IT 507 Measurement & Evaluation in Industry & Tech
TECH 646 Analysis of Research in Industry & Technology

Lecture 1, Part 2

A Core Course for Purdue University M.S. in Technology Degree Program

Industrial Technology/Manufacturing

and

IT and Advanced Computer Applications Tracks

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Lecture note based on the text books:

Book 1: Montgomerry, D. C., and Runger, G. C., *Applied Statistics and Probability for Engineers* (6th Edition), Wiley, ISBN 978-1-118-53971-2

Book 2: Cooper, D.R., & Schindler, P.S., *Business Research Methods* (11th edition), 2011, McGraw-Hill/Irwin, ISBN 978-0-07-337370-6

IT 507
Lecture 1 – Part 2

Book 2: ***Applied Statistics and Probability for Engineers*****, 5th Edition, 2011, by D.C. Montgomery and G. C. Runger, from Wiley**

- **Chapter 1: The Roles of Statistics**
  - Engineering/Scientific Method
  - Reasoning Methods
  - An Example: Engineering Design with Comparison Experiments
- **Beginning Statistics**
- **Chapter 9. Tests of Hypothesis for a Single Sample**
- **Minitab 1.6 Related**

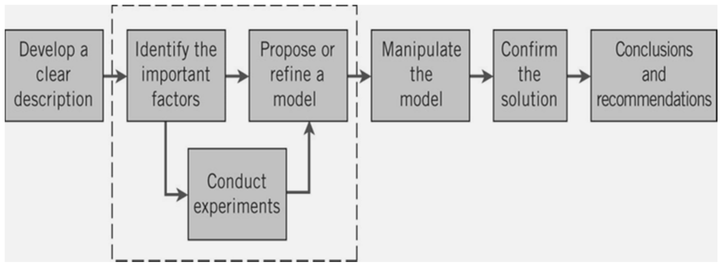
The Roles of Statistics

- Industry Technology research
- Business research
- Engineering
- Quality Control, Statistical Process Control: Manufacturing and Production
- Other Fields: Medical, Healthcare, etc.,

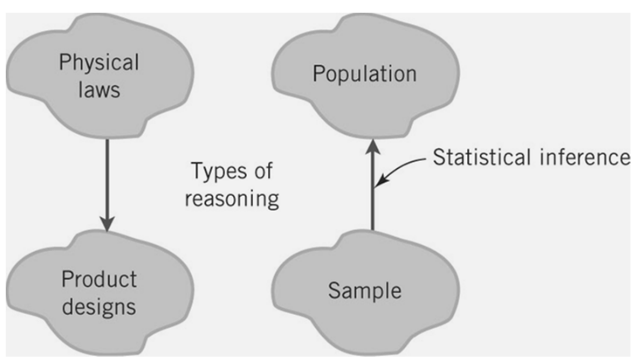
Engineering and Scientific Methods

1. **Develop a clear and concise description of the problem**
2. **Identify important factors**
3. **Propose a model, State any limitations or assumptions**
4. **Conduct experiments, Collect data to test or validate the tentative model**
5. **Refine the model based on the observed data**
6. **Manipulate/Refine the model**
7. **Conduct an appropriate experiment to confirm the proposed solution: Effective & Efficient**
8. **Draw Conclusions or Make Recommendation**

Engineering and Scientific Methods
(cont.)



Reasoning Methods



An Example: Engineering Design with a Comparison Experiment

Problem Statement – Variability, pp. 3-4 (Book 1)

- A Nylon connector, with minimum a pull-force of 12.75 pounds, to be housed in an automotive engine application is in the design phase. The design engineer asks for a design with a wall thickness of 2/32 inch and 8 prototypes for experiment. The pull-force measurement, in lb, is as follows: 12.6, 12.9, 13.4, 12.3, 13.6, 13.5, 12.6, 13.1.

An Example: Engineering Design with a Comparison Experiment

Problem Statement – Variability, pp. 3-4 (Book 1)

- A random variable X represent a measurement, which is represented using the model:

  $X = \mu + \varepsilon$

where μ is a constant and ε is a random disturbance.

The actual measurements X exhibit variability. We need to describe, quantify, and ultimately reduce variability.

