Review from lecture 1 — Monday, Sep 28, 2015

- Definition of Mechanical Design
- Uncertainty => 220 MPa
  220 ± 10 MPa
  220 ± 5% MPa

- Design Factor
- Safety Factor (Factor of Safety)

Selection of Design Factor

- subjective
- follow industry Standards

Factor of safety → Design Factor

Depends on:

- degree of uncertainty about loading
- degree of uncertainty about material strength and structure
- consequences of failure → human safety, economics
- cost of providing a high safety factor

reliability method of design

stochastic method

distributions strength and stress

reliability, R

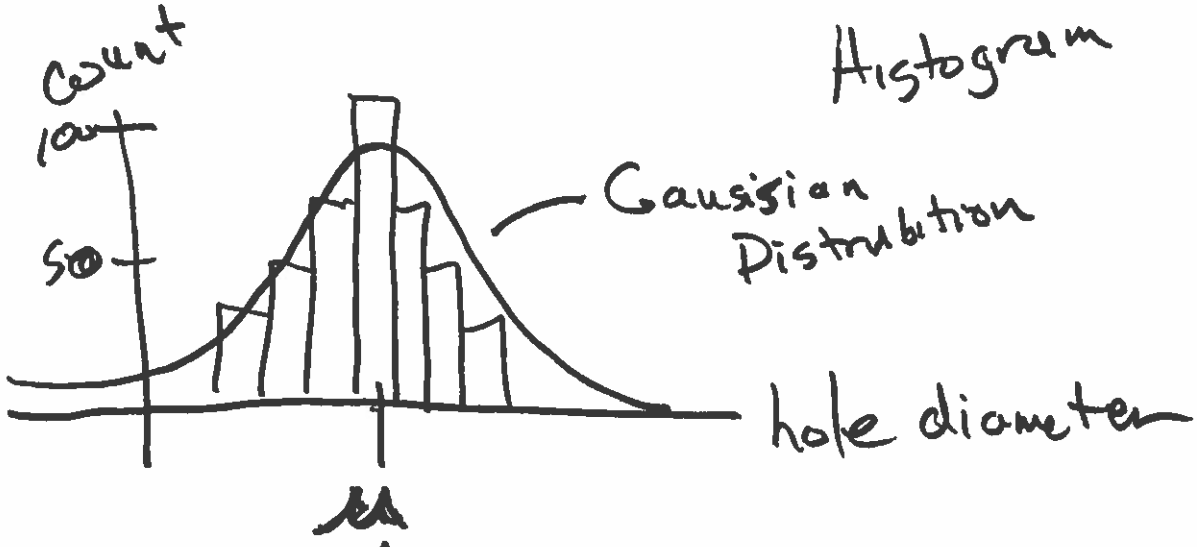
statistical measure

probability that something won't fail

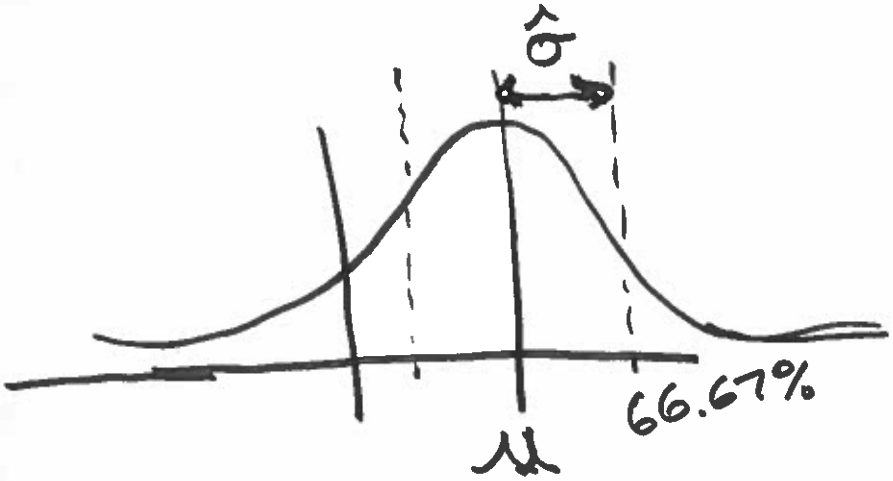
probability of failure, P_f

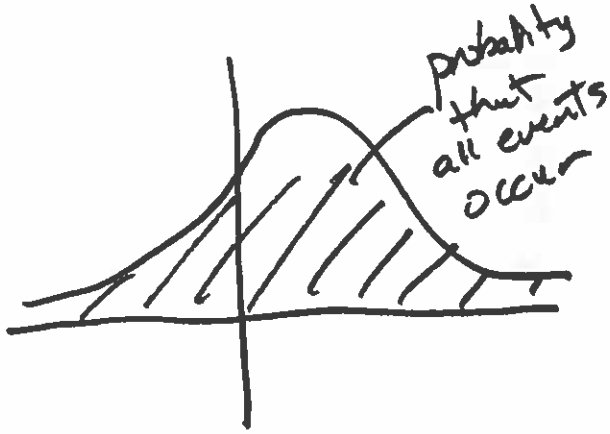
probability that something will fail

