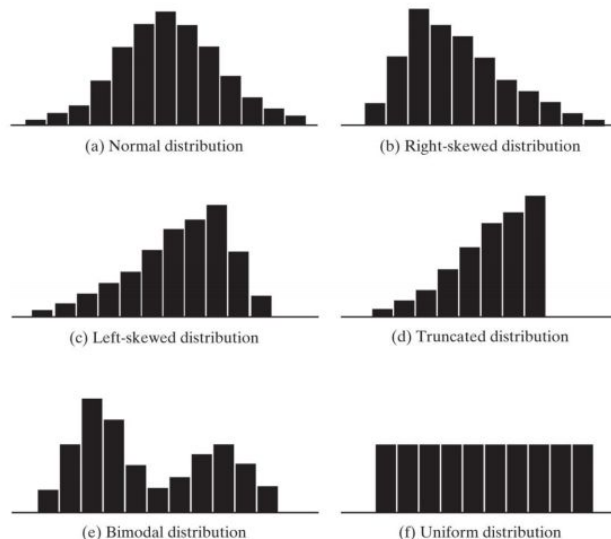


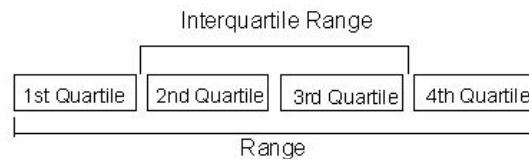
- Lecture 11,12,13
  - Statistical Analysis:
    - Definition: The science of data collection and data interpretation
    - Summarize data
    - Compute probabilities of future occurrences
    - Make rational decisions based off analysis
    - Quantify ignorance
  - Statistics
    - Mark Twain:
      - “There are three types of falsehoods, each worse than the one before – lies, damned lies, and statistics.”
    - Definition: A specified, determinable function of a set of observations
    - Arithmetic average
      - Tells where the center of the measurement distribution is
    - Histogram
      - How to make:
        - Find the range (max-min)
        - Make multiple bins with small equal size ranges
        - See how many data fit in small ranges
      - Useful to analyse frequency distribution of data

## Frequency Distributions (Histograms)

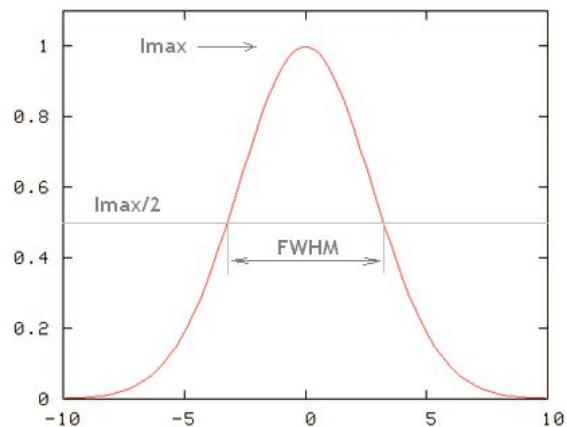


- 
- Distribution becomes smoother as sample gets larger
- Normal distribution=Gaussian distribution=bell curve
- Histogram appearance dependant on number of bins and bin ranges
- Distribution
  - Distribution is dependent on the physics behind the data

- Most engineering measurements are normal distributions
- Outlier
  - Definition: An observation which deviates from the other data that was obtained
  - Valid extreme errors should not be omitted from the distribution
  - Gross errors of measurements should be deleted
  - Censoring of good data can lead to a bias in the results making data look better than it is
  - Median does not get affected by outliers
- Descriptive Statistics Analysis
  - **3 conditions must be met**
    - **Data must be independent (exchangeable)**
    - **Arbitrary inclusion of repeat measurements is not allowed**
    - **Data cannot be correlated such that exchangeability is violated**
  - Summary statistics
    - Mean and median give central tendency
    - Mode determines most probable bin range
    - Standard deviation and range indicate width of distribution
    - Interquartile range



