2414	2.5758	2.8070	3.2905	

Tabela 3: Valores Limites de DRo

N	DRo
3	1.383
4	1.534
5	1.645
7	1.803
10	1.960
15	2.128
25	2.326
50	2.576
100	2.807
300	3.144
500	3.291
1000	3.481

- 5) Aplique o Teste de Chauvenet nos dados do exercício 1. Recalcule a média e desvio para o resultado sem inconsistências.
- 6) Realize o teste do Qui-quadrado ($\alpha=95\%$) para avaliar se uma distribuição normal com média 5,8 cm e desvio 0,8cm se adere aos dados originais coletados no exercício 4. A Tabela 4 apresenta os valores do Erro máximo em função do Grau de Liberdade [GL] e confiança estatística $[1-\alpha]$.

$$Erro\ Quadrático = \frac{(Valor_{Teórico} - Valor_{Observado})^2}{Valor_{Teórico}} \quad (9)$$

$$Grau\ de\ Liberdade = n^{\circ} \text{ classes} - 1 - n^{\circ} \text{ de parâmetros teóricos utilizados} \quad (10)$$

- 7) Refaça o exercício 6 com os dados corrigidos por Chauvenet. Compare os resultados com o exercício anterior.
- 8) Calcular $y = K R F L / T$, conhecendo o intervalo de confiança ($\alpha = 95\%$) de cada uma das medidas:
 $K = 0.000952$ (propriedade física constante)
 $R = 1200 \pm 1$ $F = 10,00 \pm 0,01 \rightarrow \Delta R = 1$ e $\Delta F = 0,01$
 $L = 14,00 \pm 0,06$ $T = 60 \pm 1 \rightarrow \Delta L = 0,01$ e $\Delta T = 1$
- 9) Supondo que Δy DEVE ser igual a $\pm 6\%$ de Δy , estime quais devem ser os limites para os erros ΔR , ΔF , ΔL e ΔT ?

Tabela 4: Valores Limites para Teste Quiquadrado

TABELA A-4		Distribuição Qui-Quadrado (χ^2)									
		Área à Direita do Valor Crítico									
Graus de Liberdade		0,995	0,99	0,975	0,95	0,90	0,10	0,05	0,025	0,01	0,005
1		—	—	0,001	0,004	0,016	2,706	3,841	5,024	6,635	7,879
2		0,010	0,020	0,051	0,103	0,211	4,605	5,991	7,378	9,210	10,597
3		0,072	0,115	0,216	0,352	0,584	6,251	7,815	9,348	11,345	12,838
4		0,207	0,297	0,484	0,711	1,064	7,779	9,488	11,143	13,277	14,860
5		0,412	0,554	0,831	1,145	1,610	9,236	11,071	12,833	15,086	16,750
6		0,676	0,872	1,237	1,635	2,204	10,645	12,592	14,449	16,812	18,548
7		0,989	1,239	1,690	2,167	2,833	12,017	14,067	16,013	18,475	20,278
8		1,344	1,646	2,180	2,733	3,490	13,362	15,507	17,535	20,090	21,955
9		1,735	2,088	2,700	3,325	4,168	14,684	16,919	19,023	21,666	23,589
10		2,156	2,558	3,247	3,940	4,865	15,987	18,307	20,483	23,209	25,188
11		2,603	3,053	3,816	4,575	5,578	17,275	19,675	21,920	24,725	26,757
12		3,074	3,571	4,404	5,226	6,304	18,549	21,026	23,337	26,217	28,299
13		3,565	4,107	5,009	5,892	7,042	19,812	22,362	24,736	27,688	29,819
14		4,075	4,660	5,629	6,571	7,790	21,064	23,685	26,119	29,141	31,319
15		4,601	5,229	6,262	7,261	8,547	22,307	24,996	27,488	30,578	32,801
16		5,142	5,812	6,908	7,962	9,312	23,542	26,296	28,845	32,000	34,267
17		5,697	6,408	7,564	8,672	10,085	24,769	27,587	30,191	33,409	35,718
18		6,265	7,015	8,231	9,390	10,865	25,989	28,869	31,526	34,805	37,156
19		6,844	7,633	8,907	10,117	11,651	27,204	30,144	32,852	36,191	38,582
20		7,434	8,260	9,591	10,851	12,443	28,412	31,410	34,170	37,566	39,997
21		8,034	8,897	10,283	11,591	13,240	29,615	32,671	35,479	38,932	41,401
22		8,643	9,542	10,982	12,338	14,042	30,813	33,924	36,781	40,289	42,796
23		9,260	10,196	11,689	13,091	14,848	32,007	35,172	38,076	41,638	44,181
24		9,886	10,856	12,401	13,848	15,659	33,196	36,415	39,364	42,980	45,559
25		10,520	11,524	13,120	14,611	16,473	34,382	37,652	40,646	44,314	46,928
26		11,160	12,198	13,844	15,379	17,292	35,563	38,885	41,923	45,642	48,290
27		11,808	12,879	14,573	16,151	18,114	36,741	40,113	43,194	46,963	49,645
28		12,461	13,565	15,308	16,928	18,939	37,916	41,337	44,461	48,278	50,993
29		13,121	14,257	16,047	17,708	19,768	39,087	42,557	45,722	49,588	52,336
30		13,787	14,954	16,791	18,493	20,599	40,256	43,773	46,979	50,892	53,672
40		20,707	22,164	24,433	26,509	29,051	51,805	55,758	59,342	63,691	66,766
50		27,991	29,707	32,357	34,764	37,689	63,167	67,505	71,420	76,154	79,490
60		35,534	37,485	40,482	43,188	46,459	74,397	79,082	83,298	88,379	91,952
70		43,275	45,442	48,758	51,739	55,329	85,527	90,531	95,023	100,425	104,215
80		51,172	53,540	57,153	60,391	64,278	96,578	101,879	106,629	112,329	116,321
90		59,196	61,754	65,647	69,126	73,291	107,565	118,145	118,136	124,116	128,299
100		67,328	70,065	74,222	77,929	82,358	118,498	124,342	129,561	135,807	140,169