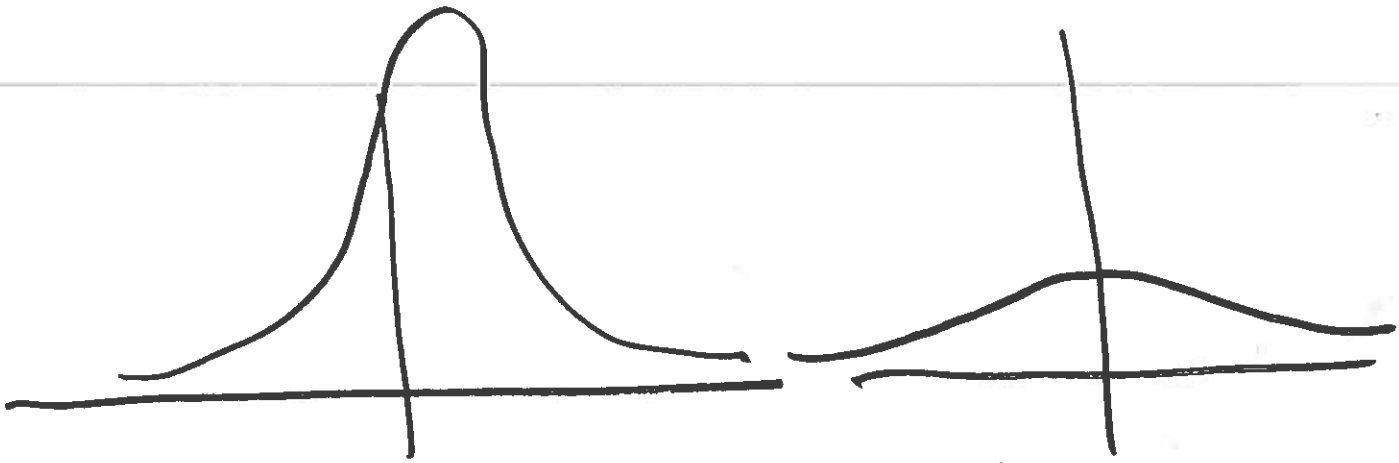
$$1 - R = P_f$$



μ: mean σ: standard deviation







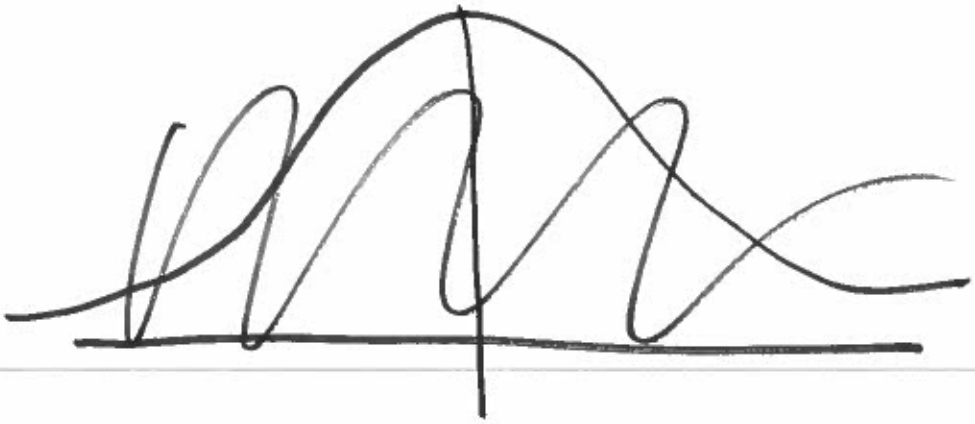
$\hat{\sigma}$ small

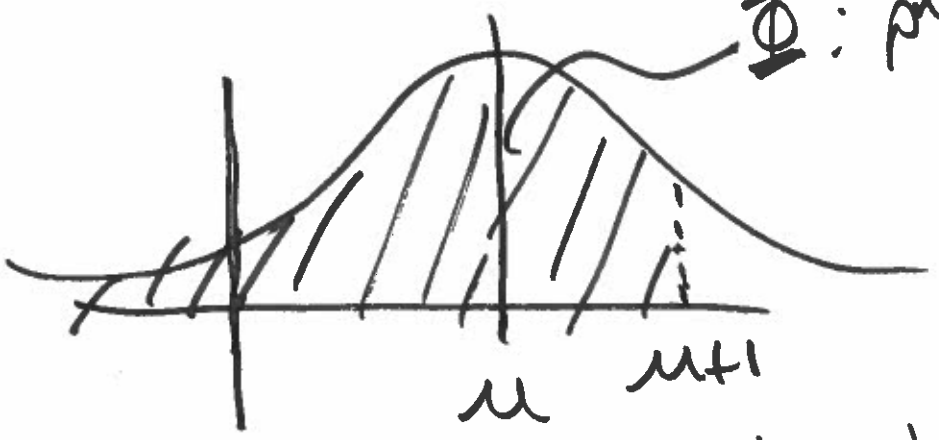
$\hat{\sigma}$ large

Probability Distribution Function

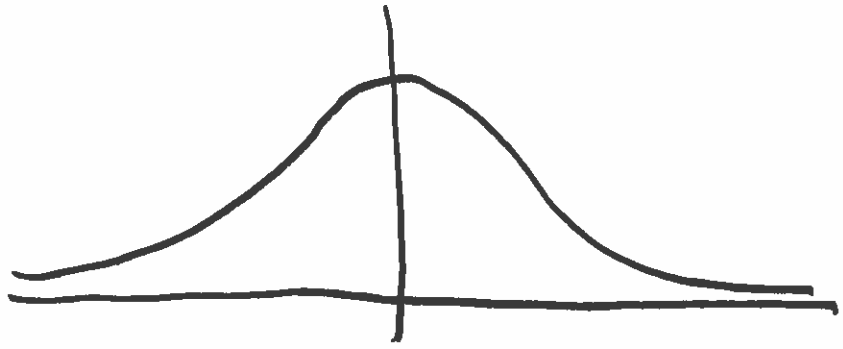
$$f(x) = \frac{1}{\hat{\sigma}\sqrt{2\pi}} e^{\left[-\frac{1}{2}\left(\frac{x-\mu}{\hat{\sigma}}\right)^2\right]}$$

