Data Management

MDM4U

Qinghao Hu

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Contents

Chapter 1

Unit 1

1.1 Lecture 1

1.1.1 The Fundamental or Multiplicative Counting Principle

If a task is made up of *several stages*, then the number of choices is the **product** of the number of possibilities at each stage.

1.1.2 Additive Counting Principle

In a situation with actions that cannot occurred at the "same time" than the number of possibilities is the sum of the possibilities of all the actions

!!! Remember, $0! = 1$

1.2 Lecture 1.2

A permutation is an ARRANGEMENT of items in a definite order.

$$nPr = \frac{n!}{(n-r)!}$$

and

$$nPr = P(n, r)$$

1.3 Like Term Permutations

The number of permutations of a set of n objects containing a identical objects of one kind, b identical objects of a second kind, c identical objects of a third kindand so on is $\frac{n!}{a!*b!*c!}$

1.4 Pascal Triangle

Do what the hell you want to do about Pascal

1.5 Venn Diagrams

Concepts:

- In mathematics, a set is a well-defined collection of *distinct* objects/elements

- A Venn diagram is used to organize the (number of) elements in different *set* of data.
- Elements that are in set a and set b are described as the intersection of A and B. The notation of $A \cap B$ describes this situation
- Elements that are in set a or set b are discribed as the combine of A and B. The notation of of $A \cup B$ describes this situation
- The Complement, A' of a set A is the set of all elements in the universal set that are NOT elements of A.

1.6 Combination

$$nCr = C_n^r = \frac{n!}{r! * (n-r)!}$$

Remainder, $0! = 1$

Chapter 2

Unit 2, Probability

2.1 Probability

2.1.1 Definitions of Probability

Probabiilty: *The Likehood that a result will occur, a value that ranges from 0 (impossible) to 1 (must happen)*

Subjective Probabiilty: *An ESTIMATE of the likehood a result occurs based on intuition and experience*

Experimental or Empirical probability: *The number of times that a result OCCURS divided by the number of trails in an experiment involving chances*

Theortical Probabiilty: *The probability of a result deduced from an Analysis of the possible outcomes of a scenario*

2.1.2 Definitions of other stupid stuffs

Sample Space: *the set of all possible outcomes in a probability experiment*

event: *an outcome or a collection of outcomes SATISFYING a particular condition*

Complement: *Complement of an event E, expressed as E', is all the outcomes that are in the sample space and NOT in event E*

2.1.3 Formulas

Assume s is the set of total outcomes, the theortical probability of Event D is given by:

$$P(D) = \frac{n(D)}{n(s)}$$

The Complement of event D, D' is given by this:

$$P(D') = 1 - P(D)$$

2.1.4 Examples

Example 1. Two standard 6-sided dice are rolled and the sum of the dice is recorded. What is the (theoretical) probability of rolling a sum of 8?

Let E be the event that a sum of 8 is rolled

$$P(E) = \frac{n(\text{E})}{n(\text{total outcomes that can be rolled})}$$

$$P(E) = \frac{5}{36}$$

$\therefore$ Conclusion

2.2 Dependent Events

2.2.1 Definitions

Definition 2.2.1. *If events A and B are independent, then $P(A \cap B) = P(A) * P(B)$*

Definition 2.2.2. *$P(A \cap B)$ can be described as the probability of the intersection of events A and B.*

Definition 2.2.3. *For dependent events A and B, $P(A \cap B) = P(A) * P(B|A)$ and $P(A$ and $B) = P(B) * P(A|B)$*

Note: Two events cannot happen at the same time

2.3 Mutually Exclusive Events

2.3.1 Some boring Definitions

Definition 2.3.1. *Mutually exclusive events are events that cannot occur simultaneously*

Definition 2.3.2. *If events A and B are mutually exclusive, then $P(A$ and $B) =$ zero.*

Definition 2.3.3. *In general, for events A and B, $P(A \cup B) = P(A) + P(B) - P(A \cap B)$*

Definition 2.3.4. *$P(A \cup B)$ can be describe as the probability of the UNION of events A and B*

Chapter 3

One Variable Statistics

3.1 Variables and Data

3.1.1 Definitions

Categorical variables represent data that are generally grouped into categories, and are also known as qualitative variables

