Postgraduate Diploma in Actuarial Science

A module for Postgraduate diploma in Actuarial Science is offered for both the students of the MS program as well as for those who want to take these courses in order to prepare themselves for certificates in Actuarial Science. In addition to other undergraduate and graduate courses, the courses for Actuarial Science are offered simultaneously. After the successful completion of these courses, each participant will receive a diploma certificate and grade report. The courses will be taught at night or weekends. This course is designed to prepare students for Actuarial profession, which is concerned with the application of mathematical and statistical techniques to problems in: life insurance, casualty insurance, pension funds, medical schemes, investment plans and market structures among others. The course is primarily intended for graduates with a good mathematics background. The students of the applied statistics program will be waived from taking some of the courses already completed in their undergraduate/graduate studies.

A total of 13 core courses and 3 optional courses are offered under this module. A student would be able to complete these courses within 3 semesters.

Who May Apply
An acceptable prerequisite are:
(a) A four-year B.S. (Honours)/B.Sc. (Honours) in Applied Statistics/ Statistics, (b) A three-year undergraduate degree or one/two year Masters degree in Statistics, or (c) a four-year B.Sc. undergraduate degree or three-year undergraduate degree and one year Masters degree in science/social science/business. Students with background mentioned in (c) will have to undertake some courses on preliminaries of Statistics and Mathematics. The courses will be assigned by the course advisor after reviewing the background of the students.
(b) Minimum GPA of 3 out of 5/ 2nd Division in both SSC and HSC Examinations and 2.5 out of 4/ 2nd class at the undergraduate level.

Tuition Fees
Students are required to pay initial admission, tuition and computer lab fees. The current fees structure is:

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount in TK.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admission Fee</td>
<td>15000</td>
</tr>
<tr>
<td>Tuition Fee Per Credit</td>
<td>3100</td>
</tr>
<tr>
<td>Lab Fee Per Semester</td>
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<tr>
<td>Library Fee Per Semester</td>
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<td>Students Activity Fee</td>
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</table>
Credit Distribution:

Core Courses: Students must complete these courses to get a postgraduate diploma in Actuarial Science.

<table>
<thead>
<tr>
<th>Course Title and Course Code offered in Postgraduate Diploma in Actuarial Science Program</th>
<th>Credit</th>
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</thead>
<tbody>
<tr>
<td>ASTD 501 : Financial Mathematics</td>
<td>3</td>
</tr>
<tr>
<td>(CT1: Financial Mathematics)</td>
<td></td>
</tr>
<tr>
<td>ASTD 502 : Introduction to Statistics and Probability</td>
<td>3</td>
</tr>
<tr>
<td>(CT3: Probability and Mathematical Statistics Core Technical)</td>
<td></td>
</tr>
<tr>
<td>ASTD 503 : Probability and Sampling Distribution</td>
<td>3</td>
</tr>
<tr>
<td>(CT3: Probability and Mathematical Statistics Core Technical)</td>
<td></td>
</tr>
<tr>
<td>ASTD 504 : Statistical Inference</td>
<td>3</td>
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<td>(CT3: Probability and Mathematical Statistics Core Technical and CT4 : Models Core Technical)</td>
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<tr>
<td>ASTD 505 : Applied Regression Analysis and Time Series Data</td>
<td>3</td>
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<tr>
<td>(CT3: Probability and Mathematical Statistics Core Technical and CT6:Statistical Methods Core Technical)</td>
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</tr>
<tr>
<td>ASTD 506 : Analysis of Variance and Design of Experiments</td>
<td>3</td>
</tr>
<tr>
<td>(CT3: Probability and Mathematical Statistics Core Technical)</td>
<td></td>
</tr>
<tr>
<td>ASTD 507 : Demography</td>
<td>3</td>
</tr>
<tr>
<td>(CT4 : Models Core Technical)</td>
<td></td>
</tr>
<tr>
<td>ASTD 508 : Advanced Probability and Stochastic Process</td>
<td>3</td>
</tr>
<tr>
<td>(CT4 : Models Core Technical and CT6:Statistical Methods Core Technical)</td>
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</tr>
<tr>
<td>ASTD 509 : Survival Analysis</td>
<td>3</td>
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<tr>
<td>(CT4 : Models Core Technical)</td>
<td></td>
</tr>
<tr>
<td>ASTD 510 : Generalized Linear Models</td>
<td>3</td>
</tr>
<tr>
<td>(CT4 : Models Core Technical and CT6:Statistical Methods Core Technical)</td>
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</tr>
<tr>
<td>ASTD 511 : Life Contingencies I</td>
<td>3</td>
</tr>
<tr>
<td>(CT5: Contingencies Core Technical)</td>
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<tr>
<td>ASTD 512 : Life Contingencies II</td>
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<td>(CT5: Contingencies Core Technical)</td>
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<tr>
<td>ASTD 513 : Bayesian Inference, Decision Theory and Theory of Games</td>
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<td><strong>Total</strong></td>
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</table>
**Optional Courses:** In addition to the core courses, students can take one or more of the following courses as optional choices for strengthening their scope of learning.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>ASTD 514: Advanced Multivariate Statistical Analysis</td>
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<tr>
<td>ASTD 515: Linear Models</td>
<td>3</td>
</tr>
<tr>
<td>ASTD 516: Econometrics</td>
<td>3</td>
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</table>
# Table of Contents

