



Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT521	Title of the Course	Statistical Inference-II	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite	Statistical Inference-I	Co-requisite					
Course Objectives	To introduce the concepts of Bayesian and advanced statistical inference and its applications in real data analysis including sample surveys, design of experiments, and econometrics						

Course Outcomes	
CO1	Students will be able to understand the concept of Statistical decision problem: Decision problem and 2-person game, non-randomized and randomized decision rules, concept of loss and risk functions, admissibility, Bayes rules, mini max rules, least favourable distributions, complete class and minimal complete class
CO2	Students will be able to understand the Decision problem for finite parameter space, convex loss function, Admissible and mini max estimators under various loss functions
CO3	Students will be able to understand the concept of Bayes theorem and computation of posterior distribution, Bayesian point estimation as a prediction problem from posterior distribution, Test of simple hypothesis against a simple alternative from decision theoretic view point
CO4	Students will be able to understand the procedure of Bayes estimators under (i) absolute loss function, (ii) squared error loss function, (iii) '0-1' loss function, Evaluation of estimates in terms of the posterior risk.
CO5	Students will be able to understand the concept and applications of Bayesian interval estimation, Bayesian testing of hypothesis, Bayes factor for various types of testing hypothesis problem depending upon whether the null and alternative hypotheses are simple or composite, Bayesian prediction problems

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Statistical decision problem: Decision problem and 2-person game, non-randomized and randomized decision rules, concept of loss and risk functions, admissibility, Bayes rules, mini max rules, least favourable distributions, complete class and minimal complete class	08	CO-1
2	Unit-2	Decision problem for finite parameter space, convex loss function, Admissible and mini max estimators under various loss functions	08	CO-2
3	Unit-3	Bayes theorem and computation of posterior distribution, Bayesian point estimation as a prediction problem from posterior distribution, Test of simple hypothesis against a simple alternative from decision theoretic view point	08	CO-3
4	Unit-4	Bayes estimators under (i) absolute loss function, (ii) squared error loss function, (iii) '0-1' loss function, Evaluation of estimates in terms of the posterior risk.	08	CO-4
5	Unit-5	Bayesian interval estimation, Bayesian testing of hypothesis, Bayes factor for various types of testing hypothesis problem depending upon whether the null and alternative hypotheses are simple or composite, Bayesian prediction problems	08	CO-5

Reference Books:

1. Ferguson, T.S.: Mathematical Statistics, Academic Press, Inc., USA.
2. Berger, J.O.: Statistical Decision Theory and Bayesian Analysis, Springer-Verlag.
3. Liese, F. and Miescke, K.J. : Statistical Decision Theory, Springer.
4. Sinha, S.K.: Bayesian Estimation, New Age International Limited.
5. Robert, C.P.: The Bayesian Choice, 2nd Edition, Springer.
6. Srivastava, M. K., Khan, A.H. and Srivastava, N.: Statistical Inference: Theory of Estimation, PHI Learning Private Limited.
7. Bolstad, W.M. and Curran, J.M.: Introduction to Bayesian Statistics, 3rd Edition, John Wiley & Son, Inc., USA.

e-Learning Source:

- <http://heecontent.upsdc.gov.in/SearchContent.aspx>
- <https://swayam.gov.in/explorer?searchText=statistics>
- <https://nptel.ac.in/course.html>
- <https://www.edx.org/search?q=statistics>

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	1	1	3	3	3	3	2	2
CO2	3	1	1	1	1	1	3	3	3	3	3	3
CO3	3	1	1	1	1	1	3	3	3	3	3	2
CO4	3	1	1	1	1	1	3	3	3	3	3	3
CO5	3	1	1	1	1	1	3	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT522	Title of the Course	Demography	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite	Descriptive Statistics	Co-requisite					
Course Objectives	To introduce the elementary and advanced concepts of demography and application of demographic techniques in various aspects of population studies						

Course Outcomes	
CO1	Students will be able to understand the concept of coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices, population transition theory
CO2	Students will be able to understand the measures of fertility, stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters, estimation of parity progression from open birth interval data
CO3	Students will be able to understand the concept of measures of Mortality, construction of abridged life tables, infant mortality rate and its adjustments, model life table, Stable and quasi-stable populations, intrinsic growth rate
CO4	Students will be able to understand the procedure of models of population growth and their filling to population data internal migration and its measurement, migration models, concept of international migration
CO5	Students will be able to understand the concept of methods for population projection, component method of population projection, Nuptiality and its measurements

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	coverage and content errors in demographic data, Chandrasekharan—Deming formula to check completeness of registration data, adjustment of age data- use of Whipple, Myer and UN indices, population transition theory	08	CO-1
2	Unit-2	Measures of fertility, stochastic models for reproduction, distributions of time of birth, inter-live birth intervals and of number of births (for both homogeneous and homogeneous groups of women), estimation of parameters, estimation of parity progression from open birth interval data	08	CO-2
3	Unit-3	Measures of Mortality, construction of abridged life tables, infant mortality rate and its adjustments, model life table, Stable and quasi-stable populations, intrinsic growth rate	08	CO-3
4	Unit-4	Models of population growth and their filling to population data internal migration and its measurement, migration models, concept of international migration	08	CO-4
5	Unit-5	Methods for population projection, component method of population projection, Nuptiality and its measurements	08	CO-5

