OPERATING SYSTEM

Course Code : 315319

Programme Name/s	**: Artificial Intelligence/ Artificial Intelligence and Machine Learning/ Cloud Computing and Big Data/ Computer Technology/ Computer Engineering/ Computer Science & Engineering/ Data Sciences/ Computer Hardware & Maintenance/ Information Technology/ Computer Science & Information Technology/ Computer Science**
Programme Code	**: AI/ AN/ BD/ CM/ CO/ CW/ DS/ HA/ IF/ IH/ SE**
Semester	**: Fifth**
Course Title	**: OPERATING SYSTEM**
Course Code	**: 315319**

I. RATIONALE

An Operating System is to manage a Computer Hardware and software resources efficiently and provide user friendly environment. An Operating System is a System Program that controls the execution of application program and acts as an interface between applications and the computer hardware. It also place a curtail role in maintaining system security, protecting data and ensuring that processes do not interfere with one another. This course enables to learn internal functioning of Operating System and will help in identifying appropriate Operating System for given Application/Task.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Interpret features of Operating System.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Explain the services and components of an Operating System.
- CO2 - Describe the different aspects of Process Management in an Operating System.
- CO3 - Implement various CPU Scheduling algorithms and evaluate their effectiveness.
- CO4 - Analyze the Memory Management techniques used by an Operating System.
- CO5 - Apply techniques for effective File Management in an Operating System.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme Actual Contact Hrs./Week CL	TL	LL	SLH	NLH	Credits	Paper Duration	Assessment Scheme Theory FA-TH Max	SA-TH Max	Total Max	Min	Based on LL & TL Practical FA-PR Max	Min	SA-PR Max	Min	Based on SL SLA Max	Min	Total Marks
315319	OPERATING SYSTEM	OSY	DSC	5	-	2	2	9	3	3	30	70	100	40	25	10	25@	10	25	10	175

OPERATING SYSTEM **Course Code : 315319**

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe functions of an Operating System. TLO 1.2 Explain different services of Operating System. TLO 1.3 Explain use of system call of Operating System. TLO 1.4 Explain activities of Operating System in concern with their components.	**Unit - I Operating System services and components** 1.1 Operating System: concept, functions 1.2 Different types of Operating System: Batch Operating System, Multi-programmed, Time Shared Operating System, Multiprocessor System, Distributed System, Real Time System, Mobile OS (Android OS) 1.3 Command line based Operating System: DOS, UNIX GUI based Operating System: WINDOWS, LINUX, MaC OS 1.4 Different Services of Operating System, System Calls: Concept, types of system calls 1.5 Operating System Components: Process Management, Main Memory Management, File Management, IO Management, Secondary Storage Management	Presentations Lecture Using Chalk-Board
2	TLO 2.1 Explain the different states of a process. TLO 2.2 Describe the functions of different component of process stack in PCB (Process Control Block). TLO 2.3 Explain multiple processes access shared resources without interfering each other. TLO 2.4 Compare Multithreading models.	**Unit - II Process Management** 2.1 Processes: process state, process control block 2.2 Process Scheduling: scheduling queues, types of schedulers, context switch 2.3 Inter Process Communication: Shared memory system, Message passing system 2.4 Threads: Benefits, User and Kernel level threads, Multithreading Models: One to One, Many to One, Many to Many 2.5 Execute process commands like: top, ps, kill, wait, sleep, exit, nice	Lecture Using Chalk-Board Presentations

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Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
3	TLO 3.1 Justify the need of given scheduling criteria with relevant example. TLO 3.2 Explain with example the procedure of allocating CPU to the given process. TLO 3.3 Calculate turnaround time and average waiting time of the given scheduling algorithm. TLO 3.4 Explain functioning of the given necessary conditions leading to Deadlock.	**Unit - III CPU Scheduling** 3.1 Scheduling: Basic concept, CPU and I/O burst cycle 3.2 Preemptive and Non-preemptive scheduling, scheduling criteria 3.3 Types of Scheduling algorithms: First Come First Serve(FCFS), Shortest Job First (SJF), Shortest Remaining Time Next (SRTN), Round Robin (RR), Priority Scheduling, Multilevel Queue Scheduling 3.4 Deadlock: System Models, Necessary conditions Leading to Deadlock, Deadlock Handling: Deadlock prevention, Deadlock avoidance- Banker's Algorithm	Presentations Lecture Using Chalk-Board
4	TLO 4.1 Compare fixed and variable memory partitioning. TLO 4.2 Differentiate between Bit map and Linked list technique. TLO 4.3 Explain working of various partitioning algorithm. TLO 4.4 Calculate page fault for given page reference string.	**Unit - IV Memory Management** 4.1 Basic Memory Management: Partitioning - Fixed and Variable, Free Space Management Techniques: Bit map, Linked List 4.2 Swapping, Compaction, Fragmentation, Partitioning Algorithms: First fit, Best fit, Worst fit 4.3 Non-contiguous Memory Management Techniques: Paging, Segmentation 4.4 Virtual Memory: Basics, Demand paging, Page Fault 4.5 Page Replacement Algorithm: First In First Out (FIFO), Least Recently Used (LRU), Optimal	Lecture Using Chalk-Board Presentations Video Demonstrations
5	TLO 5.1 Explain structure of the given file system with example. TLO 5.2 Describe mechanism of file access method. TLO 5.3 Explain procedure to create access directories and assign the given file access permissions.	**Unit - V File Management** 5.1 File Concepts: Attributes, Operations, File types and File system structure 5.2 Accessing Methods: Sequential, Direct 5.3 File Allocation Methods: Contiguous allocation, Linked allocation, Indexed allocation 5.4 Directory Structure: Single level, Two level, Tree structured Directory	Presentations Lecture Using Chalk-Board