$$\int_{-\infty}^{\infty} f(x) \Rightarrow 100\% \text{ probability}$$





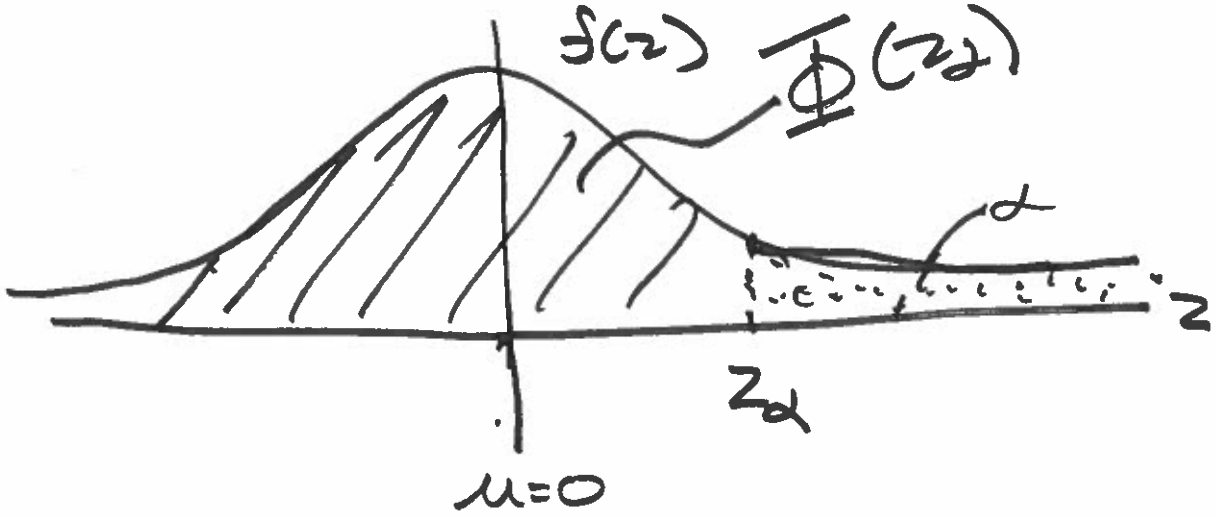
What is the probability that the observation is less than $\mu+1$?