- Full Width Half Max (FWHM)



- Half Width Half Max (HWHM)
  - Just half the value of FWHM
- Graphics Displays

- Dot plots
- Box and Whisker Plot
- Scatter plot
- Frequency plots (histograms)
- Measure of variation
  - Definition: A number that show hows the data is spread out around the mean
  - Examples:
    - Standard deviation
      - Population

$$\sigma = \left[ \frac{\sum_{i=1}^N (x_i - \mu)^2}{N} \right]^{\frac{1}{2}}$$

- 
- Sample

$$s = \left[ \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1} \right]^{\frac{1}{2}}$$

- Variance
  - Population

$$\sigma^2 = \frac{1}{N} \sum_{i=1}^N (x_i - \mu)^2$$

- 
- Sample

$$s^2 = \frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2$$

- Range
- Golden Rule
  - Data is count of real entities
  - Conclusions should be made in the context of their meaning in relation these entities
- Central limit theorem is why we get normal distribution curves

- Standard error = standard deviation of the mean
  - Standard deviation of the sample means
  - Standard error tells how much u know mean

$$\mu = \bar{x} \pm z_c S_{\bar{x}}$$

where

$z_c$  = confidence level

e.g.  $z_{95} = 1.96$  for 95% confidence

▶ At 95% confidence, the true mean,  $\mu$ , lies within this  $\pm$  interval.

- 
- Random number generation
  - Normal, lognormal, poisson, binomial, uniform
- T stats
  - Only use when  $n < 30$
  - Sample variance is weighted
  - Gosset published his work under the name 'student'

$$x = \bar{x} \pm t_{\nu,c} S_{\bar{x}}$$

where

$t_{\nu,c}$  = t-statistic for  $\nu$  degrees of freedom

$\nu = n - 1 = \text{DOF} = \text{Degrees of Freedom}$

- 
- Population mean for proportions

## Population Mean for Proportions

- Estimate the proportion  $p$  by sampling

$$\bar{p} \pm z_c \sqrt{\frac{\bar{p}(1-\bar{p})}{n}}$$

$$n\bar{p} > 5$$

$$n(1-\bar{p}) > 5$$

} Must be satisfied to use this method

- 
- Where  $p$  bar = number of correct/total attempts
- Lecture 14,15
  - Bivariate relationships

- Looking at stats when 2 variables are measured
  - Linear Correlation
    - Correlation is a measure of the strength of a relationship
    - Linear correlation determines how good a straight line can relate 2 variables (-1 to 1)
      - Close to 1 or -1 means there is a good relationship
  - Regression
    - The process of fitting a mathematical model to a set of data
    - Residuals
      - Errors of the fitted line
      - Difference between collected and predicted data
  - Sum of Squared Errors (SSE)
    - Determines how well the model fits the data
    - Called least-squares fit/regression
    - **Residual Variation=SSE/TSS**
  - Coefficient of Determination
    - Determines the quality of the fit
  - Sources of variation
    - Variation explained by regression model
    - Variation not explained by regression model
    - Total variation = Explained + unexplained/Residual
  - Sum of Squares of the Deviations (SSR)
    - Difference between regression line and mean
    - **Explained Variation= SSR/TSS= Coefficient of Determination**
  - Total Sum of Squares (TSS)
    - Total Variation
    - **TSS= SSR+SSE**
  - Linear Least Squares Regression/Fits
    - Refers to the fact that equation is linear by the determined parameters m and b ( $m^1$ ,  $b^1$ , linear=power of 1)
    - Each term in the equation must have a coefficient of m and the equation must have a +b constant at the end as well
  - **Rule**
    - **Cannot do coefficient of correlation if relationship is not linear**
- Lecture 16, 17, 18
  - $A = m \times n$  matrix
    - $M = \text{row}$
    - $n = \text{column}$
  - 3 instances may occur when solving linear system
    - Unique solution
      - Two lines meet at a point
    - Infinitely many solutions