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Execute the system call commands.	1	* System call commands in Linux such as fork(), exec(), getpid, pipe, exit, open, close, stat, uname.	2	CO1
LLO 2.1 Execute process related commands.	2	* Process related commands in Linux - top, ps, kill, wait, sleep, nice, renice,bg,fg.	2	CO2
LLO 3.1 Execute message passing and shared memory commands.	3	* a. Commands for Sending Messages to Logged-in Users -who, cat, wall, write, mesg. * b. List Processes Attached to a Shared Memory Segment: ipcs.	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Implement First Come First Serve (FCFS) Scheduling algorithm.	4	* Write a C/Python program to calculate average waiting time and Turnaround Time of n processes with First Come First Serve (FCFS) CPU scheduling algorithm.	2	CO3
LLO 5.1 Implement Shortest Job First (SJF) Scheduling algorithm.	5	Write a C/Python program to calculate average waiting time and Turnaround Time of n processes with Shortest Job First (SJF) CPU scheduling algorit hm.	2	CO3
LLO 6.1 Implement Priority Scheduling algorithm.	6	Write a C/Python program to calculate average waiting time and Turnaround Time of n processes with Priority CPU scheduling algorithm.	2	CO3
LLO 7.1 Implement Round Robin (RR) Scheduling algorithm.	7	Write a C/Python program to calculate average waiting time and Turnaround Time of n processes with Round Robin (RR) CPU scheduling algorithm.	2	CO3
LLO 8.1 Implement Banker's algorithm for deadlock avoidance.	8	Write a C/Python program to implement Banker's Algorithm.	2	CO3
LLO 9.1 Execute memory management commands.	9	Basic memory management commands - df, free, vmstat, /proc/meminfo, htop.	2	CO4
LLO 10.1 Implement First In First Out (FIFO) Page Replacement algorithm .	10	* Write a C/Python program on First In First Out (FIFO) Page Replacement algorithm.	2	CO4
LLO 11.1 Implement Least Recently Used (LRU) Page Replacement algorithm.	11	Write a C/Python program on Least Recently Used (LRU) Page Replacement algorithm.	2	CO4
LLO 12.1 Implement sequential file allocation method.	12	* Write a C/Python program on sequential file allocation method.	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Assignment

- Find out the total number of page faults using – i) First In First Out ii) Least recently used page replacement ii) Optimal page replacement Page replacement algorithms of memory management, if the page are coming in the order 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
- Compare between CLI based Operating System and GUI based Operating System.
- Differentiate between process and thread (any two points). Also discuss the benefits of multithreaded programming.
- Enlist different file allocation methods? Explain contiguous and indexed allocation method in detail.

Micro project

- Create a report depicting features of different types of operating systems- Batch operating system, Multi programmed, Time shared, Multiprocessor systems, Real time systems, Mobile OS with examples.
- Implement and Compare Memory Allocation Strategies - First Fit, Best Fit, Worst Fit

OPERATING SYSTEM   **Course Code : 315319**

- Create a report on different operating system tools used to perform various functions.

Self learning

- Complete any one course related to the operating system on MOOCS such as NPTEL, Coursera, Infosys Springboard etc.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Computer system with basic configuration. Linux or alike operating system such as Ubuntu, CentOS or any other.	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Operating System services and components	CO1	10	2	8	4	14
2	II	Process Management	CO2	10	4	4	6	14
3	III	CPU Scheduling	CO3	10	2	6	8	16
4	IV	Memory Management	CO4	12	2	6	8	16
5	V	File Management	CO5	8	2	4	4	10
		Grand Total		**50**	**12**	**28**	**30**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Continuous assessment based on process and product related performance indicators. Each practical will be assessed considering 1) 60% weightage is to process 2) 40% weightage to product

Summative Assessment (Assessment of Learning)

- End Semester Examination, Lab Performance, Viva-voce

XI. SUGGESTED COS - POS MATRIX FORM

MSBTE Approval Dt. 24/02/2025   **Semester - 5, K Scheme**

OPERATING SYSTEM   **Course Code : 315319**

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	-	-	2	-	-	1			
CO2	1	-	-	2	1	-	-			
CO3	1	1	1	2	1	-	-			
CO4	2	2	2	2	1	-	2			
CO5	2	2	2	2	1	-	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII.   SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Dhananjay M. Dhamdhere	Operating System: A Concept-Based Approach	McGraw Hill Education 3rd edition, ISBN: 978-1259005589
2	William Stallings	Operating Systems : Internals and Design Principles	Pearson Education 9th Edition, ISBN: 978-9352866717
3	Richard Petersen	Linux The Complete Reference	McGraw Hill, 6th edition, ISBN: 978-0071492478
4	Richard Blum	Linux command line and shell scripting	Wiley India, ISBN: 978-1118983843
5	Abraham Silberschatz and James Peterson	Operating System Concepts	Wiley India, ISBN: 9781119454083

