STAT-2201: Engineering Statistics

Course Outline

1. a	What is a sampling distribution, and why is it important in statistics?
1. b	Differentiate between a sampling distribution and a parent distribution.
1. c	Define the chi-square distribution and explain how it is derived from standard normal variables.
1. d	What are the properties of the chi-square distribution? List at least five.
1. e	How does the chi-square distribution behave as the degrees of freedom increase?
1. f	How is the chi-square distribution used to test the goodness of fit?
1. g	Derive the moment generating function (MGF) of the chi-square distribution.
1. h	Using the MGF, find the mean and variance of the chi-square distribution.
1. i	Maths based on Chi square distribution
2. a	Define the Student's t-distribution and explain how it is derived.
2. b	What are the key properties of the t-distribution? List at least four.
2. c	How is the t-distribution used to test the significance of a sample mean?
2. d	Derive the first four moments of the t-distribution.
2. e	Define the F-distribution and explain how it is derived from two independent chi-square variables.
2. f	How is the F-distribution used to test the equality of population variances?
2. g	Explain how the t-distribution converges to a normal distribution as the degrees of freedom increase.
2. h	Maths based on T-distribution
2. i	Maths based on F-distribution
3. a	Define: random sample, population, sample, parameter, statistic
3. b	Explain the criteria of good estimator.
3. c	State and prove the Cramer-Rao Lower Bound theorem.
3. d	Find the minimum variance bound unbiased estimator.
3. e	For Bernoulli distribution, find MVBUE of θ.
3. f	if $X \sim N(\mu, \sigma^2)$, then find the MVBUE of μ.
3. g	if $X \sim N(\mu, \sigma^2)$, then find the MVBUE of σ^2 .
3. h	Establish the method of finding MVB for an unbiased estimator intended to estimate function of a parameter.
3. i	Define with terms: Estimation, Estimator and Estimate. Show that sample mean is unbiased estimate of the population mean.
4. a	Define maximum likelihood estimator with an example.
4. b	Write down the properties of MLE.
4. c	Is MLE always unbiased? Distinguish between joint density function and likelihood function.
4. d	State and prove the invariance property.
4. e	Show that at the same point of value of $L(\theta)$ and $\log L(\theta)$ are equal.
4. f	State and prove the limiting distribution property of MLE.
4. g	Show that by an example, the property of unbiasedness not in general property of MLE.
4. h	Let $x_1, x_2 \dots \dots x_n$ be a random sample from the exponential distribution with pdf $f(x) = \theta e^{-\theta x}; x \geq 0,\ \theta \geq 0$ (i) Find the MLE of θ

	(ii) Show that MLE of θ is unbiased, sufficient and consistent estimator.
4. i	Let $x_{1,}x_2 \dots \dots x_n$ be a random sample from the exponential distribution with pdf $f(\mathrm{x};\theta) = \frac{e^{-\theta}\theta^x}{x!}; x \geq 0,\ \theta \geq 0$ (iii) Find the MLE of θ Show that MLE of θ is unbiased, sufficient and consistent estimator.

5. a	Explain the concept of hypothesis testing and its importance in statistical analysis.
5. b	What are Type I and Type II errors in hypothesis testing? How are they related to the level of significance (α) and the power of the test?
5. c	List the applications of test statistics.
5. d	Explain the steps in hypothesis testing.
5. e	What is the difference between a one-tailed and a two-tailed test? When would you use each?
5. f	What is the p-value and critical value, and how are these interpreted in hypothesis testing?
5. g	Explain the concept of the critical region and acceptance region in hypothesis testing. How is it determined?
5. h	Example: 16.6.1, 16.6.2, 16.6.3
5. i	Example: 16.6.4, 16.6.5, 16.6.6
6. a	Explain the hypothesis testing for single pollution mean.
6. b	Describe steps of mean test when variance unknown and sample size it small (n < 30).
6. c	What do you mean by Z-test? Mention the applications of it.
6. d	What is test of hypothesis concerning attributes? Discuss test procedure of a hypothesis about proportion test of a population.
6. e	What is the $\chi 2$ test, and what are its applications in hypothesis testing?
6. f	What is the role of the test statistic in hypothesis testing? How is it used to make decisions about the null hypothesis?
6. g	Explain the test of hypothesis about difference between two population proportions.
6. h	Example: 16.6.9, 16.6.10, 16.6.11
6. i	Example: 16.6.12, 16.6.13, 16.6.14
7. a	What are non-parametric tests, and how do they differ from parametric tests?
7. b	List the advantages and disadvantages of using non-parametric tests.
7. c	What types of data are suitable for non-parametric tests?
7. d	What is the Runs Test for Randomness, and how is it used to determine whether a sample is random?
7. e	Explain the Sign Test and its application as a non-parametric alternative to the one-sample t-test.
7. f	Describe the Wilcoxon Signed Ranks Test and explain how it improves upon the Sign Test.
7. g	Example 1, 2, 3
7. h	Example 4, 5, 6
7. i	Example 7, 8
8. a	What is the Paired Sample Sign Test, and when should it be used?
8. b	What is the Mann-Whitney U-test, and when is it used as an alternative to the two-sample t-test?
8. c	How does the Siegel-Tukey Test determine whether two populations have equal variability?
8. d	What is the Kruskal-Wallis H-Test, and how does it serve as a non-parametric alternative to ANOVA?
8. e	Explain the Friedman Test and describe its use in analyzing data from related samples.
8. f	What is the Median Test, and how is it used to compare multiple samples?
8. g	Exercise 1, 2, 3
8. h	Exercise 4, 5, 6
8. i	Exercise 7, 9