Reference Books:	
1.	Kumar, R.: Technical Demography, Wiley Eastern Ltd.
2.	Benjamin, B.: Demographic Analysis, George, Allen and Unwin.
3.	Chiang, C.L.: Introduction to Stochastic Progression
4.	Cox, P.R. : Demography, Cambridge University Press
5.	Keyfitz, N.: Introduction to the Mathematics of Population-with Revisions, Addison-Wesley, London.
6.	Spiegelman, M.: Introduction to Demographic Analysis, Harvard University Press.
7.	Wolfenden, H.H.: Population Statistics and Their Compilation, Am Actuarial Society.

e-Learning Source:	
	https://www.youtube.com/watch?v=pCuW6FUBIEA
	https://www.youtube.com/watch?v=G-v42D4IMf0
	https://www.ined.fr/en/everything_about_population/videos/what-is-demography/
	https://studv.com/learn/lesson/what-is-demographv.html

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	2	1	1	1	1	1	3	3	3	3	2	2
CO2	3	1	1	1	1	1	2	3	2	3	3	3
CO3	3	1	1	1	1	1	2	3	3	2	3	2
CO4	3	1	1	1	1	1	2	3	3	3	3	3
CO5	2	1	1	1	1	1	3	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation



Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT523	Title of the Course	Statistical Process & Product Control	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To introduce the advance concepts of statistical quality control						

Course Outcomes	
CO1	Students will be able to understand the concept of Quality, Causes of variations in Quality, Variables Control charts, Attributes Control charts, Moving Average and Moving Range, Exponentially weighted moving average, Cu-Sum Control Charts.
CO2	Students will be able to understand the Concepts of Specification Limits, Quality loss functions, Development of loss function, Nominal the best type Loss functions (Equal and unequal tolerances cases), Larger the better type loss function, Smaller the better type loss functions, Capability indices Cp, Cpk, and Cpm, Estimation of the proportion of defectives (rework and scrap) for Cp, Cpk, and Cpm
CO3	Students will be able to understand the concept of Acceptance Sampling, Single Sampling Plan, Consumer's Risk and Producer's Risk, OC Function, Corrective Sampling Plan, Average Sample Number (ASN), Average Outgoing Quality (AOQ), Average Outgoing Quality Limits (AOQL), Goodness of Sampling Inspection Plan, Curtailed and Semi Curtailed Sampling Inspection Plan
CO4	Students will be able to understand the procedure Methods of determination of sample size for sampling inspection Plan. Inspection by Variables of Single Sampling Plan, Single Specification Limit (when S. d. known & Unknown Case), Double Sampling Plan. Illustrations Based on the Concepts
CO5	Students will be able to understand the concept of Design of Experiments in process control, signal and input variables, full factorial experiments, 2 ^k full factorial experiments, 2 ² design Analysis in Process Control, 2 ³ design Analysis in Process Control. Illustrations Based on the Concepts

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Concepts of Quality, Causes of variations in Quality, Variables Control charts, Attributes Control charts, Moving Average and Moving Range, Exponentially weighted moving average, Cu-Sum Control Charts	08	CO-1
2	Unit-2	Concepts of Specification Limits, Quality loss functions, Development of loss function, Nominal the best type Loss functions (Equal and unequal tolerances cases), Larger the better type loss function, Smaller the better type loss functions, Capability indices Cp, Cpk, and Cpm, Estimation of the proportion of defectives (rework and scrap) for Cp, Cpk, and Cpm	08	CO-2
3	Unit-3	Students will be able to understand the concept of Acceptance Sampling, Single Sampling Plan, Consumer's Risk and Producer's Risk, OC Function, Corrective Sampling Plan, Average Sample Number (ASN), Average Outgoing Quality (AOQ), Average Outgoing Quality Limits (AOQL), Goodness of Sampling Inspection Plan, Curtailed and Semi Curtailed Sampling Inspection Plan	08	CO-3
4	Unit-4	Students will be able to understand the procedure Methods of determination of sample size for sampling inspection Plan. Inspection by Variables of Single Sampling Plan, Single Specification Limit (when S. d. known & Unknown Case), Double Sampling Plan. Illustrations Based on the Concepts	08	CO-4
5	Unit-5	Students will be able to understand the concept of Design of Experiments in process control, signal and input variables, full factorial experiments, 2 ^k full factorial experiments, 2 ² design Analysis in Process Control, 2 ³ design Analysis in Process Control. Illustrations Based on the Concepts.	08	CO-5

Reference Books:

1. Montgomery, D. C.: Introduction of Statistical Quality Control; Wiley.
2. G. Schilling: Acceptance Sampling in Quality Control; Marcel Dekker
3. Amitava Mitra: Fundamentals of Quality Control and Improvements; John Wiley.
4. J.R. Evans. W.M. Lindsay: The Management and Control of Quality; West Publishing Company. 6. Kaoru Ishikawa: Introduction to Quality Control, Chapman and Hall
5. John S. Oakland: Statistical Process Control; Elsevier.