Ordinary variables are categorical variables whose data has a natural order but the difference between values cannot be determined or is not meaningful

Nominal variables describe names, labels, or categories that have no natural order

Quantitative variables describe data values that are numerical, and are also known as numerical variables

Continuous variables are numerical variables which can assume an infinite number of values in a given interval

Descrete variables are numerical variables that only take on a finite number of possible values in a given interval

Primary data are data that are collected by the statisticians who are analyzing the data, from first-hand sources such as surveys or experiments

Secondary data are data that the statisticians who are analyzing the data did not participate in the first hand data collection process (ie Surveys or experiments)

Microdata contains records for each individual surveyed

Aggregate or summary data are data that are combined or summarized in such a way that the individual microdata can no longer be determined.

Data gathered from a **cross** sectional study considers individuals from different groups at the same time

Data gathered from a **longitudinal** study considers how the characteristics of a specific sample changes over time

An **index** is a continous variable such that it is an arbitrarity defined number that provides a measure of scale. It is used to related the values of a variable to a base level

The **consumer** price index, CPI, provides a broad picture of the cost of living in Canada by comparing the cost of a wide variety of consumer goods, such as food, clothing, fuel, heating cost, transportation, shelter, and recreation

Health officials use the **body** mass index to determine whether a person is overweight. The BMI is calculated by dividing a person's mass in kilograms by the square of their height in meters

3.2 One Variable Graphs

3.2.1 Some Definitions

A **Frequency** bar (column) graph is a visual display of data in which quantities are represented by bars of equal width, typically used with categorical or discrete data

A **CIRCLE** graph or **PIE** chart contains a circle divided into sectors whose areas are proportional to the categories represented. It is used to show how each category is compared to the whole

A **PICTOGRAPH** is a graph that uses pictures or symbols to represent categorical quantities. It's advantage is being visually appealing, hence it is the most often used graphical format. However, it may be difficult to present exact values when using the format, depending on the data given

A **STEN** and **LEAF** plot can be created easily to see the distribution of a set of numerical data. However, its appearance is not as scientific as a histogram.

A **HISTOGRAM** is used to represent numerical data or data organized using intervals. The bars of a histogram are attached and each bar is placed between two intervals endpoints. The area of each bar is proportional to the frequency of data in the interval. Typically, 5 15 intervals/bins of equal length are used and every piece of data must fall into exactly one bin. The width of each bin is the **bin width**

Values of a continuous varialbe can be grouped into intervals in the form of $(a, b]$ such that this interval includes all values from a to b, including a but excluding b.

A bin width of **5** units witht he first bin being $[10, 15)$ is reasonable if a set of continuous data has 26 values, a minimum of 12

Example 2.

A group of students' heights, in centimetres, are shown. [35, 40)
Draw a stem and leaf graph for the data.
Use the first two digits of the numbers as the stems.

150	150	154	161	162	163	165
174	175	175	176	179	180	182

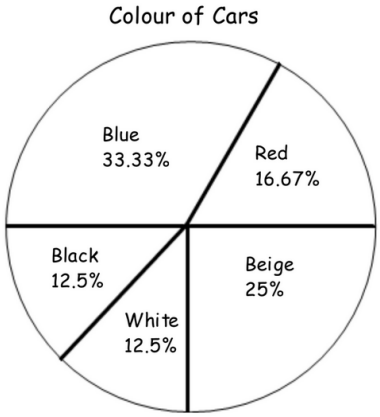
Stem	Leaf
15	0, 0, 4
16	1, 2, 3, 5
17	4, 5, 5, 6, 9
18	0, 2

This is an example of **STEM and LEAF graph**

Example 3.

3. Consider the given pie chart then complete the table.

Colour	Frequency	Relative Frequency	Degrees
Beige	30	1/4	90°
Black	15	1/8	45°
Blue	40	1/3	120°
Red	20	1/6	60°
White	15	1/8	45°
Total	120	1	360°



This is an Example of PIE Graphs

4. In a study of travel time to school, 29 students were surveyed.

   a) Use the grid on the left to create a (frequency) histogram for the data. Label fully. A title is not required.

   b) Relative frequency shows the frequency of each interval with respect to the total number of data values (i.e. the proportion of data contained in each interval is calculated). Complete the given table.