<table>
<thead>
<tr>
<th>Course Title and Course Code offered in Postgraduate Diploma in Actuarial Science Program</th>
<th>Credit</th>
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<tbody>
<tr>
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<tr>
<td>(CT1: Financial Mathematics)</td>
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<td>ASTD 502 : Introduction to Statistics and Probability</td>
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<tr>
<td>ASTD 503 : Probability and Sampling Distribution</td>
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<td>ASTD 504 : Statistical Inference</td>
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<td>ASTD 505 : Applied Regression Analysis and Time Series Data</td>
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<td>ASTD 507 : Demography</td>
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<tr>
<td>ASTD 508 : Advanced Probability and Stochastic Process</td>
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<td>ASTD 509 : Survival Analysis</td>
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<td>ASTD 510 : Generalized Linear Models</td>
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<tr>
<td>ASTD 511 : Life Contingencies I</td>
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<td>ASTD 512 : Life Contingencies II</td>
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<td>ASTD 513 : Bayesian Inference, Decision Theory and Theory of Games</td>
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<td>ASTD 514 : Advanced Multivariate Statistical Analysis</td>
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<td>ASTD 515 : Linear Models</td>
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<tr>
<td>ASTD 516: Econometrics</td>
<td>3</td>
<td>21</td>
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</table>
Syllabus for Actuarial Science

Core Courses:

Subject CT1-- Financial Mathematics

Course to be covered: ASTD 501

ASTD 501: Financial Mathematics

Pre-requisite for CT1

- A generalized cash flow model for financial transactions
- Concepts of compound interest and discounting
- Interest or discount rates in terms of different time periods
- Concepts of real and money interest rates
- Calculation of present value, accumulated value and net present value assuming a constant rate of inflation
- Annuities
- Definition of an equation of value
- Repayment of loan by regular installments
- Discounted cash-flow techniques
- Investment and risk characteristics
- Analysis of elementary compound interest problems
- Arbitrage free pricing methods
- Term structure of interest rates
- Simple stochastic models for investment returns

References:


Subject CT3 – Probability and Mathematical Statistics Core Technical

Courses to be covered:

1. ASTD 502: Introduction to Statistics and Probability
2. ASTD 503: Probability and Sampling Distribution
3. ASTD 504: Statistical Inference
4. ASTD 505: Applied Regression Analysis and Time Series Data Analysis
5. ASTD 506: Analysis of Variance and Design of Experiments

Additional Reference:


