Course outline for M.SC Statistics Semester 4th

S. No.	Course Code	Course Title	Credits	L	T	P	S	Hours per week
1	STA652C	Financial derivative	4	4	0	0	0	4
2	STA651E	Advanced Inference	4	4	0	0	0	4
3	STA653E	Contingencies	4	4	0	0	0	4
4	ACT651E	Economics	4	4	0	0	0	4
5	MTH660E	Operation Research	4	4	0	0	0	4
6	ACT652E	Principles of Insurance	4	4	0	0	0	4
7	STA660E	Quality Control & Reliability	4	4	0	0	0	4
8	STA655C	Time Series Analysis	4	3	0	2	0	5
9	STA690C	Internship & Project	5					

Course Title: Financial Derivatives	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: STA652C	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: Introduces the students regarding the fundamentals of financial derivatives. The students' will also get overview of stock markets and trading strategies involving options.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Understand and evaluate complex dimensions of the financial derivatives
2. Map statistical concepts and techniques to finance for risk assessment
3. Understand to Quantify risks
4. Develop basic financial Decisions

Unit I: Types of Options, Option positions, Underlying Assets , Specification of stock options, Stock option pricing, Factors affecting option prices , Upper and lower bounds for option prices. Trading strategies involving options, Binomial model: One-step and two-step models, Binomial trees. Risk neutral valuation.

Unit II: Brownian Motion, Arithmetic and Geometric Brownian motion, Markov property of Brownian Motion, Ito Lemma, Ito integral, Applying Ito Lemma.

Unit III: Black-Scholes model: Distribution of rate of returns, volatility, risk neutral pricing, Discrete and Continuous Martingale pricing. Idea underlying the Black-Scholes-Merton differential equation. Estimating volatility, the exponential weighted moving average models.

Unit IV: Value at Risk (Var), The GARCH(1,1) models, Maximum likelihood methods **,** Greek Letters and hedging. Interest rate derivatives, Black model.

Textbooks/References:

1. Hull John C. and Basu S. (2010) Options, Futures and Other derivatives, 3rd Prentice hall of India Private Ltd., New Delhi.
2. Sheldon M Ross (2005): An elementary Introduction to Mathematical Finance, Cambridge University Press.
3. Joshi M.S. (2010): The Concept and Practice of Mathematical Finance, Cambridge University Press.
4. Shreve Steven E.(2009) Stochastic Calculus for Finance I: The Binomial Asset Pricing models, Springer.

Course Title: Advanced Inference	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: STA651E	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The main objective of this course is to introduce the elements of statistical decision theory and Bayesian inference.

Course Outcomes: After successful completion of the course students will be able to

1. Distinguish between frequentist and Bayesian approach.
2. Understand concept of Bayesian inference.
3. Solve and analyze the real life problem through the technique of statistical decision theory.
4. Apply the Bayesian inference in real life scenario.

Unit I: Sequential Analysis: Sequential Probability Ratio Test (SPRT). Fundamental relations among alpha, beta, A and B. Determination of A and B in practice. Wald's fundamental identity, Operating characteristic and Average sample number functions. Proof of the ultimate termination of SPRT for simple hypothesis. Applications based on Bernoulli, Binomial, Poisson, Normal and Exponential distributions.

Unit II: Fundamentals of Bayesian Statistics, Overview of Classical and Bayesian Estimation. Advantages of Bayesian inference, Prior distribution and its types, proper prior, improper prior, conjugate and non-conjugate prior, Jeffrey's prior, informative and non-informative priors. Posterior distribution, Bayesian method of estimation for Binomial, Poisson, Normal, exponential, Gamma, Weibull and Rayleigh distributions by using various types of priors.

Unit III: Concept of loss and risk functions, Loss functions: squared error and weighted squared error loss, 0-1, absolute error, entropy and LINEX loss functions, Bayes Principle, normal and extensive form of analyses. Bayes estimation under various loss functions.

Unit IV: Bayesian credible intervals, highest posterior density intervals, testing of hypotheses. Comparison with classical procedures. Bayesian approximation techniques: Normal approximation, Lindley approximation, Monte-Carlo Integration, Accept-Reject Method, Idea of Markov chain Monte Carlo technique.

Textbooks/References:

1. Berger, J.O.: Statistical Decision Theory and Bayesian Analysis, Springer Verlag.
2. Robert, C.P. and Casella, G.: Monte Carlo Statistical Methods, Springer Verlag.
3. Rohatgi, V. (1988): An Introduction to Probability and Mathematical Statistics.Wiley Eastern Ltd. New Delhi (Student Edition).
4. Casella G, Berger R. L. (2001). Statistical Inference, 2/e, Cengage Learning Pvt. Ltd.
5. J.K.Ghosh, D.Delampady and T. Samanta. (2006). Introduction to Bayesian Inference, Theory & Methods, Springer.

