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Faculty Of Engineering & Technology

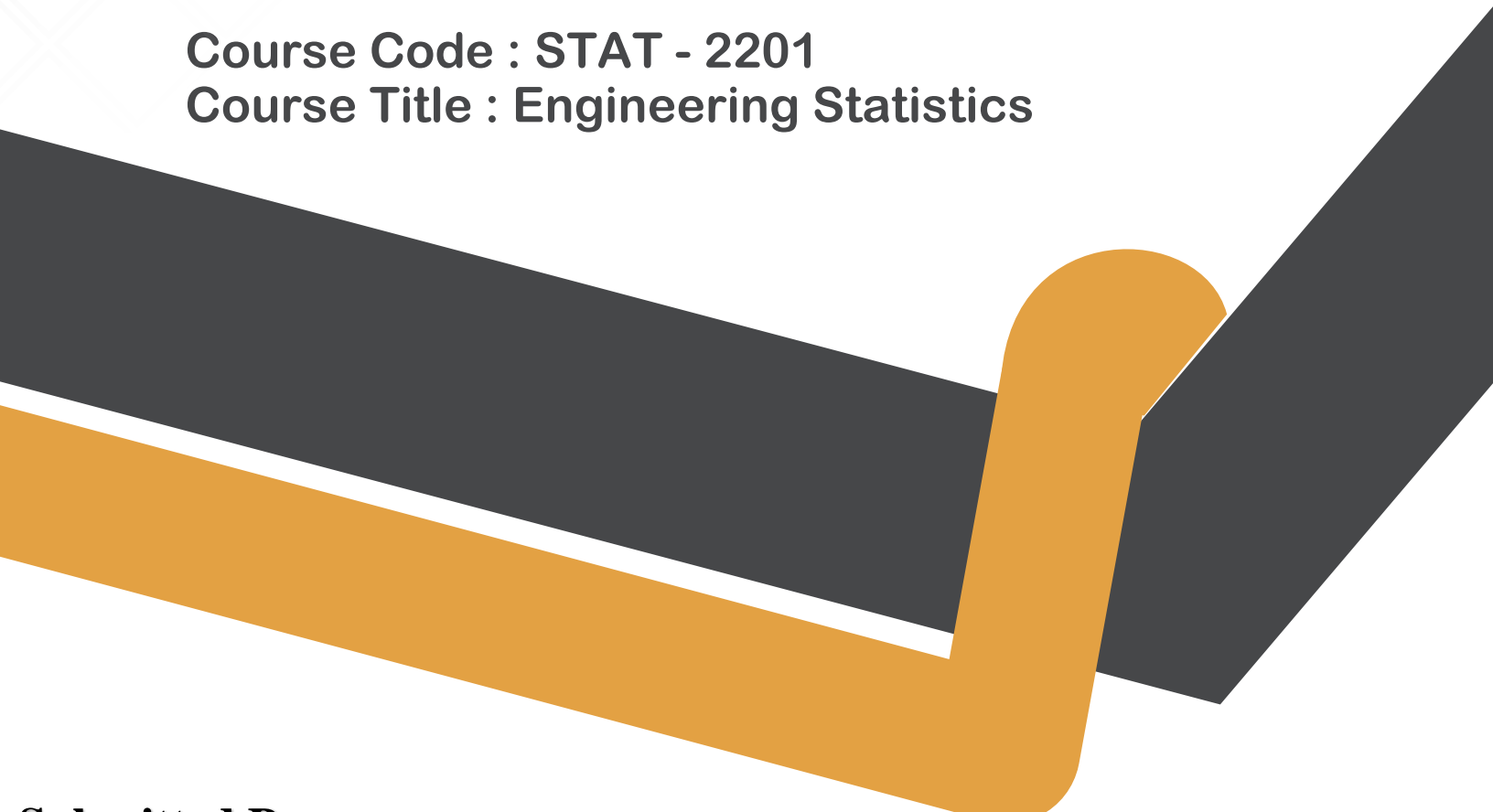
Department Of

Information And Communication Engineering

ASSIGNMENT TOPIC : Most Powerful Test , Standard Error

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Assignment Topic: Most Powerful Test and Standard Errors

Introduction:

In statistics, hypothesis testing plays a crucial role in decision-making under uncertainty. Among the many tests used to evaluate hypotheses, the concept of the **Most Powerful Test** stands out as a standard for choosing the best test under a given significance level. At the same time, understanding **Standard Errors** is essential for interpreting the reliability of estimates and test results. Together, these concepts form the backbone of sound statistical inference, influencing conclusions in research, data analysis, and evidence-based decision-making.