ASTD 502: Introduction to Statistics and Probability Credit-3

Prerequisite for CT3

- **Statistics and its origin:**
  Definition, Characteristics, Uses & Importance, Population & Sample, Sources of Statistical Data, Parameter and Statistic.
- **Summarizing Data:**
  Data, Level of Measurement, Variable and attribute, Summarizing and Presenting Data, Frequency Distribution, Presenting Data by Graphs and Diagrams,
- **Descriptive Statistics I: Measures of Central Tendency**
  Measures of central tendency, arithmetic mean, median, quartiles, percentiles and deciles, mode, geometric mean, harmonic mean, other measures of average, stem and leaf plot
- **Descriptive Statistics II: Measures of Dispersion**
  Measures of dispersion, empirical relations among measures of dispersion, moments, shape characteristics of a distribution, box and whisker plots.
- **Simple Linear Regression and Correlation:**
  Correlation analysis, measuring the correlation, rank correlation, regression analysis, simple linear regression model, scatter diagram, least square method, properties of regression coefficient, partitioning of the total variation in regression, Coefficient of multiple determination
- **Probability:**
  Meaning, definition, scope, set theory, sample space, elements of set theory; axiomatic definition of probability. Permutation and Combination
- **Conditional Probability**
  Conditional probability and rules of probability for dependent and independence cases; Bayes theorem;
- **Probability function**
  Random variables; probability density function; Distribution function; joint probability function; marginal and conditional distributions.
- **Mathematical expectations;**
  Mathematical Expectation, expectations of sums and products of random variables; variance, Conditional expectation and variance.

References:


**ASTD 503: Probability and Sampling Distribution**

**Credit-3**

**Prerequisite for CT3**

- Discrete Probability Distributions: Bernoulli, binomial, Poisson, geometric, negative binomial, Hypergeometric, uniform
- Continuous Probability Distributions: uniform, exponential, gamma, beta, normal, log-normal, Weibull
- Identification of Moment and cumulant generating functions; characteristic function of discrete and continuous distributions
- Determination of probability generating function of discrete and integer-valued random variables
- Sampling: basic concepts of random samples, sampling and sampling distribution
- Expectations of functions of random variables: expectation two ways, sums of random variables, product and quotient;
- Independence of random variables, mean and variance of linear combinations of random variables
- Deriving distributions of the linear combinations of random variables
- Cumulative distribution function technique, Moment generating function technique: Transformations technique.
- law of large numbers, central limit theorem, Bernoulli and Poisson distribution, exponential distribution, uniform distribution, Cauchy distribution;
- Sampling distribution: the normal distributions, chi-square distribution, the F-distribution, Student’s t-distribution.
- Cauchy-Schwartz, Markov and Chebyshev’s inequality

**References:**


ASTD 504: Statistical Inference

Prerequisite for CT3 & CT4

- **Methods of finding estimators**: methods of moments, maximum likelihood, and other methods;
- **Properties of point estimators**: closeness, mean-squared error, loss and risk functions;
- **Sufficiency**: sufficient statistics, factorization criterion, minimal sufficient statistics, ancillary statistics;
- **Completeness**: complete statistics, exponential family;
- **Likelihood Functions**
- **Parameter Estimation (point and interval)**: Maximum Likelihood estimation, Bayesian estimation
- **Large sample properties and procedures**
- **Empirical distribution function**
- **Introduction to test of hypothesis**: Best critical region, Most powerful tests, Concept of confidence interval, Confidence interval for parameters
- **Parametric tests**: Basic concepts, Simple hypothesis & composite hypothesis, critical region, best critical region, Neyman-Pearson fundamental lemma, most powerful tests, uniformly most powerful critical region, UMP tests.
- **Non-Parametric Tests**: Goodness-of-fit Tests (Kolmogorov-Smirnov two-sample test for general differences, Run test), Sign test and associated interval and point estimates for one-sample data, Signed rank test, interval and point estimates for one-sample data, Wilcoxon signed rank test, Wilcoxon sum rank test, Mann-Whitney U test, Kruskal-Wallis test, Asymptotic relative efficiency comparisons, Rank sum test, interval and point estimates for two-sample data, One-Way Layout: tests and multiple comparison procedures, Two-Way Layout: tests and multiple comparison procedures, Kendall’s tau procedures for independence of two random variables