XIII .   LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://archive.nptel.ac.in/courses/106/105/106105214/	Introduction to Operating System
2	https://www.geeksforgeeks.org/processes-in-linuxunix/	Process Related commands
3	https://ubuntu.com/download/desktop	Installation of Ubuntu
4	https://developers.redhat.com/products/rhel/download	RedHat Linux download
5	https://www.digitalocean.com/community/tutorials/linux-commands	Basic Linux commands
6	https://www.geeksforgeeks.org/what-is-an-operating-system/	Operating System

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

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MSBTE Approval Dt. 24/02/2025   **Semester - 5, K Scheme**

DATA ANALYTICS   **Course Code : 315326**

Programme Name/s	**: Computer Technology/ Computer Engineering/ Computer Science & Engineering/ Information Technology/ Computer Science & Information Technology/ Computer Science/ Electronics & Computer Engg.**
Programme Code	**: CM/ CO/ CW/ IF/ IH/ SE/ TE**
Semester	**: Fifth**
Course Title	**: DATA ANALYTICS**
Course Code	**: 315326**

I. RATIONALE

Data Analytics uses statistical and computational methods to analyze data, aiding informed decision-making. Excel dashboards effectively present vital data at a glance, enhancing user interactivity. A Data Analyst collects, cleans, and visualizes Datasets to solve problems.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Perform Data Analytics in various business domains for improved decision making

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Elaborate the fundamental concepts of Data Analytics.
- CO2 - Apply appropriate statistical techniques to analyze and interpret complex Datasets.
- CO3 - Analyze numerical data by creating pivot table.
- CO4 - Represent data in terms of various types of charts.
- CO5 - Visualize the data using a Python library.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme											Total Marks
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315326	DATA ANALYTICS	DAN	DSE	4	-	2	-	6	2	3	30	70	100	40	25	10	25#	10	-	-	150

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment

Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination

Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

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DATA ANALYTICS   **Course Code : 315326**

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Describe the importance of data analytics. TLO 1.2 Differentiate between types of data analytics. TLO 1.3 Describe the quality and quantity of data. TLO 1.4 Measures the central tendency of given dataset. TLO 1.5 Use various sampling techniques.	**Unit - I Introduction to Data Analytics** 1.1 Data Analytics: An Overview, Importance of Data Analytics 1.2 Types of Data Analytics: Descriptive Analysis, Diagnostic Analysis, Predictive Analysis, Prescriptive Analysis, Visual Analytics 1.3 Life cycle of Data Analytics, Quality and Quantity of data, Measurement 1.4 Data Types, Measure of central tendency, Measures of dispersion 1.5 Sampling Funnel, Central Limit Theorem, Confidence Interval, Sampling Variation	Presentations Lecture Using Chalk-Board Case Study
2	TLO 2.1 Create a box plot of the test scores and interpret its key components. TLO 2.2 Perform correlation and regression analysis. TLO 2.3 Use various methods to address missing values in Dataset. TLO 2.4 Apply Anova and Chi Square test. TLO 2.5 Use scatter diagrams. TLO 2.6 Test hypothesis. TLO 2.7 Explain the concept of a sampling distribution. TLO 2.8 Analyze the probability distribution.	**Unit - II Statistical Analysis** 2.1 Graphical techniques, box plot, skewness and kurtosis, Descriptive Stats 2.2 Correlation and Regression, Data Cleaning 2.3 Imputation Techniques 2.4 Anova and Chi Square 2.5 Scatter Diagram 2.6 Estimation and Hypothesis Testing 2.7 Sampling Distributions, Counting 2.8 Probability,Probability Distributions	Presentations Lecture Using Chalk-Board Hands-on
3	TLO 3.1 Describe the steps for making excel dashboard. TLO 3.2 Create a pivot Table. TLO 3.3 Sort and filter the pivot tables. TLO 3.4 Create a pivot chart for different types of grouping items. TLO 3.5 Describe various formatting operations on pivot table.	**Unit - III Data Analytics with Excel** 3.1 Excel Dashboard: Tables and Data Grids, Dynamic Filters and Controls, Trend Analysis and Forecasting 3.2 Pivot Tables: Creating a Pivot Table Specifying Pivot Table Data 3.3 Changing a Pivot Tables, Calculation Filtering and Sorting a Pivot Table 3.4 Creating a Pivot Chart, Grouping Items 3.5 Updating a Pivot Table, formatting a Pivot Table using Slicers	Presentations Hands-on Demonstration