An Example: Engineering Design with a Comparison Experiment

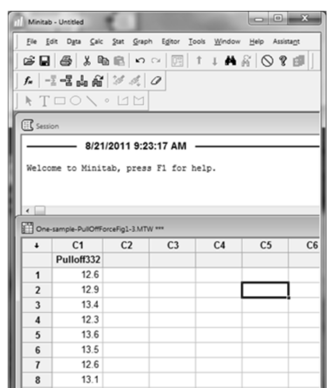
Problem Statement

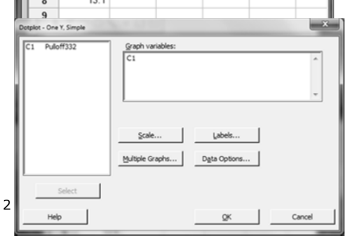
- **Wanting to know if the mean pull-off force of this 2/32-inch design exceeds the required maximum load of 12.75 lb to be encountered in it's expected application.**
- **Sample – 8 measurements of eight connectors**
- **Population – connectors that will be in the products that are sold to customers**

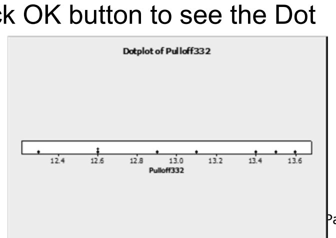
7 Step Process for Hypothesis Testing

6) Minitab 17: Enter 8 measured pull-force data

- Display Dot Plot diagram
  - Graph => Dotplot =>select One Y (Simple)
  - Click OK button to see the next dialog box
  - Enter C1 into the Graph Variable text box
  - Then click OK button to see the Dot Plot







Display Descriptive Statistics

Stat => Basic Statistics => Display Descriptive Statistics

- Mean $\bar{X}$ = 13.000, Standard Deviation σ or s = 0.478. μ_0 = 12.75, n =8

Descriptive Statistics: Pulloff332

Variable	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Pulloff332	8	13.000	0.478	12.300	12.600	13.000	13.475	13.600

7 Step Process for Hypothesis Testing (Reference - Chapter 9)

1) Parameter of interest: pull-off force
2) Null-hypothesis: H_0: μ = 12.75 pounds
3) Alternative Hypothesis: H_1: μ > 12.75 pounds; we want to reject H_0 if the mean pull-off force exceeds 12.75 pounds
4) Test statistics (t-statistics)
5) Reject H_0: if the P-value is less than α = 0.05

7 Step Process for Hypothesis Testing (Reference - Chapter 9)

6) Computation: (Minitab 17, 1-Sample t): Stat => Basic Statistics =>1 Sample t

- Variable C1
- Mean $\bar{X}$ = 13.000
- Standard Deviation σ or s = 0.478
- $\mu 0$ = 12.75 (Null hypothesis)
- n =8

- $t_0 = \frac{\bar{X}-\mu_0}{s/\sqrt{n}} = 1.48$

t-Distribution (Section 8-2.1, pp.283)

- **Let X1, X2, …, Xn be a random sample from a normal distribution with unknown mean μ and unknown variance σ^2. The random variable**

$$T = \frac{\bar{X} - \mu_0}{S/\sqrt{n}}$$

has a t distribution with n-1 degrees of freedom.

Minitab 17 – 1-Sample t

Minitab 17, 1-Sample t

StatGuide – One-Sample t (Summary)

The one-sample t-confidence interval and test procedures are used to make inferences about a population mean (μ), based on data from a random sample.

- **Suppose you have a sample of hole sizes from a drill press and you want to determine if the machine is drilling the correct size hole. Or, you may have a sample of pizza delivery times and wish to determine if you are beating your competitors advertised delivery time of 30 minutes.**

Minitab 17 – 1-Sample t

Minitab 17, 1-Sample t

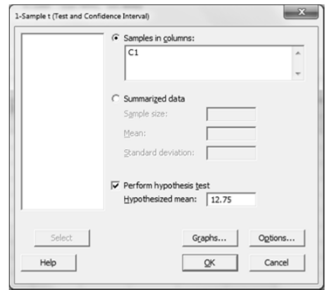
StatGuide – One-Sample t (Summary)