**References:**


ASTD 505: Applied Regression Analysis and Time Series Data Analysis  Credit-3

Prerequisite for CT3

Regression Analysis:

Simple Linear Regression Model
Regression analysis, simple linear regression model, scatter diagram Least squares estimation, Estimation of variance

Inferences for Simple Linear Model
Inferences, Confidence interval estimation, Prediction of interval, Analysis of Variance, R-square

Diagnostic Procedures for Aptness of model
Residual analyses, Transformations as solution to problems with the model

Multiple Regression Models and Estimation
Extension to simple linear model, Basic estimation and inference for multiple regression, Generalized Least Squares and Weighted Least Squares, Extra Sum of Squares Principles and related Tests
Multicollinearity, Model diagnostics and Selecting the Best Regression Equations

Time Series Analysis:
**Introduction to Time Series:** Examples of time series, Objectives, Types of variation, Stationarity, Trends and Seasonal Components, No Seasonal Component, Trend and Seasonality, time plot

**The Autocovariance of a Stationary Time Series:** Strict stationarity, applied to stationary time series, drawbacks of shift operator, backwards difference, the spectral density, Time series models, Box-Jenkins Model, concept of a filter, root characteristic equation of time series, Estimation of the mean and the autocovariance

**The Wold decomposition and Partial correlation:** Partial autocorrelation, AR process, MA process, ARMA processes, Calculation of the ACVF, Prediction of an ARMA Process, conintegrated time series, ARIMA time series

**Random Walk:** Concept and properties of discrete random walks and random walks with normally distributed increments, both with and without drift

**Multivariate Autoregressive Model:** Concept

**Forecasting:** Introduction, univariate procedures, multivariate procedures, comparative review of forecasting procedures, prediction theory

**Identification, Estimation and Diagnosis of a Time Series:** Criteria for choosing between models, diagnostic tests applied to residuals

Reference:

ASTD 506: Analysis of Variance and Design of Experiments Credit-3

Prerequisite for CT3

**The analysis of Variance:**
Some typical examples of experimental design; basic principles, ANOVA, Analysis of fixed effects, random effect and mixed effect model; estimation of model parameters; model adequacy checking; regression model; comparisons among treatment means, graphical comparisons of means, contrasts, orthogonal contrasts, multiple testing, Scheffe's method, comparing pairs of treatment means, comparing treatment means with a control; Determining sample size; operating characteristic curve, least squares estimation of the model parameters, normality test.

**Design of Experiments:**
Complete randomize design (CRD), Randomized blocks design (RBD), Latin squares design (LSD), model adequacy checking; estimating model parameters; example of real life application of these methods, model adequacy checking; estimating model parameters; Gareco-Latin square design; balanced incomplete block design (BIBD); statistical analysis of BIBD; least squares estimation of BIBD; example of real life application of these methods.

**Introduction to Factorial Designs:** Basic definition and principles; The advantage of factorials; The two-factor factorial design; statistical analysis of fixed effects model, model adequacy checking, estimating the model parameters, choice of sample size, the assumption of no interaction in a two-factor model, one observation per cell; The general factorial design; Fitting response curve and surfaces; Blocking in a factorial design.

**Analysis of Covariance:** Description of the procedure; Factorial experiments with covariates.

References:

Subject CT4 – Models Core Technical

Courses to be covered:

1. 507: Demography
2. 508: Advanced Probability and Stochastic Process
3. 509: Survival Analysis
4. 510: Generalized Linear Models
5. 504: Statistical Inference

ASTD 507: Demography

Credit-3

Prerequisite for CT4

Introduction: Basic concept of demography; Role and importance of demographic/population studies; Sources of demographic data: census, vital registration system, sample surveys, population registers and other sources especially in Bangladesh.

