



# AIML ZC418 Course Handout

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Probability and Statistics (Birla Institute of Technology and Science, Pilani)



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## **BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI WORK INTEGRATED LEARNING PROGRAMMES**

First Semester 2025-2026

Part A: Content Design

<b>Course Title</b>	<b>Introduction to Statistical Methods</b>
<b>Course No(s)</b>	AIML ZC418
<b>Credit Units</b>	4
<b>Credit Model</b>	3 – 1 - 0
<b>Content Authors</b>	Dr YVK Ravi Kumar
<b>Date</b>	February ,2025

### **Course Description**

Basic probability concepts, Conditional probability, Bayes Theorem, Probability distributions, Continuous and discrete distributions, Transformation of random variables, estimating mean, variance, covariance, Hypothesis Testing, Maximum likelihood, ANOVA – single factor, dual factor, time series analysis: AR, MA, ARIMA, SARIMA, sampling based on distribution, statistical significance, Gaussian Mixture Model, Expectation Maximization.
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### **Course Objectives**

<b>CO1</b>	Introducing basic concepts of probability and statistics to students
<b>CO2</b>	Students will be able to apply statistical techniques to understand the data
<b>CO3</b>	Students will be able to do statistical analysis of the model / algorithm

### **Text Books**

No	Author(s), Title, Edition, Publishing House
T1	Statistics for Data Scientists, An introduction to probability ,statistics and Data Analysis,MauritsKaptein et al, Springer 2022
T2	Probability and Statistics for Engineering and Sciences,8 <sup>th</sup> Edition, Jay L Devore, Cengage Learning
T3	Introduction to Time Series and Forecasting, Second Edition, Peter J Brockwell, Richard A Davis, Springer.

### **Reference Books**

No	Author(s), Title, Edition, Publishing House
R1	Miller and Freund's Probability and statistics for Engineers, 8 <sup>th</sup> Edition, PHI
R2	Statistics for Business and Economics by Anderson, Sweeney and Williams, CENAGE learning

### **Modular Content Structure**

#### **1. Basic Probability & Statistics**



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1.1. Measures of Central Tendency

1.2. Measures of Variability

1.3. Basic Probability concepts

1.3.1. Axioms of Probability

1.3.2. Definition of Probability

1.3.3. Mutually exclusive and independent events

**2. Conditional Probability & Bayes theorem**

2.1. Conditional Probability

2.2. Conditional Probability of Independent events

2.3. Bayes Theorem

2.4. Introduction to Naïve Bayes concept

**3. Probability Distributions**

3.1. Random Variables

3.1.1. Discrete random variable – Single and two variables

3.1.2. Discrete random variable – Single and two variables

3.1.3. Mean, Variance, Co – Variance of Random variables

3.1.3. Transformation of random variables

3.2. Probability Distributions

3.2.1. Bernoulli Distribution

3.2.2. Binomial Distribution

3.2.3. Poisson Distribution

3.2.4. Normal(Gaussian) distribution

3.2.5. Introduction of t – distribution , F – distribution , Chi Square distribution.

**4. Hypothesis Testing**

4.1. Sampling – random sampling and Stratified sampling

4.2. Sampling distribution – Central Limit theorem

4.3. Estimation – Interval Estimation, Confidence level

4.4. Testing of Hypothesis

4.4.1. Mean based

4.4.2. Proportions related

4.4.3. ANOVA – Single and dual factor

4.5. Maximum likelihood

**5. Prediction & Forecasting**

5.1. Correlation

5.2. Regression

5.3. Time Series Analysis

5.3.1. Introduction, Components of time series data

5.3.2. MA model – basic and weighted MA model

5.3.3. Time series models

5.3.3.1. AR Model

5.3.3.2. ARIMA Model

5.3.3.3. SARIMA, SARIMAX, VAR, VARMAX

5.3.3.4. Simple exponential smoothing model

**6. Gaussian Mixture model & Expectation Maximization**

**Learning Outcomes:**

No	Learning Outcomes



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<b>LO1</b>	Clear understanding of the various statistical models to model the data
<b>LO2</b>	Drawing conclusions from the models selected to understand the data