Travel Time to School (min)	Frequency	Relative Frequency	Cumulative Frequency
[0, 5)	2	$\frac{2}{29}$	2
[5, 10)	5	$\frac{5}{29}$	7
[10, 15)	10	$\frac{10}{29}$	17
[15, 20)	7	$\frac{7}{29}$	24
[20, 25)	3	$\frac{3}{29}$	27
[25, 30)	2	$\frac{2}{29}$	29

   c) Use the grid on the right to create a relative frequency histogram for the data. Label fully. A title is not required.

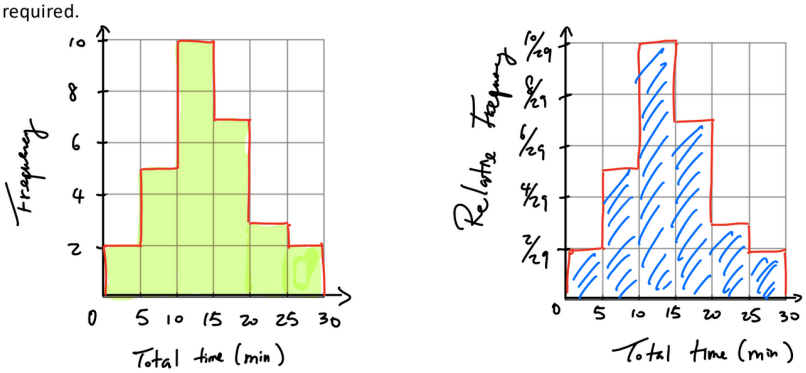


Figure 3.1: Example

Like a histogram, a **frequency polygon** gives an idea of the shape of the data distribution. It helps show the changes in frequency from one interval to the next. If the midpoint of each interval is used as an estimate for the all the values in the interval, then a frequency polygon is a line graph joining the mindpoints of the top of adjacent bars of a histogram.

Check the note

3.3 Central Tendency

3.3.1 Definitions of Central Tendency

CENTRAL

Measure of **CENTRAL** tendency are used to determine the averages of a set of data

Mean

The **Mean** of a set of numerical data is equal to the sum of the values of a variable divided by the number of values. That is:

$$\text{population mean} = \mu = \frac{x_1 + x_2 + \cdots + x_N}{N} = \frac{\sum_{i=1}^{N} x_i}{N}$$

$$\text{sample mean} = \bar{x} = \frac{x_1 + x_2 + \cdots + x_n}{n} = \frac{\sum_{i=1}^{n} x_i}{n}$$

If a set of numerical data is listed from least to greatest, then:

1. the median is the middle number (or the mean of the Two middle numbers), and,

2. the values can be ranked such that the minimum has rank=1 and the maximum has rank = N or n

The **Mode** is the most frequently occurred value in the data

The **MODAL** interval is the interval that contains the msot number of values

OUTLIERS are values that are significantly distant from the majority of the data

How to choose form

1. If the data is **not** numeric, use the Mode
2. if the data contain outliers and/or mean is skewed, use the median
3. otherwise use the mean

Weighted

the Weighted mean reflects the relative importance of each value of the data set. They could be calculated by two formulas:

Population:

$$\mu_w = \frac{w_1x_1 + w_2x_2 + \cdots + w_Nx_N}{w_1 + w_2 + \cdots + w_N} = \frac{\sum_{i=1}^{N} w_ix_i}{\sum_{i=1}^{N} w_i}$$

Sample:

$$\bar{x}_w = \frac{w_1x_1 + w_2x_2 + \cdots + w_Nx_N}{w_1 + w_2 + \cdots + w_N} = \frac{\sum_{i=1}^{n} w_ix_i}{\sum_{i=1}^{n} w_i}$$

3.4 Standard Deviation

Spread

Measures of **spread** are frequently calculated when analyzing numerical data. These measures are values that quantify how consistent or spread out of a set of data is. A measure of spread is often used to determine which of serval sets of data is more consistent

The **spread** of a set of data is **zero** if all the values in the set are identical

Just as there are several measures of central tendency, there are **several** different measures of spread. Variance and standard deviation are two of these measures.