Errors and Adjustment of demographic data: types of errors and methods of testing the accuracy of demographic data, Quality checking and adjustment of population data. Post enumeration check (PEC) and detection of errors and deficiencies in data and the needed adjustments and corrections.

Fertility: Basic measures of fertility. Crude birth rate, age specific fertility rates (ASFR), general fertility rate (GFR), total fertility rate (TFR), gross reproduction rate (GRR) and net reproduction rate (NRR), child-woman ratio, Concept of fecundity and its relationship with fertility.

Demographic Theory: Transition theory and the present situation in Bangladesh, Malthus' theory and its criticism. Mortality: Basic measures of mortality: crude death rate (CDR), age specific death rates (ASDR), infant mortality rate, child mortality rate, neo-natal mortality rate, Standardized death rate its need and use, Direct and indirect standardization of rates, Commonly used ratios: Sex ratio, child-woman ratio, dependency ratio, density of population.

Nuptiality: Marriage, types of marriage, age of marriage, age at marriage and its effect on fertility, celibacy, widowhood, divorce and separation, their effect on fertility and population growth.
**Migration**: Definition, internal and international migration, Sources of migration data, Factors affecting both internal and international migration, laws of migration. Impact of migration on origin and destination, its effect on population growth, age and sex structure, labor supply, employment and unemployment, wage levels, and other socio-economic effects, Migration of Bangladeshis abroad and its impact on overall economic development of the country.

**Graduation of data**: Meaning and its need, techniques of graduation, graduation of age distribution.

**Life Table**: Its concept, structure and calculation, complete life table (life table by single year of age) and abridged life table, multiple decrement life tables, working life table, different life table functions and inter-relationships among them, use of life table, etc.

Stable and stationary population, their characteristics and uses, Lotka's characteristics equation, intrinsic birth and death rates, effect of uniform drop in force of mortality on the growth rate, effects of changes in fertility and mortality on the age distribution of population. Model life tables, Coale and Demeney regional model life tables.

**References**:


• Modern probability: probability as a set function; Borel field and extension of probability measure;
• Probability measure notion of random variables; probability space; distribution function; expectations and moments.
• Convergence of random variables; Laplace transformation.
• Stochastic Process: Introduction, distinction between deterministic and stochastic models
• Markov Chains: introduction, transition probability matrices of a Markov chain, First step analysis; Some special Markov chains; Regular transition probability matrices;
• The classification of states; Basic limit theorem of Markov chain; Reducible Markov chains; Lundberg’s inequality
• Poisson process: the Poisson distribution, counting and Poisson process; the law of rare events;
• Continuous time Markov chains: pure birth processes; pure death processes; birth and death processes;
• Limiting behavior of birth and death processes; birth and death process with absorbing states; finite state continuous time Markov chains.
• Renewal theory and its applications: introduction, distribution of N(t), limit theorems and their applications,
• renewal reward process regenerative process, semi-Markov process, queuing process
• the connection between Poisson process and the Poisson distribution, Poisson process as
  i. the distribution of waiting between events
  ii. the distribution of process increments
  iii. the behavior of the process over an infinitesimal time interval
• Compound Processes: Compound Binomial, Compound Poisson, Compound Negative Binomial Random variables