Course Title: Operations Research	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: MTH660E	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: The aim of the course is to give knowledge to students to use quantitive methods and techniques for effective decisions–making; model formulation and applications that are used in solving business decision problems.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Identify, formulate and analyze mathematical models to optimize organizational resources and maximize profit in real-life situations.
2. Apply linear programming and its extensions to solve decision-making problems using appropriate mathematical tools.
3. Evaluate strategic decision problems using game theory concepts and methods.
4. Solve transportation and assignment problems effectively to achieve cost optimization.
5. Analyze and interpret results from network models and queuing theory to improve operational efficiency.

Unit I: Linear programming; concept and uses of linear programming, formulation of linear programming problem. Solution of LP problem- graphical method, simplex method. Duality in linear programming, properties of the primal-dual pair- Dual simplex method. Complementary slackness theorem and complementary slackness conditions.

Unit II: Transportation and Assignment problems: Formulation of transportation and assignment problems as linear programs. Methods of obtaining the initial basic feasible solution to a transportation problem. Solution of the Transportation problem by MODI Method. Unbalanced transportation problems and their solutions. Degeneracy in Transportation problem and its resolution. Solution of Assignment Problem by Hungarian Method.

Unit III: Sequencing problems- problems with n jobs and 2 machines, problems with n jobs and k machines. Games and Strategies: Two person zero-sum games, Maximin-Minimax Principle, Mixed Strategies, Solution of 2×2 and $m\times n$ games.
Concept of PERT/CPM networks, estimating the activity time, determination of earliest expected and latest allowable times, determination of critical path Drawing network diagram, probability consideration in PERT networks PERT/CPM- cost analysis, applications of PERT/CPM.

Unit IV: Integer Programming: Gomory's Cutting Plane algorithm & branch and bounded method for all integer and mixed integer, Dynamic programming: Single additive constraint; additive separable return, single multiple constraints; additive separable returns, Single additive constraints; multiple separable returns.

Textbooks/References:

1. Hillier & Liberman: Introduction to Operations Research, Mc. Graw Hill Book Co.
2. Taha, H.A.: Operations Research-An introduction, Pentice Hall of India Pvt. Ltd. New Delhi. (7th Edition-2003).
3. Swaroop K, Gupta, P.K. & Mohan, M.: Operations Research, Sultan Chand & Sons, New Delhi.
4. Vohra, N D: 'Quantitative Techniques in Management' Tata McGraw Hill
5. Sharma S.D.: 'Operational Research', Kedar Nath Ram Nath and Co., Meerut

Course Title: Quality Control and Reliability	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: STA660E	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The main purpose of this paper is to introduce the most important field of applied statistics that contributes to quality control in almost all industries.

Course Outcomes: At the end of this course, a student will have developed ability to:

1. Apply the knowledge of statistics and probability to attain the quality improvement in industries.
2. Understand and apply control charts for variables and attributes.
3. Analyze the product quality using statistical tools.
4. Explain simple and double sampling plans and discuss the measures for the evaluation of performance of sampling plans.
5. Determine the reliability and maintainability of systems.

Unit I: Meaning and scope of SQC, Stewarts control chart, Statistical basis of a control chart, control chart for variables (X, R, & S) charts. Control charts for attributes (np, p & C) charts. Moving average charts. Operating Characteristic function (OC) and Average Run length (ARL) of X-bar chart.

Unit II: Consumer and producer's risk, Operating Characteristic curve/function (OC). Corrective Sampling Plan (CSP), Average Sample Number (ASN), Average out-going Quality (AOQ), Graphical method of drawing AOQ, Average out-going Quality Limit (AOQL), Single Sampling Plan, Methods of finding n and c, Double Sampling Inspection Plan and sequential sampling plan.

Unit III: Capability indices Cp, Cpk and Cpm. estimation, confidence intervals relating to capability indices for normally distributed characteristics. Reliability concepts, hazard rate, distribution of longevity and moments. Some important theorems based on reliability theory.

Unit IV: Common life time distributions: exponential, Weibull, gamma, Gumbel and Rayleigh distributions. Type I and Type II censored samples. Reliability and hazrad rate of a system with independent units connected in (a) series and (b) Parallel systems.