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DATA ANALYTICS **Course Code : 315326**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 Create relevant chart based on requirement. TLO 4.2 Describe the process of selecting the data range. TLO 4.3 Explain the features of Chart Wizard. TLO 4.4 Explain the steps to move an embedded chart to a new position within the same worksheet. TLO 4.5 Format various components of given type of chart.	**Unit - IV Data Visualization** 4.1 Creating a Simple Chart, Charting Non-Adjacent Cells 4.2 Creating a Chart Using the Chart Wizard, Modifying Charts, Moving an Embedded Chart, Sizing an Embedded Chart 4.3 Changing the Chart Type, Changing the Way Data is Displayed, Moving the Legend 4.4 Formatting Charts, Adding Chart Items, Formatting All Text, Formatting and Aligning Numbers, Formatting the Plot Area, Formatting Data Markers 4.5 Pie Charts, Creating a Pie Chart Moving the Pie Chart to its Own Sheet Adding Data Labels, Exploding a Slice of a Pie Chart	Presentations Hands-on Demonstration
5	TLO 5.1 Describe the steps for Installing and setting up Matplotlib in Python. TLO 5.2 Create various types of plots. TLO 5.3 Customize Plots. TLO 5.4 Write steps to Export plots in different formats.	**Unit - V Data Visualization using Python** 5.1 Overview of Matplotlib and its role in data visualization, Installing and setting up Matplotlib in Python 5.2 Basic plotting with Matplotlib, Line plot, Scatter plots, Bar charts, Histograms, adding titles, labels, and legends to plots 5.3 Changing figure size and aspect ratio, Customizing axes (limits, ticks, and labels) 5.4 Exporting and Saving Visualizations: Saving plots in different formats (PNG, PDF, SVG), Adjusting the resolution and quality of saved plots, creating interactive visualizations using Matplotlib widgets	Presentations Hands-on Demonstration

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Perform Statistical Analysis in Excel.	1	*a. Calculate mean, median, and mode for a given dataset using Excel functions (AVERAGE, MEDIAN, MODE). *b. Calculate range, interquartile range (IQR), variance, and standard deviation using Excel functions (STDEV, VAR). *c. Calculate the correlation coefficient between two variables using the CORREL function	2	CO1
LLO 2.1 Construct box plot. LLO 2.2 Perform the different types of function using linear regression. LLO 2.3 Perform T-test in Excel. LLO 2.4 Calculate confidence intervals for the mean of a dataset. LLO 2.5 Apply Chi-square test for independence.	2	*a. Construct a box plot using the Insert Chart feature to identify the median, quartiles, and outliers of a dataset. *b. Perform a simple linear regression analysis *c. Conduct a t-test to compare means between two groups *d. Calculate confidence intervals *e. Conduct a Chi-square test	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 3.1 Create a table to execute the function using dashboard. LLO 3.2 Perform various operations for data cleaning.	3	*Create a Data Table a. Import a sample dataset (e.g., sales data) into Excel. b. converts the dataset into an Excel Table using the "Format as Table" feature and apply appropriate styles. c. Create a dashboard sheet that summarizes key metrics (e.g., total sales, average sales per region) using tables. *Data Cleaning a. Identify and remove duplicates from a dataset. b. Use functions like TRIM, UPPER, LOWER, and PROPER to clean text data. c. Find and replace values using the Find & Replace feature.	2	CO3
LLO 4.1 Create a pivot table to analyze the data set. LLO 4.2 Sort and filter the given data set.	4	Create a Pivot Table a. A basic pivot table from a dataset b. Specify and filter data in a pivot table c. Add a calculated field to a pivot table d. Group data within a pivot table. Refresh pivot table data after making changes to the source data. Filter and sort a PivotTable a. Apply a Filter to the PivotTable b. Sort Data in the Pivot Table. c. Add slicers to the PivotTable for interactive filtering.	2	CO3
LLO 5.1 Customize your chart with titles, labels, colors, and legends as desired.	5	Create a Pivot Chart a. A basic pivot chart from a dataset b. A dynamic pivot chart that updates based on user selection c. Group date items in a pivot table to summarize data by month or year d. Group product categories in a pivot table	2	CO3

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 6.1 Create a simple chart to visualize the data sets.	6	*Create a Simple Chart a. A simple bar chart to visualize data sets b. A chart using non-adjacent cells to visualize data from different ranges. *Create a Chart Using the Chart Wizard a Select the chart you created and experiment with the Chart Tools options b. Modifying Charts c. Moving an Embedded Chart d. Sizing an Embedded Chart	2	CO4
LLO 7.1 Change the chart type with adding data labels, axis format, and adjusting the gridlines.	7	*Change the Chart Type a. Create a basic bar chart using a dataset and change its type to a different chart b. Experiment with different data display options, such as adding data labels, changing the axis format, and adjusting the gridlines c. Experiment with position and style of the legend	2	CO4
LLO 8.1 Design a pie chart.	8	a. Create a pie chart from a dataset b. Move the pie chart to a new worksheet for better visibility c. Emphasize a specific category by exploding a slice of the pie chart d. Customize the appearance of the pie chart for better presentation	2	CO4
LLO 9.1 Generate and Save the plot in various formats.	9	* Create different types of plots.Write a Python script to save the plot in different formats: PNG, PDF, and SVG.	2	CO5
LLO 10.1 Analyze data analytics applications across various business domains.	10	Application of data analytics across various industries through case study	2	CO5

Note : Out of above suggestive LLOs -

- '*' Marked Practicals (LLOs) Are mandatory.
- Minimum 80% of above list of lab experiment are to be performed.
- Judicial mix of LLOs are to be performed to achieve desired outcomes.