e-Learning Source:

- <https://www.youtube.com/watch?v=RD5vomChhwk>
- https://www.youtube.com/watch?v=z9xxS_pmDAY
- <https://www.youtube.com/watch?v=e5g2NmIUdck>

Course Articulation Matrix: (Mapping of COs with POs and PSOs)													
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4	
CO1	3	1	1	1	1	1	2	3	3	3	2	3	
CO2	3	1	1	1	1	1	2	3	3	2	3	3	
CO3	3	1	1	1	1	1	2	3	3	2	3	2	
CO4	3	1	1	1	1	1	2	3	3	3	3	3	
CO5	3	1	1	1	1	1	2	3	3	3	3	2	

1. Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT524	Title of the Course	Operations Research-I	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To introduce the basic and advanced concepts of Operations Research and its techniques.						

Course Outcomes	
CO1	Students will be able to understand the Operations Research (OR), scopes and applications of Operations Research, characteristics and methodology of Operations Research, phases and models of Operations Research
CO2	Students will be able to understand the Definitions and Formulation of linear programming problems (LPP) Graphical method, Simplex method, Big-M method, Two Phase method, solution of LPP through MS-Excel Solver
CO3	Students will be able to understand the concept of Primal & Dual problems, economics interpretation of dual problem, dual simplex method, sensitivity analysis, All integer and Mixed integer programming problems, Branch and Bound Method
CO4	Students will be able to understand the procedure of finding initial basic feasible solution of transportation problem, Optimality criterion in transportation problem, Solution of assignment problem using Hungarian method
CO5	Students will be able to understand the Elements of decision problem, Types of decision making environments, Decision tree. Two person zero sum games, Pure and mixed strategies, Maxi min and mini max principle, Principle of dominance, Solution of game by graphical method

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Introduction to Operations Research (OR), scopes and applications of Operations Research, characteristics and methodology of Operations Research, phases and models of Operations Research	08	CO-1
2	Unit-2	Definitions and Formulation of linear programming problems (LPP) Graphical method, Simplex method, Big-M method, Two Phase method, solution of LPP through MS-Excel Solver	08	CO-2
3	Unit-3	Primal & Dual problems, economics interpretation of dual problem, dual simplex method, sensitivity analysis, All integer and Mixed integer programming problems, Branch and Bound Method	08	CO-3
4	Unit-4	Definition and various method of finding initial basic feasible solution of transportation problem, Optimality criterion in transportation problem, Solution of assignment problem using Hungarian method	08	CO-4
5	Unit-5	Introduction, Elements of decision problem, Types of decision making environments, Decision tree. Two person zero sum games, Pure and mixed strategies, Maxi min and mini max principle, Principle of dominance, Solution of game by graphical method	08	CO-5

Reference Books:

1. H.A. TAHA "Operations Research- An Introduction" Pearson.
2. K. Swarup, P.K.Gupta and A. Manmohan, "Operations Research", S. Chand.
3. Hiller and Lieberman, "Introduction to Operations Research", McGraw Hill Company.
4. J.K. Sharma, "Operations Research", Pearson.

e-Learning Source:

- <http://heecontent.upsdc.gov.in/SearchContent.aspx>
- <https://swayam.gov.in/explorer?searchText=statistics>
- <https://nptel.ac.in/course.html>
- <https://www.edx.org/search?q=statistics>

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO- PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
	CO1	3	1	1	1	1	1	2	3	3	3	2
CO2	3	1	1	1	1	1	3	3	3	2	2	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	2	3	3	2	3	3
CO5	3	1	1	1	1	1	2	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT525	Title of the Course	Basics of Python Programming	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To introduce the basis and advanced elements of Python language.						

Course Outcomes	
CO1	Students will be able to understand the Python data structures, data types, indexing and slicing, vectors, arrays, developing programs, functions, modules and packages, data structures for statistics, tools for statistical modeling
CO2	Students will be able to understand the String, List, Tuples & Dictionary; Python Libraries: Pandas and NumPy, Data visualization, data input and output
CO3	Students will be able to understand the procedure to Display of Statistical data with Python- Univariate and multivariate data, discrete and continuous distributions: binomial, Poisson, normal, Weibull. Sampling distributions: t, chi-square and F.
CO4	Students will be able to understand the procedure of Hypothesis testing with Python- Test for means: t test for single and two samples, Wilcoxon and Mann-Whitney test, test for categorical data, one proportion and frequency tables, chi-square test for independence, relation between hypothesis and confidence intervals
CO5	Students will be able to understand the concept and procedure of Analysis of variance (ANOVA), analysis of covariance (ANCOVA), Statistical Modeling with Python-Correlation and Regression coefficients, simple and multiple regression analyses, model selection criteria