Textbooks/References:

1. Barlow, R.E. and Proschan, F. (1985). Statistical Theory of Reliability and Life Testing; Holt, Rinehart and Winston.
2. Biswas, S.(1996). Statistical Quality Control, Sampling Inspection and Reliability; New Age International Publishers.

3. Montgomery, D.C. (1985) Introduction to Statistical Quality Control; Wiley.
4. Phadke, M.S. (1989) Quality Engineering through Robust Design; Prentice Hall.
5. Wetherill, G.B. (1977) Sampling Inspection and Quality Control; Halsted Pres

Course Title: Economics	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: ACT651E	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: To understand the concepts of cost, nature of production and its relationship to business operations.

Course Outcomes: At the end of this course, a student will have developed ability to:

1. Understand fundamentals of decision making of consumers and producers.
2. Understand the basics of demand and supply.
3. Understand and measure the degree to which demand responds to changes in income and prices of related commodities.
4. Understand how consumers make consumption decision.

Unit I: Interaction between supply and demand, elasticity and its calculation. Utility theory, utility function, risk aversion, dominance and its various types, its applications to insurance problems. Cost and revenue, profit maximization.

Unit II: Different sorts of markets. Microeconomic principles to understand markets, competitive firm, long run costs game theory, surplus economics.

Unit III: Public Sector finances direct and indirect taxes. Progressive and regressive systems of taxation, revenue and expenditure of the government's Debt Repayment and National Debt. National income: GDP, GNP, NNP, Effects of propensity to save or to consume by public or private sector on national income.

Unit IV: Fiscal and monetary policies, government interventions, banking system, Exchange rates, international trade and BoP. Factors affecting inflation, interest rates, exchange rates, unemployment and growth.

Textbooks/References:

1. Begg, D., Ficher, S. and Dornbusch,R.(2005). Economics, 7th edition McGraw Hill.
2. Sloman, J. and Hinde, K. (2007): Economics for Business, 4th edition, Prentice Hall
3. A.Nag, (2004) Macroeconomics for Management Students, Macmillan Publishers India Limited
4. Institute of Actuaries core reading material for *CT7.Economics (2013).*

Course Title: Principles of Insurance	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: ACT652E	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: Introduces the students to understand the insurance mechanism and to identify the relationship between insurers and their customers.

Course Outcome: Upon successful completion of this course, the student will be able to:

1. Understand different types of insurable risk.
2. Learn about different insurance products
3. Understand Basic Principles of Insurance.
4. Learn insurance Terminology.

Unit I: The concept of risk, kinds and classification of risk, assessment, transfer risk, appraisal risk selection, underwriting risk appraisal, Mortality tables, physical and moral hazards, representations, warranties, conditions.

Unit II: The business of insurance-risk managed by individuals, risk managed by insurers, premium fixing, reinsurance and its important role of insurance in economic development, the insurance market, role of intermediaries, specialists regulators.

Unit III: Insurance customers, types of customers, customer mindset and customer satisfaction, importance of ethical behaviour

Unit IV: Basic principles of Insurance, utmost good faith, insurable Interest- material facts, economic principles of Insurance Sharing, Subrogation, contribution, Legal principles of Insurance, Actuarial principles.

Unit V: Insurance terminology-terms that are specific to life insurance, traditional product offered by life insurance companies, features of MODULE linked policies, features of annuities and group policies, Insurance terminology specific to general insurance, products offered by non-life insurance companies.

Textbooks/References:

1. Neelam C Gulati “Principles of Insurance Management” (2007). Excel Books, New Delhi.
2. Harriett E Jones “Principles of Insurance “FLMI Insurance Education Program. Life Management Institute LOMA, (Dec 1995).
3. Robert I Mehr “Principles of Insurance” Richard Irwin edition, (8th Edition, 1985).
4. Ben G Baldwin (2002).The New Life Insurance Investment Advisor” 2nd Edition. Mc Graw Hill.

5. Black and Skipper (2000). “Life and Health Insurance”, Pearson Education

Course Title: Contingencies	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: ACT653E	**4**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 4					

Course Objective: Introduces the students the mathematical techniques which can be used to model and value cash flows dependent on death, survival or other uncertain risks and also help to calculate premium and reserve for the insurance company.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Demonstrate a foundational understanding of life insurance principles, including traditional and variable insurance products.
2. Apply mathematical models to evaluate cash flows dependent on life contingencies and mortality patterns.
3. Compute net premiums for various life insurance and annuity products using actuarial methods.
4. Determine gross premiums and reserves using both prospective and retrospective approaches.
5. Interpret and utilize actuarial functions, mortality laws, and life tables in insurance computations.