The **Deviation** of a piece of data is the difference between the value of that piece of data and the mean of the set

Deviation of Detum

Population:

$$x - \mu$$

Sample:

$$x - \bar{x}$$

Definition 3.4.1. *Variance: The mean of the squares of the deviations. Larger variance = spread of the data is larger*

Population Variance:

$$\sigma^s = \frac{\sum(x-\mu)^2}{N}$$

Sample variance:

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

Sample variance's denominator being $n-1$ as opposed to n because in a sample the deviations tend to be underestimated.

Standard deviation

Definition 3.4.2. *Standard Deviation approximates the **TYPICAL** distance from the mean to each datum in the set*

Population standard deviation:

$$\sigma = \sqrt{\frac{\sum(x-\mu)^2}{N}}$$

Sample standard deviation:

$$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}}$$

Remark. Always calculate the sample variance/standard deviation if it is not clear whether the data is from a census or from a sample

Z-score

A datum's z-score is the number of standard deviations that datum is above or below the mean of the data set. Hence:

$$z = \frac{x-\mu}{\sigma}$$
$$z = \frac{x-\bar{x}}{s}$$

3.5 Quartiles

3.5.1 Definitions

Definition 3.5.1. *Interquartiles range is the measures of spread*

Range

Range is the difference between the largest and smallest values and it does not give any information about the spread of the other data values in the set

Quartiles

Quartiles divide a set of ordered data into 4 equal groups, similar to a median that divides the data into 2 equal groups. The three dividers are the first quartile Q_1, the second quartile Q_2 and the third quartile Q_3

Q_2 can be seen as the median of a data set. Q_1 and Q_3 can be defined as the **Median** of the lower and upper halves of the set, respectively, with an understanding of that, if the ordered set has an odd number of values then the middle number is not part of the lower or upper half of the data set

InterQuartile

It is the range of the middle half of the data. It can be calculated by this formula:

$$IQR = Q_3 - Q_1$$

A larger IQE indicates a greater spread of the central half of the data. The **semi-interquartile** range is the IQE divide by 2

Box-and-whisker plots

This graph illustrate the spread of the data around the **MEDIAN**. The box shows three quartile values, a left and a right whisker that "lead" to the minimum and the maximum values of the data set

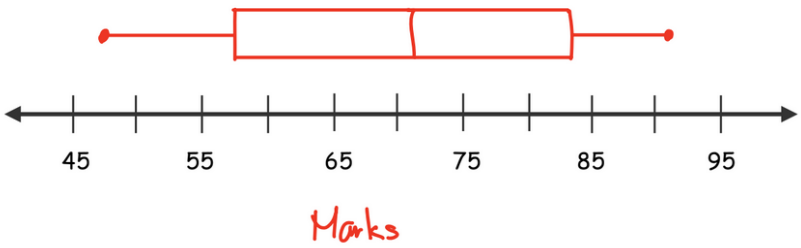


Figure 3.2: An example of box-and-whisker plot

Outlier

A **Modified** box plot may be used if the data contains outliers. Any value of x that is at least 1.5 times the box length from the box are considered outliers. These outliers must be plot as separate points instead of including them as part of the whiskers

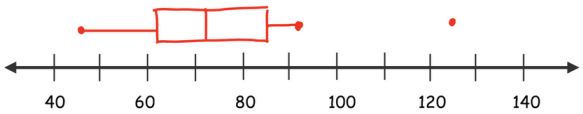


Figure 3.3: In this graph, 125 is an example of outlier

3.5.2 Percentiles

Percentiles divide a set of data into 100 equal intervals. A common definition for percentiles states that "A value corresponds to the k^{th} percentile if k % of the data are less than or equal to the value"

For a data set of n:

The Rank of the percentile p is:

$$R = \frac{p * n}{100}$$

Else linear interpolate the values with rank R and $R+1$ to determine the value that corresponds to percentile p

The percentile that corresponds to a specific datum is:

$$p = \frac{100L}{n}$$

L is the number of data values less than or equal to that specific datum

Remainder

Q_1 and the 25^{th} percentile corresponds to the same location of the data set, two different methods are being used to find the two statistics, for the purpose of convenience. Hence, they may not be equal to each other even though they should.