- Two planes meet in a line
  - No solution
    - Two planes or line never meet if they are parallel
- 2 types of solutions
  - Under determined
    - Fewer equations than unknowns
    - Solutions may exist, but not unique
    - If solution exists, infinite solutions are possible
  - Over determined
    - More equations than unknowns
    - A finite solution may exist
      - May or may not be unique
  - Determined
    - The number of equations equals the number of unknowns
    - Can solve the system for unknowns
  - **Equations must be independent**
- Matlab=MatrixLaboratory
  - Functions
    - Basic maths
    - Matrix multiplication
    - 2d graphing
    - 3d graphing
    - Surface plotting
    - Sound visualization
    - Data analysis
    - Computer programming
  - Windows
    - Editor window
      - Programming and making reusable code
    - Command window
      - Math operations
      - Testing and throw away code
    - Figure Window
      - Appears when plot is made
  - Syntax
    - Semicolons are used to suppress output
    - Variables
      - Variable dont need initializing/setting type
      - 4 different type of variable
        - Double
        - Integers
        - Boolean
        - Strings

- Can be multidimensional (array,vector)
- Use disp() to display stuff

( ) used to denote elements of a matrix/vector

A(1,2)=2

$$\mathbf{A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

- 
- Clear erases all variables from workspace
- Clc cleans command window
- Use semi colons to denote new row
- % is for comment
- Use columns to separate values on same row
  - Use a full colon to pick out rows or columns

```
>> A = [1, 2, 3; 4, 5, 7; 8, 9, 10]
```

```
A =
```

```
1 2 3
4 5 7
8 9 10
```

```
>> A(:,2)
```

```
ans =
```

```
2
5
9
```

```
>> A(3,:)
```

```
ans =
```

```
8 9 10
```

- Raise each element of the matrix to a Power

```
>> A.^4
```

#### ■ Script

- Sequence of commands
- Cannot accept arguments
- Uses global variables

#### ■ Function

- Can accept arguments
- Uses local variables, dont appear in matlab workspace

- Cos (angle between 2 vectors) = coefficient of correlation

### ● Lecture 19

- Maple

#### ■ Functions

- 2d plotting
- 3d plotting
- symbolic and numerical computations
- Differential and integral calculus
- Matrix manipulation
- Statistics and data management
- Algebraic geometry

- Differential geometry
  - Output types
    - Rtf
    - Latex
    - Pdf
    - Txt
    - Zip
    - Html
  - # is for comment
  - 1D math is typing, 2D is using palette
  - Use % to take output from last command
- Lecture 22
  - Professional Engineers Ontario (PEO)
    - Outline
      - Code of ethics
      - Guideline for practice
      - Disciplinary Procedures
    - Code of ethics
      - Defines engineer's responsibility to
        - Society and environment
        - employer/client
        - Fellow engineers
      - Other obligations
        - Technical standards
        - Corporate practice
        - International treaties
    - **Do work only within ur competence (area of expertise)**
    - Misconduct
      - Negligence
        - The engineers fails to maintain the reasonable standards set forth by the governing body
      - Failure to safeguard life, health and property
      - Failure to report something that endangers public safety
      - Failure to comply with codes
      - Failure to disclose conflict of interest
      - Breach of the act
      - Doing work which you are not qualified for
      - Unprofessional conduct
      - Failure to abide by license
      - Failure to cooperate with PEO investigators
      - Assisting a person in doing engineering work when they are not an engineer
      - Harassment