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Introduction to Python- Python data structures, data types, indexing and slicing, vectors, arrays, developing programs, functions, modules and packages, data structures for statistics, tools for statistical modeling	08	CO-1
2	Unit-2	Python Data Structure: String, List, Tuples & Dictionary; Python Libraries: Pandas and NumPy, Data visualization, data input and output	08	CO-2
3	Unit-3	Display of Statistical data with Python- Univariate and multivariate data, discrete and continuous distributions: binomial, Poisson, normal, Weibull. Sampling distributions: t, chi-square and F	08	CO-3
4	Unit-4	Hypothesis testing with Python- Test for means: t test for single and two samples, Wilcoxon and Mann-Whitney test, test for categorical data, one proportion and frequency tables, chi-square test for independence, relation between hypothesis and confidence intervals	08	CO-4
5	Unit-5	Analysis of variance (ANOVA), analysis of covariance (ANCOVA), Statistical Modeling with Python-Correlation and Regression coefficients, simple and multiple regression analyses, model selection criteria	08	CO-5

Reference Books:

- Haslwanter, T.: An Introduction to Statistics with Python: with Applications in the Life Sciences, Springer.
- Sheppard, K: Introduction to Python for Econometrics, Statistics and Data analysis, Oxford University press.

e-Learning Source:
https://www.youtube.com/watch?v=woVJ4N5nl_s
https://www.youtube.com/watch?v=kqtD5dpm9C8
https://www.youtube.com/watch?v=rfscVS0vtbw
https://www.javatpoint.com/python-tutorial

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	1	1	3	3	3	3	2	3
CO2	3	1	1	1	1	1	3	3	3	2	2	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	3	3	3	2	3	3
CO5	3	1	1	1	1	1	3	2	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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Integral University, Lucknow

Effective from Session: 2022 - 23							
Course Code	MT526	Title of the Course	Demography and Statistical Process & Product Control Lab	L	T	P	C
Year	II	Semester	III	0	0	6	
Pre-Requisite		Co-requisite					
Course Objectives	To introduce the practical approach of the subject						

Course Outcomes	
CO1	Students will be able to understand the practical approach to calculate the Crude birth rate (CBR) & Crude death rate (CDR)
CO2	Students will be able to understand the practical approach to calculate specific fertility rate (SFR) & Gross reproduction rate (GPR)
CO3	Students will be able to understand the practical approach to calculate the \bar{X} & R control charts
CO4	Students will be able to understand the practical approach to calculate the np control chart as well as “p” & “c” control charts
CO5	Students will be able to understand the practical approach to calculate the single/double sampling plans

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Practical based on crude birth rate (CBR) & Practical based on crude death rate (CDR)	08	CO-1
2	Unit-2	Practical based on specific fertility rate (SFR) & Practical based on Gross reproduction rate (GPR)	08	CO-2
3	Unit-3	Practical based on \bar{X} & R control charts	08	CO-3
4	Unit-4	Practical based on “ np” control chart & Practical based on “p” & “c” control charts	08	CO-4
5	Unit-5	Practical based on single/double sampling plans	08	CO-5

Reference Books:	
1.	Kumar, R.: Technical Demography, Wiley Eastern Ltd.
2.	Benjamin, B.: Demographic Analysis, George, Allen and Unwin.
3.	Chiang, C.L.: Introduction to Stochastic Progression
4.	Cox, P.R. : Demography, Cambridge University Press

e-Learning Source:
https://www.youtube.com/watch?v=e5g2NmiUdck https://study.com/learn/lesson/statistical-process-control-operation.html/x https://sixsigmastudyguide.com/statistical-process-control-spc/

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
	CO1	2	1	1	1	1	1	3	3	2	3	2
CO2	2	1	1	1	1	1	3	3	3	2	2	3
CO3	2	1	1	1	1	1	3	3	3	2	3	2
CO4	2	1	1	1	1	1	3	3	2	2	3	3
CO5	2	1	1	1	1	1	3	2	3	2	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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Integral University, Lucknow
Department of Mathematics & Statistics
Study and Evaluation Scheme(w.e.f 2020-21)

M. Sc. (Statistics)

IInd year / IVth Semester

S. No.	Course code	Course Title	Type of Paper	Period Per hr/week/sem			Evaluation Scheme				Sub. Total	Credit	Total Credits	Attributes							Nations sustainable development Goals (SDGs)			
				L	T	P	CT	TA	Total	ESE				Employability	Entrepreneurship	Skill Development	Gender Equality	Environment & Sustainability	Human Value	Professional Ethics				
				THEORIES																				
1	MT528	Theory of Econometrics	Core	03	01	00	40	20	60	40	100	3:1:0	4	√		√						8		
2	MT529	Multivariate Analysis	Core	03	01	00	40	20	60	40	100	3:1:0	4	√		√							9	
3	MT530	Stochastic Processes	Core	03	01	00	40	20	60	40	100	3:1:0	4	√		√							8	
4	MT531	Operations Research-II	Elective	03	01	00	40	20	60	40	100	3:1:0	4	√	√	√				√			12	
	MT532	Actuarial Statistics	Elective											√		√							8	
	MT533	Official and Educational Statistics	Elective											√		√							10	
5	MT534	*Project (Field Work)	Core	07	00	00	00	00	00	200	200	07	07	√	√	√					√		8	
Total				19	04	00	60	40	240	360	600		23											