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Other

- NA

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DATA ANALYTICS
Course Code : 315326

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If a microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Microsoft Office ,Office 365	1,2,3,4,5,6,7,8,9
2	Software: Editor: Python setup	10,11
3	Computer (i5 preferable), RAM minimum 8 GB onwards.	All
4	Operating system: Windows 10 onward	All

IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Introduction to Data Analytics	CO1	10	4	4	8	16
2	II	Statistical Analysis	CO2	8	2	4	10	16
3	III	Data Analytics with Excel	CO3	8	2	2	8	12
4	IV	Data Visualization	CO4	8	2	4	6	12
5	V	Data Visualization using Python	CO5	6	2	4	8	14
		Grand Total		**40**	**12**	**18**	**40**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- Continuous assessment based on process and Product related performance indicator.Each practical will be assessed considering 1) 60% weightage is to process 2) 40% weightage to product

Summative Assessment (Assessment of Learning)

- End Semester Examination, Lab Performance ,Viva-voce

XI. SUGGESTED COS - POS MATRIX FORM

DATA ANALYTICS | **Course Code : 315326**

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	2	2	1	-	2	-	2			
CO2	2	2	2	2	1	1	1			
CO3	2	2	3	2	1	1	1			
CO4	2	2	3	1	1	2	1			
CO5	1	2	2	2	2	2	2			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Jinjer Simon	Excel Data Analysis: Your visual blueprint for analyzing data, charts, and PivotTables	Wiley Publication Edition: 3rd ISBN: 978-0-470-59160-4
2	A. J. Smalley	Data Analysis with Excel	SAGE Publications Edition: 1st, 2007 ISBN 10: 0070139903 / ISBN 13: 9780070139909
3	Fabio Nelli	Python Data Analytics: With Pandas, NumPy, and Matplotlib	Apress pubication ISBN-13 :978-1484239124 ISBN-13978-1484247372
4	Jake VanderPlas	Python Data Science Handbook	Shroff/O'Reilly Publication ISBN-10-9355422555 ISBN-13-978-9355422552
5	Business Analytics with MindTap	Jeffrey D. Camm	James J Cochran	Michael J. Fry	Jeffrey W. Ohlmann	Cengage Learning India Pvt. Ltd. Publication Edition:4th ISBN: 9789360533533

XIII . LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	https://spreadsheetpoint.com/excel/dashboard-in-excel/	Advance Excel
2	https://www.javatpoint.com/how-to-create-a-dashboard-in-excel	Excel Dashboard
3	https://www.simplilearn.com/tutorials/excel-tutorial/data-analysis-excel	Data Visualization
4	https://www.freecodecamp.org/news/introduction-to-data-vizualization-using-matplotlib/	Matplotlib in Python
5	https://archive.nptel.ac.in/courses/106/107/106107220/	Introduction to data analytics

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

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SOFTWARE ENGINEERING AND TESTING	**Course Code : 315332**

Programme Name/s	**: Information Technology**
Programme Code	**: IF**
Semester	**: Fifth**
Course Title	**: SOFTWARE ENGINEERING AND TESTING**
Course Code	**: 315332**

I. RATIONALE

Software engineering plays a pivotal role in addressing complex problems and improving efficiency to build software product. This course focuses on providing a structured framework by understanding and applying the working knowledge of the principles, techniques, and practices for estimation, designing, testing and quality management of software development projects. It enables students to blend the domain specific knowledge with the programming skills to get quality software products.

II. INDUSTRY / EMPLOYER EXPECTED OUTCOME

Apply software engineering principles to develop software product.

III. COURSE LEVEL LEARNING OUTCOMES (COS)

Students will be able to achieve & demonstrate the following COs on completion of course based learning

- CO1 - Identify relevant software process model for software development.
- CO2 - Use appropriate principles of software modeling to create data design.
- CO3 - Apply project management techniques in software development.
- CO4 - Apply different software testing types to ensure the quality of software product.
- CO5 - Identify defect to improve the overall quality of the software using automated testing tools.

IV. TEACHING-LEARNING & ASSESSMENT SCHEME

Course Code	Course Title	Abbr	Course Category/s	Learning Scheme					Credits	Assessment Scheme												
				Actual Contact Hrs./Week			SLH	NLH		Paper Duration	Theory				Based on LL & TL				Based on SL		Total Marks
															Practical						
				CL	TL	LL					FA-TH	SA-TH	Total		FA-PR		SA-PR		SLA		
											Max	Max	Max	Min	Max	Min	Max	Min	Max	Min	
315332	SOFTWARE ENGINEERING AND TESTING	SET	DSC	4	-	4	1	9	3	3	30	70	100	40	25	10	25@	10	25	10	175

Total IKS Hrs for Sem. : 0 Hrs

Abbreviations: CL- ClassRoom Learning , TL- Tutorial Learning, LL-Laboratory Learning, SLH-Self Learning Hours, NLH-Notional Learning Hours, FA - Formative Assessment, SA -Summative assessment, IKS - Indian Knowledge System, SLA - Self Learning Assessment
Legends: @ Internal Assessment, # External Assessment, *# On Line Examination , @$ Internal Online Examination
Note :

1. FA-TH represents average of two class tests of 30 marks each conducted during the semester.
2. If candidate is not securing minimum passing marks in FA-PR of any course then the candidate shall be declared as "Detained" in that semester.
3. If candidate is not securing minimum passing marks in SLA of any course then the candidate shall be declared as fail and will have to repeat and resubmit SLA work.
4. Notional Learning hours for the semester are (CL+LL+TL+SL)hrs.* 10 Weeks
5. 1 credit is equivalent to 30 Notional hrs.
6. * Self learning hours shall not be reflected in the Time Table.
7. * Self learning includes micro project / assignment / other activities.