- What it does
  - Licensing and enforcement body
  - Enforces professional engineers act
  - Enforces standards of competence
  - Enforces use of titles (P.eng, professional engineer)
  - Responsible for public safety
  - Does not protect engineers
  - Nothing to do with iron ring
- Governed by provincial law
  - Professional Engineers Act
- Professional engineers exclusively can practice engineering
- Expectations of Professional Engineers:
  - Responsibility
  - Accountability
  - No unreasonable error concerning public safety
  - Liability and liability insurance
- Requirements of Licensing
  - Be 18 years old
  - Be of good character
  - Meet education standards established by PEO
  - Pass the professional practice exam
  - 4 years of engineering practical experience in Ontario
    - Application of theory
    - Practical experience
    - Management of Engineering
    - Communication Skills
    - Social Implications of Engineering
  - Only 12 out of 48 months can be gained before graduation
    - Must be gained after 2nd year
    - Graduate and master degree count towards this time
  - Academic requirements
    - Minimum  $\frac{1}{8}$  Math
    - Minimum  $\frac{1}{8}$  Basic Science
    - Minimum  $\frac{1}{8}$  Engineering science
    - Minimum  $\frac{1}{8}$  Engineering design
    - Minimum ES + ED = minimum  $\frac{1}{2}$  of program
    - Minimum  $\frac{1}{8}$  Complementary studies
      - Includes engineering economic
      - Environment
      - Health safety
      - Ethics and professional practice
- Must keep written records of disagreements and course of action
- Enforcement of Act

- Starts with complaint
- Complaint taken to Discipline Committee
- Discipline Committee decides whether formal hearing is needed
- Hearing
  - PEO is prosecutor
  - Engineer is defendant
  - Complaints committee is judge and jury
  - Published in article
- Practicing without a license goes to public court
  - If found guilty
    - 10 000 dollar fine
    - 50 000 repeat offender
- Certificate of Authorization
  - No person shall offer engineering services to the public without a certificate of authorization
  - Individual
    - Must be licensed
    - Must have five years of licensed practice
    - Must have demonstrate competency in C of A area
    - Must be insured
  - Engineering Firm
    - Designates p.eng as chief engineer
- Designs must not put workers in harm's way
- Safety review is required when something is
  - reconstructed , ALtered, Installed
- Letter of confirmation certifies that equipment is safe
- Responsibilities of an PE
  - Design work
  - Producing reports
  - Certifying equipment
  - Certifying structures
  - Performing safety reviews
  - Provide reports under Occupational Health and Safety Act (OHSA)
- Canadian Council of Professional Engineers (CCPE)
  - Coordinates engineering education, practice, professional qualifications and ethics
- Canadian Engineering Accreditation Board (CEAB)
  - A committee of the CCPE
  - Accredits Canadian undergraduate engineering programs
- Lecture 23
  - Occupational Health and Safety
    - Occupational Health and Safety Act (OHSA) of workers
      - Framework for health and safe workplace

- Defines rights of all parties in workplace
- Tells how to deal with hazards
- Intended for the protection of workers
- Ministry of Labour
  - Enforces the OHS Act, investigates and prosecutes
- Workspace Responsibilities
  - Internal Responsibility System (IRS)
    - Joint Health and Safety Committee
    - Identify needed changes to workplace practice
- Duties of Workers
  - Use protective equipment
  - Report defects in equipment and hazards
  - Do not bypass safety devices
  - Do not use equipment that endangers another worker
  - Do not remove protective devices
- Rights of workers
  - Right to practice
  - Right to know
  - Right to refuse work (only when unreasonable safety risks are apparent)
  - Right to stop work
- Duties of supervisor
  - Ensure workers follow safety procedures
  - Ensure workers wear safety things
  - Tell workers of hazards
  - Take every reasonable measure to ensure worker safety
- Duties of employer
  - Tell workers of hazards
  - Ensure OHS Act provisions followed
  - Provide training
  - Supply protective equipment
  - Take reasonable measure to ensure safety
- Duties of engineer
  - Ensure public safety
  - Maintain competence
  - Report hazards
  - Do not perform work outside expertise
  - Apply codes and standards
- Workplace Hazardous Materials Information (WHMIS)
  - Inform users of hazardous material
  - Material Safety Data Sheet (MSDS)
    - Tells people how to deal with materials
- Enforced internally and by the Ministry of Labour