$\mu = 0$

$\hat{\sigma} = 1$

$$Z = \frac{X - \mu}{\hat{\sigma}}$$

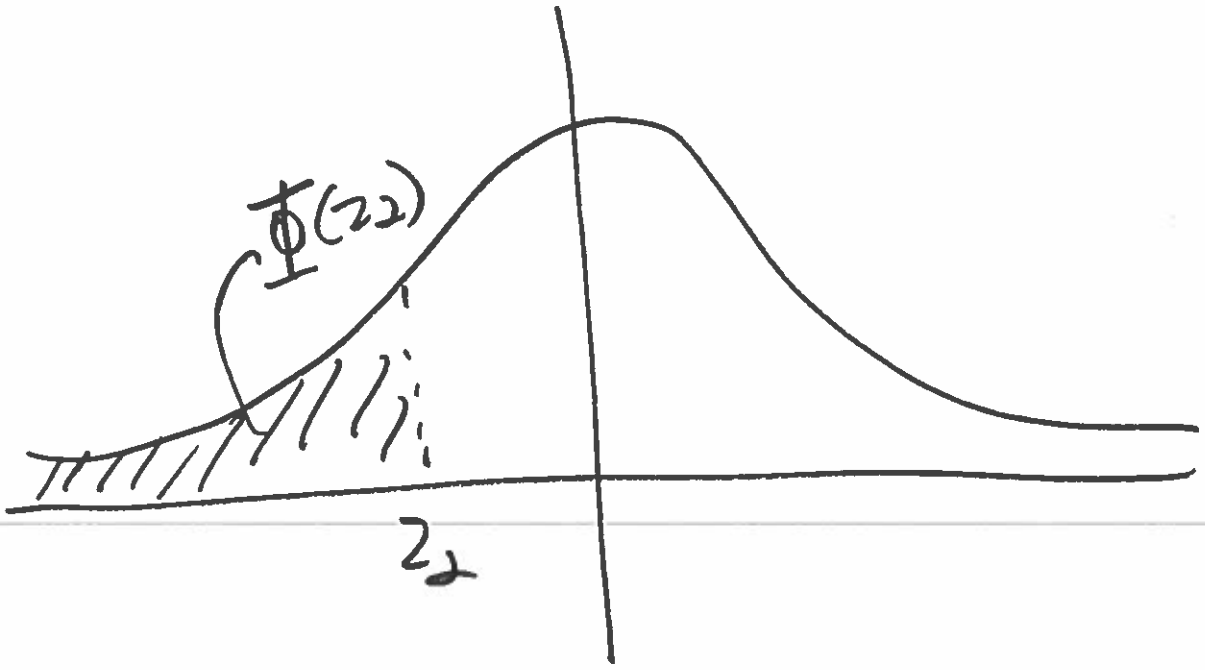


$z_\alpha > 0$

The probability that occurrence is less than z_α

↳ $1 - \Phi(z_\alpha)$

$\alpha =$



$z \leq 0$

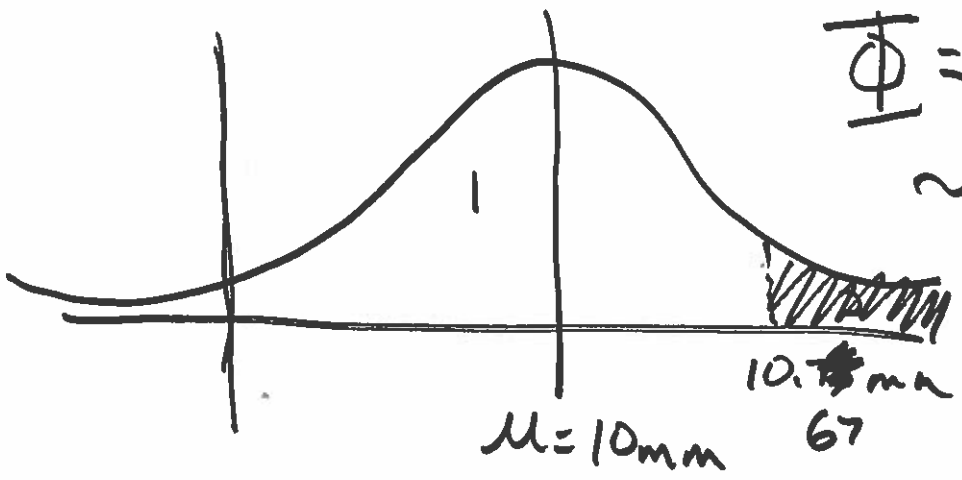
probability $\Phi(z_2)$

1M parts, measure 1000 of them to build a histogram of hole diameters

$\mu_d = 10\,mm$

$\hat{\sigma}_d = 0.5\,mm$

What is the probability that ~~a diameter~~ a randomly chosen part has a diameter $> 10.67\,mm$?



$\Phi = 0.0901$

$\sim 90K > 10.67\,mm$

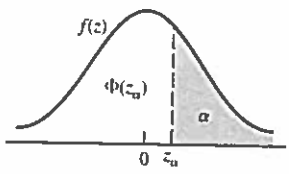
$$Z = \frac{d - \mu_d}{\hat{\sigma}_d} = \frac{10.67\,mm - 10mm}{0.5\,mm} = 1.34$$

Table A–10

Cumulative Distribution Function of Normal (Gaussian) Distribution

$$\Phi(z_\alpha) = \int_{-\infty}^{z_\alpha} \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{u^2}{2}\right) du$$

$$= \begin{cases} \alpha & z_\alpha \le 0 \\ 1 - \alpha & z_\alpha > 0 \end{cases}$$