CT = Class Test; TA = Teacher's Assessment; ESE = End Semester Examination; Sessonal = CT + TA; Subject Total = Sessonal + ESE

Total Credits = 23 + 23 + 23 + 23 = 92

*** The Evaluation scheme for Project**

	Course Code	Project Dissertation	Presentation	Viva-Voce	Total
Project(Field Work)	MT534	100	50	50	200



Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT528	Title of the Course	Theory of Econometrics	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To introduce the procedure for handling the economic data						

Course Outcomes	
CO1	Students will be able to understand the basic of econometrics, Simple linear regression models, assumptions, estimation through ordinary least square method (OLS) and Maximum likelihood method. Properties of estimators; significance test and confidence interval, Gauss- Markov Theorem
CO2	Students will be able to understand the Multiple regression models with two explanatory variables, Partial and Multiple regression coefficients, Estimation of the Regression Coefficients, Testing of Significance of Regression Coefficients and Regression Model, R- square, Adjusted R- square, Akaike Information Criteria and Schwarz Criterion
CO3	Students will be able to understand the procedure of Regression Analysis: Nature, Tests, Consequences and remedies of Problem of Multi-collinearity, Problems of specification error, Errors of Measurement
CO4	Students will be able to understand the concept of regression analysis having Time Series and Cross Section Data: Auto correlation, Nature of the problem, Consequences of using OLS in the presence of Auto correlation, Detecting Auto-correlation-Graphical Method, Durbin-Watson 'd-statistic', remedial measures of the problem
CO5	Students will be able to understand the concept of Heteroscedasticity- meaning, graphical presentation of the presence of Heteroscedasticity. Consequences of Heteroscedasticity, Detection and remedial measures of the problem

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Introduction to econometrics, Simple linear regression models, assumptions, estimation through ordinary least square method (OLS) and Maximum likelihood method. Properties of estimators; significance test and confidence interval, Gauss- Markov Theorem	08	CO-1
2	Unit-2	Multiple regression models with two explanatory variables. Partial and Multiple regression coefficients, Estimation of the Regression Coefficients, Testing of Significance of Regression Coefficients and Regression Model, R- square, Adjusted R- square, Akaike Information Criteria and Schwarz Criterion.	08	CO-2
3	Unit-3	Problems of Regression Analysis: Nature, Tests, Consequences and remedies of Problem of Multi-collinearity, Problems of specification error, Errors of Measurement	08	CO-3
4	Unit-4	Problems in Regression Analysis having Time Series and Cross Section Data: Auto correlation, Nature of the problem, Consequences of using OLS in the presence of Auto correlation, Detecting Auto-correlation-Graphical Method, Durbin-Watson 'd-statistic', remedial measures of the problem	08	CO-4
5	Unit-5	Heteroscedasticity- meaning, graphical presentation of the presence of Heteroscedasticity. Consequences of Heteroscedasticity, Detection and remedial measures of the problem	08	CO-5

Reference Books:

1. Dongherty, C.: Introduction to Econometrics, Oxford University Press, NewYork.
2. Goldberger, A.S.: Introductory Econometrics, Harvard University Press, Cambridge, Mass.
3. Gujarati, D.N.: Basic Econometrics (2nd Edition), McGraw Hill, New Delhi.
4. A. Koutsoyiannis: Theory of Econometrics –Palgrave Macmillan Second Edition

e-Learning Source:

<https://www.youtube.com/watch?v=8NU95tQaWr0>

<https://www.youtube.com/watch?v=szrcgGex9og>

<https://www.youtube.com/watch?v=PGU293RbT0c>

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO- PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
	CO1	2	1	1	1	1	1	2	3	2	2	3
CO2	3	1	1	1	1	1	2	2	2	3	2	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	3	3	3	2	3	3
CO5	3	1	1	1	1	1	3	2	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT 529	Title of the Course	Multivariate Analysis	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite	Regression Analysis	Co-requisite					
Course Objectives	To introduce the methods for multivariate analysis						

Course Outcomes	
CO1	Students will be able to understand the basic of Singular and non-singular multivariate normal distributions, Characteristic function of $N_p(\mu, \Sigma)$ Maximum likelihood estimators of μ and Σ in $N_p(\mu, \Sigma)$ and their independence. Testing of population mean vector when variance covariance Σ is known
CO2	Students will be able to understand the Wishart distribution: Definition and its distribution, properties and characteristic function. Generalized variance Testing of sets of variates and equality of covariance, Estimation of multiple and partial correlation coefficients and their null distribution, Test of hypothesis on multiple and partial correlation coefficients
CO3	Students will be able to understand the procedure of Hotelling's T^2 : Definition, distribution and its optimum properties, Application in tests on mean vector for one and more multivariate normal population and also on equality of the components of a mean vector of a multivariate normal population, Distribution of Mahalanobis's D^2
CO4	Students will be able to understand the concept of Discriminate analysis: Classification of observations in to one or two or more groups, Estimation of the misclassification probabilities, Test associated with discriminate functions
CO5	Students will be able to understand the concept of Principal component, canonical variate and canonical correlation: Definition, use, estimation and computation, Cluster analysis