3.6 Spread Grouped Data

3.6.1 For weighted data

If x_i represents the i^{th} distinct value and w_i represents the weighting of the value x_i them

Average:

$$M \text{ or } x_i = \frac{\sum(w_i * x_i)}{N} \tag{3.1}$$

Population deviation:

$$\sigma = \sqrt{\frac{\sum w_i * (x_i - M)}{N}} \tag{3.2}$$

For sample deviation:

$$s = \sqrt{\frac{\sum w_i * (x_i - \bar{x})}{n-1}} \tag{3.3}$$

3.7 Collect data

3.7.1 Anonymous and not be anonymous

Definition 3.7.1. *(Anonymous): More likely to get honest data (hence more reliable data)*

Definition 3.7.2. *(Not Anonymous): Show credibility of Survey (answers)*

3.7.2 Survey Questions

Open

Respondents answer in their own words

Closed

Definition 3.7.3. *(checklist): Choose as many as apply (With a rating scale should be evenly distributed)*

Definition 3.7.4. *(Ranking): Give a rank based on the choices*

3.7.3 Questions should be avoided

Definition 3.7.5. *(Double-Barrelled): A question that akss more than one topic. (Ex. Do you like Math and Science?)*

Definition 3.7.6. *(Leading Question): Encourages a particular answer, onften becauses of this question is phrased or presented*

Definition 3.7.7. *(Loaded Question): A question contains assumptions, where answering it means the respondent accepts what the questioner is assuming*

3.7.4 Experimental vs Observational study

Observational study

- Study about how one factor affect another factor, without make any attempt to intervene

Experimental study

- Try to determine the cause and effect relationship between two variables by changing the value or characteristics of one variable to see what effect it has on the other variable
- Randomly place participants into the experimental group and the control group, with each group having a similar demographic make-up
- One experimental(Treatment) group of an experimental study receive the specific Treatment
- The other one do not receive the specific treatment being measured

3.8 sampling

Definition 3.8.1. *(Population): referss to the entire group that is being studied. Also called descriptive statistics*

Definition 3.8.2. *(Sample): Is a portion of the population. Summary values calculated from the sample data are called statistics. The term inferential statistics describes the process of generalizing about the population based on sample data. Therefore, it is important to have a "representative sample" when performing a statistical study*

3.8.1 Some type of sampling

Definition 3.8.3. *(Simple Random Sampling): every member of the population has an equal chance of being chosen for the study.*

Definition 3.8.4. *(SYSTEMIC Random Sampling): Individuals are selected at regular intervals, starting with a randomly chosen position.*

Definition 3.8.5. *(Stratified Random Sampling): Population is divied into groups/strata such that all members in each stratum share common characteristics but are different from members in other strata, then the same proportion of members from each stratum are randomly chosen*

Definition 3.8.6. *(Cluster random sampling): The population is divied into groups/clusters such that each cluster is a representative of the whole population, then every member of a random sample cluster are are surveyed*

Definition 3.8.7. *(Multi-stage random sampling): more than one loevel of random sampling techniques are applied*

Definition 3.8.8. *(Voluntary-response random sampling): members of the population are invited to participate in the survey and anyone who choose to participate is the sample*

Definition 3.8.9. *(Voluntary-response random sampling): members of the population are invited to participate in the survey and anyone who choose to participate is the sample*

Definition 3.8.10. *(Convenience random sampling): the sample is selected because it is easily accesible.*

3.9 Bias

Definition 3.9.1. *(Sampling bias): When the sample is not representative of the population*

Definition 3.9.2. *(Measurement bias): the data measuring tools are poorly designed*

Definition 3.9.3. *(Response bias): when participants in a survey deliberately give false or misleading answers*

Definition 3.9.4. *(Non-response bias): a form of sampling bias, particular groups are under-represented because they choose not to participate*

Chapter 4

Two variable Statistics

4.1 Lecture 1: Graphs

4.1.1 Definitions

Relation

In a **relation**, the variable that you need to first is called the **independent variable**. Its value determine the value of the **dependent** variable. On the scatter plot, the independent variable in located on the **horizontal** axis and the dependent variable is located on the **vertical** axis. The title of the graph should be *dependent variable vs independent variable*

Scatter Plot

A **scatter plot** is used to determine if a correlation exists between two **numerical** variables. An **outlier** is a data point that does not fit the pattern of the other data.