References:
ASTD 509: Survival Analysis

- Basic Concepts & Models: Introduction, lifetime distribution, continuous model, discrete model, hazard function, exponential distribution, Weibull distribution, log-normal distribution, log-logistic distribution, gamma distribution, regression models
- Observation schemes, Censoring & Likelihood: Types of censoring and maximum likelihood, Truncation
- Some Nonparametric & Graphical Procedures: Nonparametric estimation of a survivor function and quantiles, Non parametric methods for estimating survival function and variance of the estimator viz. Acturial and Kaplan- Meier methods product limit estimate, Nelson-Aalen estimate, plots involving survivor or cumulative hazard function, estimation of hazard or density function, methods for truncated and interval censored data, life tables
- Inference Procedure for Parametric Models: Inference procedure for exponential distribution, for gamma distribution, models with polynomial based hazard function, grouped, interval censored or truncated data
- Semi-parametric Multiplicative Hazards regression Model: Introduction, estimation of parameters, inclusion of strata, time-dependent covariates, residuals and model checking, methods for Grouped or discrete lifetimes, related topics on the Cox model.
- Rank-Type Procedures for Log-Location-Scale models: Rank tests for comparing distributions, estimation for semi-parametric accelerated failure time models.
- Multiple Modes of Failure: Basic characteristics of model specification, likelihood functions formulation, nonparametric methods, parametric methods, semi-parametric methods for multiplicative hazards model.
- Logistic regression, Goodness of fit test, Test of fit of regression model: Location-scale regression models.

References:

ASTD 510: Generalized Linear Models  Credit-3

Prerequisite for CT4 & CT6

Generalized linear models: exponential family of distributions; Properties of distributions in Exponential family, Component of GLM, Random systematic link function


Inference: sampling distribution for scores, sampling distribution for maximum likelihood estimators, Confidence intervals for model parameters, adequacy of a model, sampling distribution for log-likelihood statistic, log-likelihood ratio statistic (deviance), assessing goodness of fit, hypothesis testing;

Multiple Regression: maximum likelihood estimation, log-likelihood ratio statistic;

Models for binary responses: probability distributions, generalized linear models, general logistic regression, maximum likelihood estimation and log-likelihood ratio statistic, other criteria for goodness of fit, least square methods; Multinomial distributions; Nominal logistic regression models; Ordinal logistic regression models;

Models for count Data: probability distributions, log-linear models, maximum likelihood estimation, Hypothesis testing and goodness of fit

References:

ASTD 504: Statistical Inference  Credit-3
Prerequisite for CT3 & CT4

- Methods of Finding Estimators: methods of moments, maximum likelihood, and other methods;
- Properties of Point Estimators: closeness, mean-squared error, loss and risk functions;
- Sufficiency: sufficient statistics, factorization criterion, minimal sufficient statistics, ancillary statistics;
- **Completeness**: complete statistics, exponential family;
- **Likelihood Functions**
- **Parameter Estimation (point and interval)**: Maximum Likelihood estimation, Bayesian estimation
- Large sample properties and procedures
- Empirical distribution function
- **Introduction to Test of Hypothesis**: Best critical region, Most powerful tests, Concept of confidence interval, Confidence interval for parameters
- **Parametric Tests**: Basic concepts, Simple hypothesis & composite hypothesis, critical region, best critical region, Neyman-Pearson fundamental lemma, most powerful tests, uniformly most powerful critical region, UMP tests.
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**References:**


Subject CT5 – Contingencies Core Technical

Courses to be covered:

1. ASTD 511: Life Contingencies I
2. ASTD 512: Life Contingencies II

**ASTD 511: Life Contingencies I**

**Credits-3**

**Prerequisite for CT5**

**Introduction to Life insurance**: life insurance and annuity contracts, pension benefits, mutual and proprietary insurers

**Survival Models**: Actuarial notation, future lifetime random variable, force of mortality, curtate future lifetime

**Life tables and Selection**: Life tables, fractional age assumptions, national life tables, survival models for life insurance policy holders, mortality trends

**Insurance Benefits**: assumptions, valuation of insurance benefits

**Annuities**: Annual annuities, annuities payable continuously, increasing annuities, evaluating annuity functions

**Premiums**: Preliminaries, assumptions, future loss random variable, the equivalence principle

**Policy Values**: Policy with annual cash flows, policy with continuous cash flows, policy alterations

**Multiple State Models**: Alive Dead Model, Permanent disability model, the disability income insurance model, Markov multiple state models in discrete time,