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Singular and non-singular multivariate normal distributions, Characteristic function of $N_p(\mu, \Sigma)$ Maximum likelihood estimators of μ and Σ in $N_p(\mu, \Sigma)$ and their independence. Testing of population mean vector when variance covariance Σ is known	08	CO-1
2	Unit-2	Wishart distribution: Definition and its distribution, properties and characteristic function. Generalized variance Testing of sets of variates and equality of covariance, Estimation of multiple and partial correlation coefficients and their null distribution, Test of hypothesis on multiple and partial correlation coefficients	08	CO-2
3	Unit-3	Hotelling's T^2 : Definition, distribution and its optimum properties, Application in tests on mean vector for one and more multivariate normal population and also on equality of the components of a mean vector of a multivariate normal population, Distribution of Mahalanobis's D^2	08	CO-3
4	Unit-4	Discriminate analysis: Classification of observations in to one or two or more groups, Estimation of the misclassification probabilities, Test associated with discriminate functions	08	CO-4
5	Unit-5	Principal component, canonical variate and canonical correlation: Definition, use, estimation and computation, Cluster analysis	08	CO-5

Reference Books:	
1.	Giri, N.C.: Multivariate statistical inference, Academic Press.
2.	Anderson, T.W.: An introduction to multivariate statistical analysis. John Wile.
3.	Singh, B. M.: Multivariate statistical analysis. South Asian Publishers

e-Learning Source:	
	https://www.youtube.com/watch?v=Wxqevhpsw6A
	https://www.youtube.com/watch?v=Vs2bzT07GIM
	https://careerfoundry.com/en/blog/data-analytics/multivariate-analysis/

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO- PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
	CO1	2	1	1	1	1	1	2	3	2	2	3
CO2	3	1	1	1	1	1	2	2	2	3	2	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	3	3	3	2	3	3
CO5	3	1	1	1	1	1	3	2	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT 530	Title of the Course	Stochastic Processes	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite	Probability theory	Co-requisite					
Course Objectives	To introduce the theory of stochastic processes						

Course Outcomes	
CO1	Students will be able to understand the concept of stochastic processes: Classification of stochastic processes according to state space and time domain, Continuous state Markov Chain, Chapman- Kolmogorov equations Calculation of n-step transition probability and its limit
CO2	Students will be able to understand the Stationary distribution, classification of states, Markov – chain, one-dimensional and two-dimensional Random walk and Grabler’s ruin problem
CO3	Students will be able to understand the concept of Discrete state space, continuous time, MC. Kolmogrov –Feller differential equations Poisson process, Birth and Death process
CO4	Students will be able to understand the concept of Applications to queues and storage problems, Wiener process as a limit of random walk, first passage time and other problems
CO5	Students will be able to understand the concept of Renewal theory: elementary renewal theorem and application. Statement and uses of Key renewal theorem, study of residual life time process. Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Introduction to martingale

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Introduction to stochastic processes: Classification of stochastic processes according to state space and time domain, Continuous state Markov Chain, Chapman- Kolmogorov equations Calculation of n-step transition probability and its limit	08	CO-1
2	Unit-2	Stationary distribution, classification of states, Markov – chain, one-dimensional and two-dimensional Random walk and Grabler’s ruin problem	08	CO-2
3	Unit-3	Discrete state space, continuous time, MC. Kolmogrov –Feller differential equations Poisson process, Birth and Death process	08	CO-3
4	Unit-4	Applications to queues and storage problems, Wiener process as a limit of random walk, first passage time and other problems	08	CO-4
5	Unit-5	Renewal theory: elementary renewal theorem and application. Statement and uses of Key renewal theorem, study of residual life time process. Branching process: Galton-Watson branching process, probability of ultimate extinction, distribution of population size, Introduction to martingale	08	CO-5

Reference Books:

1. B.R. Bhatt: Stochastic Models, New Age Publisher
2. Singh, BM: Measure, Probability and Stochastic Processes, South Asian Publisher, New Delhi.
3. Seldon N Ross: Stochastic Processes, Wiley Student Publication
4. S.K Srinivasan and K.M Mehta: Stochastic Processes, Tata Macgraw Hill Publishing company
5. Karlin’S and Taylor, H.M.: A first Course in Stochastic Processes, Vol.1 Academic Press.
6. Medhi, J: Stochastic Processor, Third Edition, New age International (P) Ltd. Publication.
7. Parzen, E.: Stochastic Processes, Holden-Day.
8. Ross, S.M.: Stochastic Process, John Wiley & Sons ", McGraw Hill Company

e-Learning Source:

<https://www.youtube.com/watch?v=TuTmC8aOQJE>

https://www.youtube.com/watch?v=JYI5xKIH_MU

<https://www.youtube.com/watch?v=KUDhXlnr-gU>

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	1	1	2	3	3	2	3	2
CO2	3	1	1	1	1	1	3	2	3	3	2	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	3	3	3	2	3	3
CO5	3	1	1	1	1	1	3	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT531	Title of the Course	Operations Research-II	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To introduce the advanced topics of Operations Research						