Line of best fit

A **line of the best fit** can be used to model the data on a scatter plot whose points follow the trend of a line. A **curve** of best fit can be used to model the data on a scatter plot whose points follow the trend of a curve. The line/curve should be solid if the data is **continuous** and dashed/dotted if the data is **discrete**

Two variable graphed

Using a scatter plot has a **positive** correlation if the trend of the data points increase from left to right. The two variables graphed using a scatter plot has a **negative** correlation if the trend of the data points decrease from left to right.

Correlation

The correlation between two variables is strong if the points on the scatter plot follow a line or a curve very closely. The correlation between two variables is **moderate** if the points on the scatter plot nearly follow a line or curve. The correlation between two variables is **weak** if the points on the scatter plot are dispersed more widely, but still show a recognizable trend.

Two variables graphed on a scatter plot shows **no** correlation if the points are so scattered that no trend is discernible.

Interpolate

To **interpolate** means to estimate values lying between given data. To interpolate from a graph means to estimate coordinates of points between those that are plotted.

extrapolate

To **extrapolate** means to estimate values lying outside the given range of data. To extrapolate from a graph means to estimate coordinates of points beyond those that are plotted.

Contingency

A **contingency** table shows the frequency or percentage distribution of two categorical variables.

4.2 Linear Correlation

4.2.1 Why Scatter plot?

There are few advantages of a scatter plot:

- Correlations
- Predictions
- Positive/negative
- Strong/weak

4.2.2 Some boring Definitions

Linear Relationship

A **linear** relationship is one in which a **change** in the independent (explanatory) variable corresponds a proportional change in the dependent (response) variable.

We can use table to calculate the correlation of two variables:

x	y	$(x-\bar{x})$	$(y-\bar{y})$	$(x-\bar{x})^2$	$(y-\bar{y})^2$	$(x-\bar{x})(y-\bar{y})$
85	76	2	2	4	4	4
90	83	7	9	49	81	63
76	68	-7	-6	49	36	42
78	70	-5	-4	25	16	20
85	75	2	1	4	1	2
84	72	1	-2	1	4	-2
Σ = 498	Σ = 444	NA	NA	Σ = 132	Σ = 142	Σ = 129

$$\bar{x} = \frac{\sum x}{n} \tag{4.1}$$

$$\bar{y} = \frac{\sum y}{n} \tag{4.2}$$

In order to calculate the correlation coefficient of x and y, we need to get the sample standard deviation for x and y.

$$s_x = \sqrt{\frac{\sum(x-\bar{x})}{n-1}} \tag{4.3}$$

$$s_y = \sqrt{\frac{\sum(y-\bar{y})}{n-1}} \tag{4.4}$$

Then, we need to calculate the covariance of x and y:

$$s_{xy} = \frac{\sum(x_i-\bar{x})*(y_i-\bar{y})}{n-1} \tag{4.5}$$

Finally, the correlation coefficient is defined by this:

$$r = \frac{s_{xy}}{s_x * s_y} \tag{4.6}$$

4.3 Linear Regression

4.3.1 Residual

Definition 4.3.1. *(Residual): It is the difference between the observed value and the value predicted by the best fit line. (Ie. how "far off" is the line, vertically, from the point)*

Points abouve the line have **positive** residuals and points below the line have negative residuals.

There are some really good sample questions on teacher's handouts. You should check it though!

4.3.2 Regression

Definition 4.3.2. *(Linear Regression): an analytic technique to determine a model that can used to describe the linear correlation between two quantitative variables.*

The linear model produced by linear regression is called a **least-squares** line.

For a least-square line, there are certain properties:

- the residuals add to 0 and the sum of the squares of the residuals is **Minimized**
- the slope is defined as

$$a = \frac{s_{xy}}{(s_x)^2}$$

- the y-intercept is defined as

$$b = \bar{y} - a\bar{x}$$

4.4 Linear Formula

4.4.1 Equations

Equation solve for standard deviation

$$s = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} = \frac{n\sum x^2 - (\sum x)^2}{n-1} \tag{4.7}$$

Correlation Coefficient

$$r = \frac{s_{xy}}{s_x s_y} = \frac{n\sum xy - \sum x \sum y}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}} \tag{4.8}$$