### Part B: Learning Plan

Contact Session	List of Topic Title	Sub-Topics	Reference
1	<b>Basic Probability &amp; Statistics</b>	<ul style="list-style-type: none"> <li>• Measures of Central Tendency</li> <li>• Measures of Variability</li> <li>• Data – Symmetric &amp; Asymmetric outlier detection</li> <li>• 5 point summary</li> <li>• Introduction to probability</li> </ul>	T1 & T2
2	<b>Basic Probability &amp; Statistics</b>	<ul style="list-style-type: none"> <li>• Axioms of Probability</li> <li>• Mutually exclusive and independent events,</li> <li>• Problem solving to understand basic probability concepts</li> </ul>	T1 & T2
3	<b>Conditional Probability &amp; Bayes theorem</b>	<ul style="list-style-type: none"> <li>• Introduction to conditional probability</li> <li>• Independent events</li> <li>• Total probability</li> </ul>	T1 & T2
4	<b>Conditional Probability &amp; Bayes theorem</b>	<ul style="list-style-type: none"> <li>• Bayes theorem(with proof),</li> <li>• Introduction to Naïve Bayes concept.</li> <li>• Problems on Naïve Bayes theorem</li> </ul>	T1 & T2 and online material
5	<b>Probability Distributions</b>	<ul style="list-style-type: none"> <li>• Random variables - Discrete &amp; continuous</li> <li>• Expectation of a random variable</li> <li>• mean and variance of a random variable</li> <li>• Single random variable</li> <li>• Joint distributions</li> </ul>	T1 & T2
6	<b>Probability Distributions</b>	<ul style="list-style-type: none"> <li>• Bernoulli distribution</li> <li>• Binomial distribution</li> <li>• Poisson distribution</li> <li>• Normal distribution</li> <li>• t – distribution</li> <li>• F – Distribution</li> <li>• Chi Square distribution</li> </ul>	T1 & T2
7	<b>Hypothesis Testing</b>	<ul style="list-style-type: none"> <li>• Sampling – random sampling</li> <li>• Stratified sampling</li> <li>• Sampling distribution</li> <li>• Central Limit theorem</li> <li>• Estimation– Interval Estimation</li> <li>• Confidence level</li> </ul>	T1 & T2
8	<b>Review</b>	<ul style="list-style-type: none"> <li>• Review of contact session 1 to 7</li> </ul>	
9	<b>Hypothesis Testing</b>	<ul style="list-style-type: none"> <li>• Testing of Hypothesis</li> <li>• mean and proportions related models <ul style="list-style-type: none"> <li>◦ one mean – small and big sample</li> <li>◦ two mean – small and big sample</li> <li>◦ one proportion – small and big sample</li> </ul> </li> </ul>	T1 & T2



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		<ul style="list-style-type: none"> <li>○ Several proportions</li> </ul>	
10	<b>Hypothesis Testing</b>	<ul style="list-style-type: none"> <li>• Maximum likelihood</li> <li>• ANOVA – Single and dual factor</li> </ul>	T1 & T2
11	<b>Prediction &amp; Forecasting</b>	<ul style="list-style-type: none"> <li>• Correlation</li> <li>• Regression</li> </ul>	T1 & T2
12	<b>Prediction &amp; Forecasting</b>	<ul style="list-style-type: none"> <li>• Time Series Analysis           <ul style="list-style-type: none"> <li>○ Introduction</li> <li>○ Components of time series data</li> <li>○ Moving Averages</li> <li>○ weighted moving averages model</li> </ul> </li> </ul>	T3
13	<b>Prediction &amp; Forecasting</b>	<ul style="list-style-type: none"> <li>• Time series models           <ul style="list-style-type: none"> <li>○ AR Model</li> <li>○ ARMA Model</li> <li>○ ARIMA</li> </ul> </li> </ul>	T3
14	<b>Prediction &amp; Forecasting</b>	<ul style="list-style-type: none"> <li>• Time Series Models           <ul style="list-style-type: none"> <li>○ SARIMA</li> <li>○ SARIMAX</li> <li>○ VAR</li> <li>○ VARMAX</li> <li>○ Simple exponential smoothing model.</li> </ul> </li> </ul>	T3
15	<b>GM Model &amp; EM</b>	<ul style="list-style-type: none"> <li>• Gaussian Mixture model</li> <li>• Expectation Maximization</li> </ul>	
16	<b>Review</b>	Review of contact session 9 to 15	