Course Outcomes	
CO1	Statistical decision problem: Decision problem and 2-person game, non-randomized and randomized decision rules, concept of loss and risk functions, admissibility, Bayes rules, mini max rules, least favourable distributions, complete class and minimal complete class
CO2	Students will be able to understand the types of inventory, inventory costs and affecting factors, Deterministic inventory models for single item: Economic order quantity (EOQ) with uniform demand, production & consumption, shortage, EOQ with price breaks; Single period probabilistic inventory models for instantaneous and continuous demand
CO3	Students will be able to understand the elements of queuing system: Service Mechanism, Queuing discipline, Customer's behavior; Classification of queuing models: (M/M/1): (∞ /FIFO), (M/M/1): (N/FIFO), (M/M/C): (∞ /FIFO), (M/M/C): (N/FIFO) Models
CO4	Students will be able to understand the concept of job sequencing, Processing of n-Jobs on 2-Machines, n-Jobs on 3-Machines and 2-Jobs on k-Machines, replacement of items that deteriorate with time, money value constant or varying and maintenance cost increases, Replacement of items that fails suddenly-Individual replacement policy and Group replacement policy
CO5	Students will be able to understand the types of simulation, application of simulation, limitations and methodology, simulation models, Monte Carlo simulation, random number generation simulation languages

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Definition of project, planning, scheduling and controlling, Network diagram, rules of drawing network diagram, Critical path method (CPM), time estimations, types of float, program evaluation review techniques (PERT), estimation of activity time, probability of achieving completion data	08	CO-1
2	Unit-2	Introduction, types of inventory, inventory costs and affecting factors, Deterministic inventory models for single item: Economic order quantity (EOQ) with uniform demand, production & consumption, shortage, EOQ with price breaks; Single period probabilistic inventory models for instantaneous and continuous demand	08	CO-2
3	Unit-3	Introduction, Elements of queuing system: Service Mechanism, Queuing discipline, Customer's behavior; Classification of queuing models: (M/M/1): (∞ /FIFO), (M/M/1): (N/FIFO), (M/M/C): (∞ /FIFO), (M/M/C): (N/FIFO) Models	08	CO-3
4	Unit-4	Introduction to job sequencing, Processing of n-Jobs on 2-Machines, n-Jobs on 3-Machines and 2-Jobs on k-Machines. Introduction, Replacement of items that deteriorate with time, money value constant or varying and maintenance cost increases, Replacement of items that fails suddenly-Individual replacement policy and Group replacement policy	08	CO-4
5	Unit-5	Introduction, types of simulation, application of simulation, limitations and methodology, simulation models, Monte Carlo simulation, random number generation simulation languages	08	CO-5

Reference Books:												
1. H.A. TAHA "Operations Research- An Introduction" Pearson.												
2. K. Swarup, P.K.Gupta and A. Manmohan, "Operations Research", S. Chand.												
3. Hiller And Lieberman, "Introduction to Operations Research", McGraw Hill Company.												
4. J.K.Sharma, "Operations Research ", Pearson												

e-Learning Source:												
https://www.youtube.com/watch?v=4EUAnzLkHFU												
https://www.theorsociety.com/about-or/												
https://www.ieor.columbia.edu/masters/operations-research												

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO- PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
	CO1	3	1	1	1	1	1	3	3	3	2	3
CO2	3	1	1	1	1	1	3	3	3	3	3	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	3	3	3	2	3	3
CO5	3	1	1	1	1	1	3	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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Integral University, Lucknow

Effective from Session: 2022 2023							
Course Code	MT532	Title of the Course	Actuarial Statistics	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To impart knowledge on Actuarial Science concepts like basics of Economics, Financial Accounting and Mathematics						

Course Outcomes	
CO1	Students will be able to understand the concept of Utility theory, insurance and utility theory, models for individual claim and their sums, survival function, curate future life time, force of morality. Life table and its relation with survival function, example, assumptions for fractional ages, some analytic laws of mortality, select and ultimate tables
CO2	Students will be able to understand the distribution of aggregate claims, compound Poisson distribution and its applications, Distribution of aggregate claims, Principles of Compound Interest: nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding
CO3	Students will be able to understand the Life insurance: Insurance payable at the moment of death and at the end of the year of death, endowment insurance, deferred insurance and varying annuities, recursions, complete annuities-immediate and apportion able annuities due
CO4	Students will be able to understand the concept of Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportion able premiums, commutation functions, accumulation type benefits. Payment premium, apportion able premiums, commutation functions, accumulation type benefits
CO5	Students will be able to understand the Net Premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premium, reserves on apportion able or discounted continuous basis, reserves at fractional durations

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Utility theory, insurance and utility theory, models for individual claim and their sums, survival function, curate future life time, force of morality. Life table and its relation with survival function, example, assumptions for fractional ages, some analytic laws of mortality, select and ultimate tables	08	CO-1
2	Unit-2	Distribution of aggregate claims, compound Poisson distribution and its applications, Distribution of aggregate claims, Principles of Compound Interest: nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding	08	CO-2
3	Unit-3	Life insurance: Insurance payable at the moment of death and at the end of the year of death, endowment insurance, deferred insurance and varying annuities, recursions, complete annuities-immediate and apportion able annuities due.	08	CO-3
4	Unit-4	Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportion able premiums, commutation functions, accumulation type benefits. Payment premium, apportion able premiums, commutation functions, accumulation type benefits	08	CO-4
5	Unit-5	Net Premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premium, reserves on apportion able or discounted continuous basis, reserves at fractional durations	08	CO-5