The slope of the least-square line

$$a = \frac{s_{xy}}{s_x^2} = \frac{n\sum xy - \sum x \sum y}{n\sum x^2 - (\sum x)^2} \tag{4.9}$$

Solve for the linear equation

$$b = \bar{y} - a\bar{x} \tag{4.10}$$

4.5 Apply linear Regression

Outliers

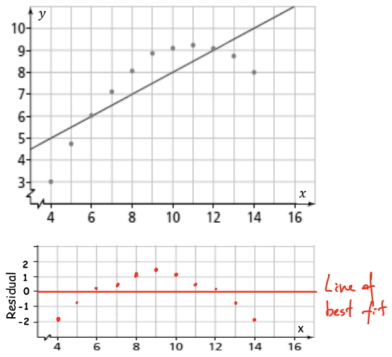
When you handle outliers, a good way is to creating two models to describe the relationship, one model includes the outliers and the other does not.

4.5.1 RESIDUAL

The **Residual** values that correspond to each respective data from a LINEAR regression can be used to create graph, called a **residual plot**, where the line of best fit is the horizontal axis of the plot. A residual plot helps us assess the fit of a regression line. If its pattern in the plot is an unstructured horizontal band centered at zero (the centre of the residuals), then the regression line fits the data well. If its pattern has a curve, then the relationship is non-linear rather than linear; hence, a straight line is not a good model for such relationshp.

b) For each data point, determine an estimate of the residual value of that point by completing the table.

x	y	$y_{estimated}$	Residual
4	3	4.9	-1.9
5	4.7	5.4	-0.7
6	6.1	5.9	0.2
7	7	6.4	0.6
8	8	6.9	1.1
9	8.9	7.4	1.5
10	9.1	7.9	1.2
11	9.2	8.4	0.8
12	9.1	8.9	0.2
13	8.7	9.4	-0.7
14	8	9.9	-1.9



c) Create a residual plot.

Formula for Residual

$$\text{Residual} = \sum(y - y_{est}) \tag{4.11}$$

4.6 Causal Relationships

A strong correlation between two variables is **not** enough evidence to say that changes in one variable causes changes in another variable

4.6.1 Definitions

Cause and Effect Relationship

A change in the independent variable directly causes a change in the dependent variable

Reverse cause and effect relationship

The independent and dependent variables are reversed in the process of determining causality.

Common cause relationship

Both variables change as a result of a third common variable

Accidential relationship

The correlation between the two variables is based purely on coincidence.

Presumed relationship

Existed when a correlation does not seem to be accidential even though no cause and effect relationship or common cause is apparent

Extraneous variable

A variable is one that is not part of the correlation study but affects the way two variables in this study appear to be related. Such variable can lead to a false correlation or a fragmented trend.

4.7 Cofficient of Determination

4.7.1 Defintions

The **Correlation coefficient** (i.e the r value) is a measure of the linearity of the data. However, the coefficient of determination (R^2) is defined such that it applies on any type of relationships, linear or non-linear.

The coefficient of **determination** ranges for 0 to 1. It measures what percent of the variation of the dependent variables is due to the variation in the independent variable. It is the ratio of the explained variation to the total variation.

The equation of Cofficient of Determination

$$R^2 = \frac{\sum(y_{est} - \bar{y})^2}{n-1} : \frac{\sum(y - \bar{y})^2}{n-1} = \frac{\sum(y_{est} - \bar{y})^2}{\sum(y - \bar{y})^2} \tag{4.12}$$

y_{est} is the value estimated by the line/curve of best fit and y is the actual given y-value

4.8 Non-linear regression

4.8.1 Types of Regression

Linear

$$y = ax + b$$

You should use correlation coefficient r to measure the accuracy of regression

Quadratic

$$y = ax^2 + bx + c$$

You should use cofficient of Determination R^2 to measure the accuracy

Power

$$y = ax^b + c$$

You should use cofficient of Determination R^2 to measure the accuracy

Exponental

$$y = ab^x + c$$

You should use cofficient of Determination R^2 to measure the accuracy

4.8.2 Natural Constant e

Similar to π, e is an irrational number and its value is approximately 2.71.

The inverse of $f(x) = \mathrm{e}^x$ is $f^{-1}(x) = \ln x$
Some software use $f(x) = a\mathrm{e}^x + b$ as Exponential Regression