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Semester - 5, K Scheme

SOFTWARE ENGINEERING AND TESTING | **Course Code : 315332**

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
1	TLO 1.1 Explain different types and characteristics of software. TLO 1.2 Describe software engineering layered technology and process framework. TLO 1.3 State software engineering principles for requirement engineering. TLO 1.4 Select software process model for the given problem statement. TLO 1.5 Apply agile development process with justification.	**Unit - I Basics of Software Engineering** 1.1 Software, software engineering as layered approach, characteristics of software, types of software 1.2 Software development framework: Software generic process framework activities and umbrella activities 1.3 Software engineering core principles, communication practices, planning practices, modelling practices, construction practices, software deployment practices 1.4 Prescriptive process models: Waterfall model, incremental model, RAD model, prototyping model, spiral model 1.5 Agile software development: Agile process, and its importance, extreme programming, scrum 1.6 Selection criteria for software process model	Presentations Chalk-Board Videos
2	TLO 2.1 Determine requirement engineering tasks in the given problem. TLO 2.2 Prepare use case diagram for given scenario. TLO 2.3 Prepare SRS for the given problem. TLO 2.4 Convert analysis model into requirement model. TLO 2.5 Apply the specified design feature for requirements software modeling. TLO 2.6 Represent the specified problem in the given design notation.	**Unit - II Software Requirement, Modeling and Design** 2.1 Requirement engineering: Requirement engineering task, types of requirement, developing use-case 2.2 SRS (Software Requirements Specifications): Need of SRS, format and it's characteristics 2.3 Translating requirement model into design model 2.4 Design modelling: Fundamental design concepts - abstraction, information hiding, patterns, modularity, concurrency, verification, aesthetics 2.5 Design notations: Data flow diagram (DFD), structured flowcharts	Presentations Chalk-Board Problem Based Learning Video
3	TLO 3.1 Explain 4 P's of management spectrum. TLO 3.2 Estimate the size of the software product using the given method. TLO 3.3 Evaluate the cost of the given software using COCOMO model. TLO 3.4 Describe the RMMM strategy for the given problem. TLO 3.5 Use various scheduling techniques for the given project. TLO 3.6 Prepare the Timeline chart / Gantt chart to track progress of the given project.	**Unit - III Software Project Management** 3.1 The management spectrum- 4P's 3.2 Metrics for size estimation: Line of code (LoC), function points(FP) 3.3 Project cost estimation using COCOMO (Constructive Cost Model), COCOMO II 3.4 Define risk, types of risk, RMMM strategy 3.5 Project scheduling: Basic principle, scheduling techniques - CPM, PERT 3.6 Project tracking: Timeline charts, Gantt charts	Presentations Chalk-Board Problem Based Learning Video

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SOFTWARE ENGINEERING AND TESTING **Course Code : 315332**

Sr.No	Theory Learning Outcomes (TLO's)aligned to CO's.	Learning content mapped with Theory Learning Outcomes (TLO's) and CO's.	Suggested Learning Pedagogies.
4	TLO 4.1 State the importance of software testing. TLO 4.2 Identify errors and bugs in the program. TLO 4.3 Prepare test case for the application. TLO 4.4 Identify the entry and exit criteria for the given test application. TLO 4.5 Describe features of the given software quality evaluation standard. TLO 4.6 Explain V model for the given application. TLO 4.7 Describe features of the given testing method. TLO 4.8 Apply specified testing levels for the given application.	**Unit - IV Basics of Software Testing** 4.1 Software testing, objective of testing, software testing life cycle (STLC) 4.2 Failure, fault, error, defect, bug terminology 4.3 Test case, when to start and stop testing 4.4 Quality assurance, quality control and verification - validation, Quality evaluation standards: Six sigma, CMMI levels 4.5 Static and dynamic testing 4.6 The box approaches: Compare white box testing, black box testing 4.7 Levels of testing: Unit testing, integration testing, system testing, acceptance testing	Presentations Chalk-Board Videos
5	TLO 5.1 Prepare test plan for the given application. TLO 5.2 Identify the resource requirement for test infrastructure management. TLO 5.3 Prepare test report of executed test cases for given application. TLO 5.4 Apply defect life cycle. TLO 5.5 Prepare defect report for identified defect for AUT. TLO 5.6 Compare automation and manual testing based on various parameters. TLO 5.7 Describe metrics and measurement for the given application.	**Unit - V Test and Defect Management** 5.1 Test planning: Preparing a test plan 5.2 Test management: Test infrastructure management 5.3 Test reporting: Executing test cases, preparing test summary report 5.4 Definition and types of defect, defect life cycle, defect template 5.5 Comparison of manual testing and automation testing 5.6 Metrics and measurement: Types of metrics - product metrics and process metrics	Presentations Chalk-Board Problem Based Learning Video

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL / TUTORIAL EXPERIENCES.

Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 1.1 Use any software tool to Write problem statement and identify scope of the project.	1	*Problem statement to define the project title with bounded scope of the software project	2	CO1
LLO 2.1 Select relevant process model to define activities and related tasks set for assigned software project like Library Management System (Teacher can assign different projects in a group).	2	*Process model to define activities and related tasks set	2	CO1
LLO 3.1 Gather application specific requirements for assimilate into RE (Requirements engineering) model. LLO 3.2 Prepare SRS (Software Requirement Software) document.	3	*Software Requirement Specification (SRS)	2	CO2

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
LLO 4.1 Write use cases for different user scenarios. LLO 4.2 Draw use case diagram for different user scenarios using any tool.	4	*Use-case diagram	2	CO2
LLO 5.1 Draw the Activity diagram to represent the flow from one activity to another activity using any tool. LLO 5.2 Design Decision table using any tool.	5	Software Design tools : a) Activity diagram b) Decision table	2	CO2
LLO 6.1 Draw data flow diagram: DFD 0 Level, DFD 1 Level, DFD 2 Level for the software project using any tool.	6	*Data Flow Diagram	2	CO2
LLO 7.1 Draw class diagram for the software project using any tool. LLO 7.2 Draw Sequence diagram for the software project using any tool. LLO 7.3 Draw Collaboration diagram for the software project using any tool.	7	UML Diagrams	2	CO2
LLO 8.1 Estimate size of the project using function point metric for the software project using any tool.	8	*Function point metric for size estimation	2	CO3
LLO 9.1 Estimate cost of the project using COCOMO (Constructive Cost Model)/COCOMO II approach for the software project using any tool.	9	*COCOMO (Constructive Cost Model) /COCOMO II for cost estimation	2	CO3
LLO 10.1 Identify risk involved in the project. LLO 10.2 Prepare RMMM(Risk Management, Mitigation and Monitoring) Plan.	10	RMMM (RMMM-Risk Management, Mitigation and Monitoring) plan	2	CO3
LLO 11.1 Use CPM (Critical Path Method) / PERT (Programme Evaluation and Review Technique) for software project scheduling.	11	CPM (Critical Path Method) / PERT (Programme Evaluation and Review Technique).	2	CO3
LLO 12.1 Prepare Timeline charts / Gantt charts to track the progress of the software project using any tool.	12	*Timeline charts / Gantt charts	2	CO3
LLO 13.1 Design test cases w.r.t. functional testing for the software project.	13	*Test cases for Functional Testing	2	CO4
LLO 14.1 Design test cases w.r.t. Control and decision making statement for the software project 1) For... Loop 2) Switch...case 3) Do... While 4) If...else	14	Test cases for Control and decision making statements	2	CO4
LLO 15.1 Design test cases for Web Page Testing for any Web Site.	15	Test cases for Web Application	2	CO4
LLO 16.1 Design test cases for e-commerce (Flipkart, Amazon) login form with respect to GUI testing.	16	*Test cases for GUI Testing	2	CO4
LLO 17.1 Prepare test plan for a standalone application.	17	*Test plan for a standalone application	2	CO5
LLO 18.1 Prepare test plan for web application like any Chatting Application.	18	Test plan for web Application	2	CO5
LLO 19.1 Prepare defect report after executing test cases for login functionality.	19	*Defect report	2	CO5
LLO 20.1 Execute test cases for e-commerce application (Flipkart, Amazon) login form using an Automation Tool.	20	Test cases for automation tool	2	CO5

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Practical / Tutorial / Laboratory Learning Outcome (LLO)	Sr No	Laboratory Experiment / Practical Titles / Tutorial Titles	Number of hrs.	Relevant COs
Note : Out of above suggestive LLOs - • '*' Marked Practicals (LLOs) Are mandatory. • Minimum 80% of above list of lab experiment are to be performed. • Judicial mix of LLOs are to be performed to achieve desired outcomes.				

VII. SUGGESTED MICRO PROJECT / ASSIGNMENT/ ACTIVITIES FOR SPECIFIC LEARNING / SKILLS DEVELOPMENT (SELF LEARNING)

Micro project

• Visit any medical shop, gather information about purchasing and selling medicines, maintaining their inventory, generating sales invoices and generating reminders of expiry date about medicines. Write the Functional and non-functional requirements for the medical shop management system.
• Visit your Institute library, Collect the functional requirements for a Library Management System and estimate cost and size of the project.
• Visit any grocery shop, collect requirements from shop keeper and prepare SRS document.

Assignment

• Estimate size of software using any tool and risk involved in any food delivery system.
• Estimate cost of software using any tool and risk involved in the Hotel management system.
• Prepare test plan and defect report for calculator.

Other

• Use Infosys Springboard or any MOOC's platform to complete any one course related to Software Engineering and Testing.
• Discuss paper titled "Case Study Based Software Engineering Project Development: State of Art" reference link: https://arxiv.org/pdf/1306.2502.