Unit I: Introduction to life Insurance; traditional and variable insurance, contract design, Future life time random variable, its distribution function and density function, concept of force of mortality, curtate future life time random variable its probability mass function, deferred probabilities, all these functions in terms of international actuarial notation

Unit II: Joint life status, last survival status, their distribution and density functions, analytical laws of mortality such as Gompertz and Makeham, single and multiple decrement life table, select and ultimate life table.

Unit III: Assurance and annuity contracts with level and varying benefits, formulae for the means and variances of the present value random variables of the payments under these contracts under the assumption of constant force of interest, in discrete and continuous set up.

Unit IV: Net premiums for insurance products and annuity schemes defined in (3), gross premiums. Concept of reserve, prospective & retrospective approach.

Textbooks/References:

1. Bowers, JR. N.L., Gerber, H.U., Hickman, J.C., Jones, D.A. and Nesbitt, C.J. (1997). Actuarial Mathematics, Second Edition, The Society of Actuaries. Sahaumburg, Illinois.

2. Palande, P. S., Shah, R. S. and Lunawat, M. L.(2003). Insurance in India – Changing Policies and Emerging Opportunities, Response Books, New Delhi.
3. Harriett, E.J. and Dani, L.L.(1999).Principles of Insurance: Life,Health, and Annuities,Second Edition, Life Office Management Association, Inc. Atlanta, Georgia. 8
4. Neill, Alistair (1977). Life Contingencies, The Institute of Actuaries, London.
5. Gerber, H.U.(1997) Life Insurance Mathematics,3/e Springer, Swiss Association of Actuaries.

Course Title: Time Series Analysis	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: ACT655C	**3**	**x**	**2**	**x**	**Max Marks**: 100
Credits: 4					

Course Objectives: The objective of this course is to develop an understanding of regression modeling and time series forecasting techniques, enabling students to analyze, interpret and predict real-world data using appropriate statistical and computational methods.

Course Outcomes: Upon successful completion of this course, the student will be able to:

1. Apply regression techniques for modeling relationships between variables and interpreting results.
2. Perform diagnostic checks and validate assumptions in multiple regression analysis.
3. Decompose time series data into its components and apply smoothing methods for forecasting.
4. Implement ARIMA and seasonal models for time series prediction and model diagnostics.
5. Analyze and interpret multivariate time series models such as VAR and VMA processes.

Unit I: Simple Linear Regression: Estimation of the model parameters. Least-squares estimates and their properties. Maximum likelihood estimation. Hypothesis testing in simple linear regression. Tests for significance of regression, tests on individual regression coefficients. Confidence intervals in simple linear regression and prediction of new observation. Extension to Multiple linear regression, Residual Analysis, Multicollinearity, Variable selection methods

Unit II: Time Series, Time Series Components, Principle of Decomposition, Moving Average, Exponential Smoothing Methods: Simple exponential smoothing, Holt linear method, Holt – Winter's seasonal method and Pegels classification.

Unit III: The Box-Jenkins Methodology for ARIMA Models: Autoregressive models, Moving Average models, Examining Correlation in Time Series Data, Examining Stationarity in Time Series Data, Non- seasonal/Seasonal ARIMA Models for Time Series Data, Parameter Estimation for ARIMA models, Diagnostic Checking of ARIMA models, Forecasting with ARIMA models

Unit IV: Multivariate Time series processes, Moments, Cross Moments and Stationarity, Wold representation, Cross spectrum analysis of bivariate time series processes, cross spectrum, coherency spectrum and squared coherency, amplitude and phase spectrum. Vector ARMA processes, Stationarity and invertibility conditions, Vector moving average processes, Vector Autoregresive (VAR) Processes.

Textbooks/References:

1. Montgomery D. C, Peck E. A, Vining G. G. (2012). *Introduction to Linear Regression Analysis*, 5th Edition, Wiley.
2. Spyros G. Makridakis, Steven C. Wheelwright, Rob J Hyndman (2015). *Forecasting: Methods and Applications*, 3rd Edition, Wiley.
3. Box George E. P, Jenkins G. M., Reinsel G. C. (2009): *Time Series Analysis-Forecasting and Control*, 3rd Ed., Pearson Education.
4. Hyndman, R.J., & Athanasopoulos, G. (2018) *Forecasting: principles and practice*, 2nd edition, OTexts: Melbourne, Australia

Course Title: Project/Internship	**L**	**T**	**P**	**S**	**Semester:** 4th
Course Code: STA690C	**5**	**x**	**x**	**x**	**Max Marks**: 100
Credits: 5					