- **Use one-sample t-procedures when you do not know the standard deviation of the population (σ). If you know s, you can use the one-sample z-confidence interval and test procedures instead.**
- **To use the one-sample t-procedures, your sample should also be normally distributed . If your sample data do not appear to be normally distributed, you should consider using an appropriate nonparametric procedure .**

7 Step Process for Hypothesis Testing (Reference - Chapter 9)

6) Computation: (Minitab 17, 1-Sample t)

- Stat => Basic Statistics => 1 Sample t
- Enter C1 into the Sample in Column dialog box
- CHECK the Perform hypothesis test and enter 12.75 as Hypothesized mean, then click OK



One-Sample T: Pulloff332

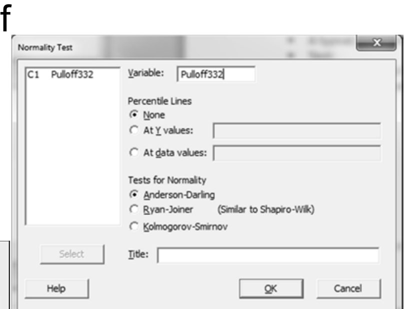
Test of mu = 12.75 vs > 12.75

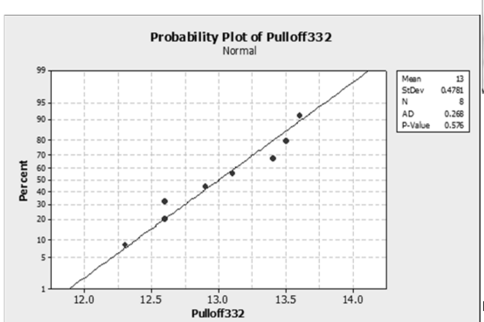
Variable	N	Mean	StDev	SE Mean	95% Lower Bound	T	P
Pulloff332	**8**	**13.000**	**0.478**	**0.169**	**12.680**	**1.48**	**0.091**

7 Step Process for Hypothesis Testing

6) Testing the Assumption of Normality (Minitab 17)

- Stat => Basic Statistics => Normality Test
- Enter the following setting, as shown, then click OK





7 Step Process for Hypothesis Testing

7) Conclusion (Ref. page 332-334, Book 1)

- From Appendix A Table V (page 745, for a t-distribution with 7 degrees of freedom (n -1=8-1), that $t_0 = 1.48$ falls between two values, 1.415 for which $\alpha = 0.1$, and 1.895, for which $\alpha = 0.05$.
- Because this is a one-tailed test, we know that the Probability value or P-value is between those two values, that is, $0.05 < P < 0.1$.
- Since $P = 0.091 > 0.05$, we do not have sufficient evidence to reject H_0 and conclude that the mean pull-off force does not exceed 12.75 pounds

Minitab – Glossary (Alpha α)

- **Used in hypothesis testing, alpha (a) is the maximum acceptable level of risk for rejecting a true null hypothesis (type I error) and is expressed as a probability ranging between 0 and 1. Alpha is frequently referred to as the level of significance. You should set a before beginning the analysis then compare p-values to a to determine significance:**
- **· If your p-value is less than or equal to the a-level, reject the null hypothesis in favor of the alternative hypothesis.**
- **· If your p-value is greater than the a-level, fail to reject the null hypothesis.**

Minitab – Glossary (Alpha α)

- The most commonly used a-level is 0.05. At this level, your chance of finding an effect that does not really exist is only 5%. The smaller the a value, the less likely you are to incorrectly reject the null hypothesis. However, a smaller value for a also means a decreased chance of detecting an effect if one truly exists (lower power).

Minitab – Glossary (p-value)

- Determines the appropriateness of rejecting the null hypothesis in a hypothesis test. P-values range from 0 to 1. The p-value is the probability of obtaining a test statistic that is at least as extreme as the calculated value if the null hypothesis is true. Before conducting any analyses, determine your alpha (a) level. A commonly used value is 0.05. If the p-value of a test statistic is less than your alpha, you reject the null hypothesis.

Minitab – Glossary (p-value)

- **Because of their fundamental role in hypothesis testing, p-values are used in many areas of statistics including basic statistics, linear models, reliability, and multivariate analysis among many others. The key is to understand what the null and alternative hypotheses represent in each test and then use the p-value to aid in your decision to reject the null.**