Note :

- Above is just a suggestive list of microprojects and assignments; faculty must prepare their own bank of microprojects, assignments, and activities in a similar way.
- The faculty must allocate judicial mix of tasks, considering the weaknesses and / strengths of the student in acquiring the desired skills.
- If microproject is assigned, it is expected to be completed as a group activity.
- SLA marks shall be awarded as per the continuous assessment record.
- For courses with no SLA component the list of suggestive microprojects / assignments/ activities are optional, faculty may encourage students to perform these tasks for enhanced learning experiences.
- If the course does not have associated SLA component, above suggestive listings is applicable to Tutorials and maybe considered for FA-PR evaluations.

VIII. LABORATORY EQUIPMENT / INSTRUMENTS / TOOLS / SOFTWARE REQUIRED

Sr.No	Equipment Name with Broad Specifications	Relevant LLO Number
1	Software Project Management Tools: open source Software such as Jira	1,2,3,10,17,18,19
2	Spreadsheet Package	13,14,15,16
3	Software Tools : SmartDraw / Draw.io / TINY TOOLS / STRS COCOMO / any other	4,5,6,7,8,9,11,12
4	Hardware: Personal computer, (i5-i7 preferable), RAM minimum 4 GB	All
5	Operating system: Windows 10/Windows 11/ Ubuntu or any other	All

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IX. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE (Specification Table)

Sr.No	Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	I	Basics of Software Engineering	CO1	6	2	6	4	12
2	II	Software Requirement, Modeling and Design	CO2	10	4	4	8	16
3	III	Software Project Management	CO3	10	2	4	10	16
4	IV	Basics of Software Testing	CO4	8	2	4	8	14
5	V	Test and Defect Management	CO5	6	2	4	6	12
		Grand Total		**40**	**12**	**22**	**36**	**70**

X. ASSESSMENT METHODOLOGIES/TOOLS

Formative assessment (Assessment for Learning)

- For theory two offline unit tests of 30 marks and average of two unit test marks will be considered for out of 30 marks.
- For formative assessment of laboratory learning 25 marks.
- Each practical will be assessed considering 60% weightage to process, 40% weightage to product.

Summative Assessment (Assessment of Learning)

- End semester assessment is of 70 marks.
- End semester examination if of 25 marks, lab performance, viva voce

XI. SUGGESTED COS - POS MATRIX FORM

Course Outcomes (COs)	Programme Outcomes (POs)							Programme Specific Outcomes* (PSOs)		
	PO-1 Basic and Discipline Specific Knowledge	PO-2 Problem Analysis	PO-3 Design/ Development of Solutions	PO-4 Engineering Tools	PO-5 Engineering Practices for Society, Sustainability and Environment	PO-6 Project Management	PO-7 Life Long Learning	PSO-1	PSO-2	PSO-3
CO1	1	2	2	2	1	-	1			
CO2	2	2	2	2	-	-	-			
CO3	1	2	2	3	-	2	1			
CO4	2	2	3	3	1	2	1			
CO5	2	2	3	3	1	1	1			

Legends :- High:03, Medium:02,Low:01, No Mapping: -
*PSOs are to be formulated at institute level

XII. SUGGESTED LEARNING MATERIALS / BOOKS

Sr.No	Author	Title	Publisher with ISBN Number
1	Roger S. Pressman & Bruce R. Maxim	Software Engineering: A practitioner's approach	McGraw Hill Higher Education, New Delhi, (Ninth Edition) ISBN 93-5532-504-5
2	Srinivasan Desikan, Gopalaswamy Ramesh	Software Testing: Principles and Practices	PEARSON Publisher: Pearson India 2007, ISBN: 978-81-7758-121-8,

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Sr.No	Author	Title	Publisher with ISBN Number
3	Richard Fairly	Software Engineering Concepts	McGraw Hill Education New Delhi -2001, ISBN-13: 9780074631218
4	Deepak Jain	Software Engineering: Principles and practices	Oxford University Press, New Delhi ISBN 9780195694840
5	Ron Patton	Software Testing	Sams Publishing; 2nd edition, 2005 ISBN: 0672327988
6	M. G. Limaye	Software Testing: Principles, Techniques and Tools	Tata McGraw Hill Education, New Delhi., 2009 ISBN 13: 9780070139909
7	Naresh Chauhan	Software Testing: Principles and Practices	Oxford University Press Noida. ISBN: 9780198061847
8	Yogesh Singh	Software Testing	Cambridge University Press, Cambridge, 2021 ISBN: 9781107012967

XIII. LEARNING WEBSITES & PORTALS

Sr.No	Link / Portal	Description
1	www.tutorialspoint.com//software_engineering/	Software Engineering Tutorial
2	https://insights.sei.cmu.edu/library/	Software Engineering Institute Digital Library
3	https://nptel.ac.in/courses/106105087	NPTEL course on Introduction to Software Engineering
4	https://www.geeksforgeeks.org/software-testing-basics/	Software Testing Tutorial
5	https://www.youtube.com/watch?v=sO8eGL6SFsA&t=12304s	Video tutorial on Software testing by Edureka
6	https://www.youtube.com/@softwaretestingmentor	Video tutorial on Software testing by RCV Academy
7	https://infyspringboard.onwingspan.com/web/en/app/toc/lex_au th_01384297011411353628269_shared/overview	Software engineering and testing courses

Note :

- Teachers are requested to check the creative common license status/financial implications of the suggested online educational resources before use by the students

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