Objective:

The main objectives of this assignment are:

1. To explain the concept and importance of the **Most Powerful Test** in hypothesis testing.
2. To define and interpret **Standard Errors** and their role in statistical estimation.
3. To highlight the connection between these concepts and their relevance in practical data analysis.

I. Most Powerful Test

Definition:

A **Most Powerful Test** is a hypothesis test that maximizes the probability of rejecting the null hypothesis H_0 when a specific alternative hypothesis H_1 is true, for a given significance level α . In other words, it's the test with the greatest **statistical power**.

Key Terms:

- **Significance Level (α)**: Probability of rejecting H_0 when it is true (Type I Error).
- **Power ($1 - \beta$)**: Probability of correctly rejecting H_0 when H_1 is true.
- **Type II Error (β)**: Failing to reject H_0 when H_1 is true.

Theoretical Foundation:

- **Neyman-Pearson Lemma:**
 - Applies when both hypotheses are **simple** (i.e., specific parameter values).
 - States that the **Likelihood Ratio Test (LRT)** provides the most powerful test for testing:

$$H_0 : \theta = \theta_0 \text{ vs } H_1 : \theta = \theta_1$$

- The test rejects H_0 if:

$$\frac{L(\theta_1|x)}{L(\theta_0|x)} > K$$

for some constant k , where L is the likelihood function.

Use Case Example:

Suppose a pharmaceutical company wants to test a new drug. The null hypothesis is that the drug has no effect ($\mu = \mu_0$), and the alternative is that the drug improves recovery time ($\mu = \mu_1$). A most powerful test ensures the best chance of detecting a real effect, minimizing missed discoveries.

Why It Matters:

- Helps in choosing the best test under constraints.
- Maximizes the ability to detect real-world effects.
- Essential in high-stakes testing scenarios (medicine, engineering, quality control).

II. Standard Errors

Definition:

The **Standard Error (SE)** is the standard deviation of a sampling distribution. It quantifies how much a sample statistic (like the mean) would vary from sample to sample.

Key Terms:

- **Sample Mean (\bar{x}):** Average of observed data.
- **Population Standard Deviation (σ)**
- **Sample Size (nnn)**

Formulas :

- Standard Error of the Mean :

$$SE\bar{x} = \frac{\sigma}{\sqrt{n}}$$

- If σ unknown and s (sample SD) is used :

$$SE\bar{x} = \frac{s}{\sqrt{n}}$$

Use Case Example:

In survey research, SE helps estimate the reliability of a sample mean. A smaller SE means the mean is likely close to the true population mean.

Applications:

- Constructing **confidence intervals**.
- Calculating **test statistics** (z-scores, t-scores).
- Evaluating the precision of estimates in regression and inferential statistics.

Common Confusion:

- **Standard Deviation vs. Standard Error:**

- SD measures variability in data.
- SE measures variability in a statistic across samples.

Connection Between the Two:

- **Standard Errors** are used in calculating test statistics, which are essential in constructing **powerful tests**.
- Lower SE → tighter confidence intervals → more accurate test decisions → higher power.
- Proper understanding of SE helps in designing tests that approach **most powerful** criteria, especially in real-world testing with complex or composite hypotheses.

Conclusion

The concepts of the Most Powerful Test and Standard Errors are fundamental to performing reliable statistical analysis. The Most Powerful Test ensures that the chosen hypothesis test has the best chance of detecting a true effect, while the Standard Error quantifies the precision of estimates. Together, they strengthen the credibility of statistical findings and support informed decision-making based on data.