1.34

z_α	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.4960	0.4920	0.4880	0.4840	0.4801	0.4761	0.4721	0.4681	0.4641
0.1	0.4602	0.4562	0.4522	0.4483	0.4443	0.4404	0.4364	0.4325	0.4286	0.4247
0.2	0.4207	0.4168	0.4129	0.4090	0.4052	0.4013	0.3974	0.3936	0.3897	0.3859
0.3	0.3821	0.3783	0.3745	0.3707	0.3669	0.3632	0.3594	0.3557	0.3520	0.3483
0.4	0.3446	0.3409	0.3372	0.3336	0.3300	0.3264	0.3238	0.3192	0.3156	0.3121
0.5	0.3085	0.3050	0.3015	0.2981	0.2946	0.2912	0.2877	0.2843	0.2810	0.2776
0.6	0.2743	0.2709	0.2676	0.2643	0.2611	0.2578	0.2546	0.2514	0.2483	0.2451
0.7	0.2420	0.2389	0.2358	0.2327	0.2296	0.2266	0.2236	0.2206	0.2177	0.2148
0.8	0.2119	0.2090	0.2061	0.2033	0.2005	0.1977	0.1949	0.1922	0.1894	0.1867
0.9	0.1841	0.1814	0.1788	0.1762	0.1736	0.1711	0.1685	0.1660	0.1635	0.1611
1.0	0.1587	0.1562	0.1539	0.1515	0.1492	0.1469	0.1446	0.1423	0.1401	0.1379
1.1	0.1357	0.1335	0.1314	0.1292	0.1271	0.1251	0.1230	0.1210	0.1190	0.1170
1.2	0.1151	0.1131	0.1112	0.1093	0.1075	0.1056	0.1038	0.1020	0.1003	0.0985
1.3	0.0968	0.0951	0.0934	0.0918	0.0901	0.0885	0.0869	0.0853	0.0838	0.0823
1.4	0.0808	0.0793	0.0778	0.0764	0.0749	0.0735	0.0721	0.0708	0.0694	0.0681
1.5	0.0668	0.0655	0.0643	0.0630	0.0618	0.0606	0.0594	0.0582	0.0571	0.0559
1.6	0.0548	0.0537	0.0526	0.0516	0.0505	0.0495	0.0485	0.0475	0.0465	0.0455
1.7	0.0446	0.0436	0.0427	0.0418	0.0409	0.0401	0.0392	0.0384	0.0375	0.0367
1.8	0.0359	0.0351	0.0344	0.0336	0.0329	0.0322	0.0314	0.0307	0.0301	0.0294
1.9	0.0287	0.0281	0.0274	0.0268	0.0262	0.0256	0.0250	0.0244	0.0239	0.0233
2.0	0.0228	0.0222	0.0217	0.0212	0.0207	0.0202	0.0197	0.0192	0.0188	0.0183
2.1	0.0179	0.0174	0.0170	0.0166	0.0162	0.0158	0.0154	0.0150	0.0146	0.0143
2.2	0.0139	0.0136	0.0132	0.0129	0.0125	0.0122	0.0119	0.0116	0.0113	0.0110
2.3	0.0107	0.0104	0.0102	0.00990	0.00964	0.00939	0.00914	0.00889	0.00866	0.00842
2.4	0.00820	0.00798	0.00776	0.00755	0.00734	0.00714	0.00695	0.00676	0.00657	0.00639
2.5	0.00621	0.00604	0.00587	0.00570	0.00554	0.00539	0.00523	0.00508	0.00494	0.00480
2.6	0.00466	0.00453	0.00440	0.00427	0.00415	0.00402	0.00391	0.00379	0.00368	0.00357
2.7	0.00347	0.00336	0.00326	0.00317	0.00307	0.00298	0.00289	0.00280	0.00272	0.00264
2.8	0.00256	0.00248	0.00240	0.00233	0.00226	0.00219	0.00212	0.00205	0.00199	0.00193
2.9	0.00187	0.00181	0.00175	0.00169	0.00164	0.00159	0.00154	0.00149	0.00144	0.00139

(Continued)

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What is the probability of occurrence for less than z = -1.23?

A. 0.1151
B. 0.1093
C. 0.8907
D. 0.8849

Tolerances

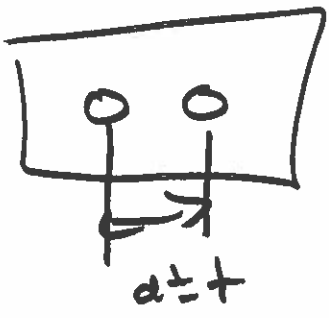
- uncertainty
- bounds (size, shape)

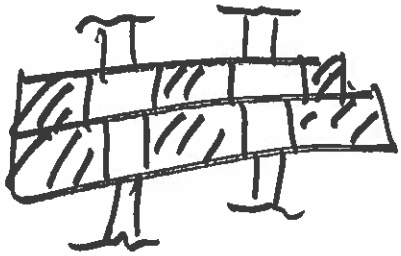
1.000 ± 0.001"

↑ is not ~~$\pm$~~ typically $\hat{\sigma}$

- tight tolerances = highe cost
- loose tolerances in general
- tight tolerance only if necessary

Dimensioning





SI: ~~Eng~~
International System of Units

US: US customary units
Burma, Liberia