Reference Books:

1. Actuarial Mathematics by N.L. Bower, Gerber, Hickman, D.A. Jones, Nesbit, The society of Actuaries
2. Actuarial Statistics by S.R. Deshmukh, University Press
3. Actuarial Theory by W.A. Robertson and F.A. Ross, Oliver and Boyd, London.
4. Economics by John Solomon, Pearson Education (LPE)
5. Life Insurance Mathematics by Hans U. Gerber, Springer

e-Learning Source:

- https://www.youtube.com/watch?v=9jvzHr_w5W0
- <https://www.youtube.com/watch?v=OSDavDUesPM>
- <https://www.youtube.com/watch?v=IVjACrCPlzQ>

Course Articulation Matrix: (Mapping of COs with POs and PSOs)

PO-PSO CO	Course Articulation Matrix: (Mapping of COs with POs and PSOs)											
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	3	1	1	1	1	1	3	3	3	2	3	3
CO2	3	1	1	1	1	1	3	3	3	3	3	3
CO3	3	1	1	1	1	1	3	3	3	2	3	2
CO4	3	1	1	1	1	1	3	3	3	2	3	3
CO5	3	1	1	1	1	1	3	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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Integral University, Lucknow

Effective from Session: 2022 - 2023							
Course Code	MT533	Title of the Course	Official and Educational Statistics	L	T	P	C
Year	II	Semester	III	3	1	0	
Pre-Requisite		Co-requisite					
Course Objectives	To impart the knowledge of Official Statistics						

Course Outcomes	
CO1	Students will be able to understand the Meaning and sources of official statistics, advantages of present official statistical system in India, Methods of collection of official statistics, their reliability and limitations, Government of India's Principal publications containing data on the topics such as population, agriculture, industry and finance
CO2	Students will be able to understand the Different official agencies responsible for data collection and their main functions, Role of Ministry of Statistics & Program Implementation (MoSPI), concept of Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission
CO3	Students will be able to understand the Role, function and activities of central and state statistical organizations, state statistical bureau, organization of large scale sample surveys, general and special data dissemination systems
CO4	Students will be able to understand the concept of Role, function and activities of Indian statistical institute, Indian agriculture statistics research institute, Indian institute of population studies, Institute of labor research, Statistical and economics departments of Reserve bank of India
CO5	Students will be able to understand the Population growth in developed and developing countries, evaluation and performance of family welfare programs, projections of labor force and manpower, scope and content of population census of India

Unit No.	Title of the Unit	Content of Unit	Contact Hrs.	Mapped CO
1	Unit-1	Meaning and sources of official statistics, advantages of present official statistical system in India, Methods of collection of official statistics, their reliability and limitations, Government of India's Principal publications containing data on the topics such as population, agriculture, industry and finance	08	CO-1
2	Unit-2	Different official agencies responsible for data collection and their main functions, Role of Ministry of Statistics & Program Implementation (MoSPI), concept of Central Statistical Office (CSO), National Sample Survey Office (NSSO), and National Statistical Commission	08	CO-2
3	Unit-3	Role, function and activities of central and state statistical organizations, state statistical bureau, organization of large scale sample surveys, general and special data dissemination systems	08	CO-3
4	Unit-4	Role, function and activities of Indian statistical institute, Indian agriculture statistics research institute, Indian institute of population studies, Institute of labor research, Statistical and economics departments of Reserve bank of India	08	CO-4
5	Unit-5	Population growth in developed and developing countries, evaluation and performance of family welfare programs, projections of labor force and manpower, scope and content of population census of India	08	CO-5

Reference Books:	
1.	Basic Statistics Relating to the Indian Economy (CSO), 1990.
2.	Guide to Official Statistics (CSO) 1999.
3.	Statistical System in India (CSO), 1995
4.	Principles and accommodation of National Population Censuses, UNESCO
5.	Family Welfare Yearbook, Annual Publication of D/o Family Welfare.
6.	Monthly Statistics of Foreign Trade in India, DGCIS, Calcutta and other Govt. Publications.
e-Learning Source:	
	https://www.youtube.com/watch?v=Vs2bzT07GIM
	https://www.youtube.com/watch?v=Vs2bzT07GIM
	https://www.youtube.com/watch?v=Wxqeyhpsw6A

Course Articulation Matrix: (Mapping of COs with POs and PSOs)												
PO-PSO CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
	CO1	3	1	1	1	1	1	3	2	3	2	3
CO2	3	1	1	1	1	1	2	3	3	2	3	3
CO3	3	1	1	1	1	1	3	3	3	2	2	2
CO4	3	1	1	1	1	1	3	3	3	2	2	3
CO5	3	1	1	1	1	1	2	3	3	3	3	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

Name & Sign of Program Coordinator	Sign & Seal of HoD
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