### **Experiential Learning Components:**

Describe objective, outcome of Experiential Learning Component and the lab infrastructure needed (virtual, remote, open source etc...) number of lab exercises needed, etc.

1. Lab work: 6
2. Project work: 0
3. Case Study: 4 Webinars
4. Simulation: 0
5. Work Integrated Learning Assignment- 2 Assignments
6. Design work/ Field work: 0

### **Objective of Experiential Learning Component:**

Hands on sessions on implementation of statistics components in understanding data.

### **Scope of Experiential Learning Component:**

Programming language - Python

### **Lab Infrastructure:**

Online/ Open source/Google Colab

### **List of Experiments:**

Lab No.	Lab Objective	Session Reference
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1	Display of statistical Data& Understanding the statistical summary	1
2	Bayes theorem & Naïve Bayes Concept	4
3	Probability Distributions& Sampling	5 & 6
4	ANOVA	10
5	Regression – Analysis of model summary	11
6	Time series	12 - 14

### **Evaluation Scheme:**

**Legend:** EC = Evaluation Component; AN = After Noon Session; FN = Fore Noon Session

Evaluation Component	Name (Quiz, Lab, Project, Mid-term exam, End semester exam, etc.)	Type (Open book, Closed book, Online, etc.)	Weight	Duration	Day, Date, Session, Time
EC – 1*	Quiz 1 & 2	Online	10%	1 week	September 01-10, 2025
	Assignment/Lab Assignment / Lab Exams	Online	20 %	10 days	November 01-10, 2025
EC - 2	Mid-Semester Test	Closed Book	30%	2 hours	20/09/2025 (AN)
EC - 3	Comprehensive Exam	Open Book	40%	2 ½ Hours	29/11/2025 (AN)

EC1\* (20% - 30%): Quiz (optional): 5-10 %, Lab Assignment/Assignment: 20% - 30%

Syllabus for Mid-Semester Test (Closed Book): Topics in Contact session: 1 to 8

Syllabus for Comprehensive Exam (Open Book): All topics

### **Important Links and Information:**

**eLearn Portal:** <https://elearn.bits-pilani.ac.in>

Students must visit the eLearn portal regularly and stay updated with the latest announcements and deadlines.

**Contact Sessions:** Students should attend the online lectures as per the schedule provided on the eLearn portal.

### **Evaluation Guidelines:**

1. EC-1 consists of either two Assignments or three Quizzes. Students will attempt them through the course pages on the eLearn portal. Announcements will be made on the portal in a timely manner.
2. For Closed Book tests: No books or reference material of any kind will be permitted.
3. For Open Book exams: “open book” means text/ reference books (publisher copy only) and does not include any other learning material. No other learning material will be permitted during the open book examinations. For Detailed Guidelines refer to the attached document.  
[EC3 Guidelines](#)
4. If a student is unable to appear for the Regular Test/Exam due to genuine exigencies, the student should follow the procedure to apply for the Make-Up Test/Exam, which will be made available on the eLearn portal. The Make-Up Test/Exam will be conducted only at selected exam centres on the dates to be announced later.

It shall be the responsibility of the individual student to be regular in maintaining the self-study schedule as given in the course handout, attend the online lectures, and take all the prescribed evaluation components such as Assignments/Quizzes, Mid-Semester Tests and Comprehensive Exams according to the evaluation scheme provided in the handout.



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