**Joint Life and Last Survivor Benefits**: Joint life and last survivor benefits, a multiple state model for independent future lifetimes, a model with dependent future lifetimes, the common shock model.
References:


**ASTD 512: Life Contingencies II**

**Credits: 3**

**Prerequisite for CT5**

Review of Survival Models, Life tables and Selection, Multiple State Models, Joint Life and last Survivor benefits

**Pension Mathematics:** Summary, Salary Scale Function, Valuation of Benefits, Service table

**Yield curves and Non-diversifiable Risk:** Yield Curve, valuation of Insurances and Life annuities, Diversifiable and non-diversifiable Risk, Monte Carlo Simulation

**Emerging Costs for Traditional Life Insurance:** Introduction, profit testing a term insurance policy, Profit testing Principles, Profit measures, Profit testing Multiple State Models

**Simulation:** The Inverse Transform method, The Box Muller method, The Polar method

References:


**Subject CT6 – Statistical Methods Core Technical**

**Courses to be covered:**

1. ASTD 508: Advanced Probability and Stochastic Process
2. ASTD 505: Applied Regression Analysis and Time Series Data Analysis
3. ASTD 510: Generalized Linear Models
4. ASTD 513: Bayesian Inference, Decision Theory and Theory of Games
ASTD 508: Advanced Probability and Stochastic Processes

Prerequisite for CT4 & CT6

- Modern probability: probability as a set function; Borelfield and extension of probability measure;
- Probability measure notion of random variables; probability space; distribution function; expectations and moments.
- Convergence of random variables; Laplace transformation.
- Stochastic Process: Introduction, distinction between deterministic and stochastic models
- Markov Chains: introduction, transition probability matrices of a Markov chain, First step analysis; Some special Markov chains; Regular transition probability matrices;
- The classification of states; Basic limit theorem of Markov chain; Reducible Markov chains; Lundberg’s inequality
- Poisson process: the Poisson distribution, counting and Poisson process; the law of rare events;
- Continuous time Markov chains: pure birth processes; pure death processes; birth and death processes;
- Limiting behavior of birth and death processes; birth and death process with absorbing states; finite state continuous time Markov chains.
- Renewal theory and its applications : introduction, distribution of N(t), limit theorems and their applications,
- renewal reward process regenerative process, semi-Markov process, queuing process
- the connection between Poisson process and the Poisson distribution, Poisson process as
  iv. the distribution of waiting between events
  v. the distribution of process increments
  vi. the behavior of the process over an infinitesimal time interval
- Compound Processes: Compound Binomial, Compound Poisson, Compound Negative Binomial Random variables

References:
ASTD 505: Applied Regression Analysis and Time Series Data Analysis    Credit-3

Prerequisite for CT3 & CT6

Regression Analysis:
Simple Linear Regression Model
Regression analysis, simple linear regression model, scatter diagram Least squares estimation, Estimation of variance

Inferences for Simple Linear Model
Inferences, Confidence interval estimation, Prediction of interval, Analysis of Variance, R-square

Diagnostic procedures for Aptness of model
Residual analyses, Transformations as solution to problems with the model

Multiple Regression Models and Estimation
Extension to simple linear model, Basic estimation and inference for multiple regression, Generalized Least Squares and Weighted Least Squares, Extra Sum of Squares Principles and related Tests

Multicollinearity, Model Diagnostics and Selecting the Best Regression Equations

Time Series Analysis:
Introduction to Time Series: Examples of time series, Objectives, Types of variation, Stationarity, Trends and Seasonal Components, No Seasonal Component, Trend and Seasonality, time plot

The autocovariance of a Stationary Time Series: Strict stationarity, applied to stationary time series, drawbacks of shift operator, backwards difference, the spectral density, Time series models, Box-Jenkins Model, concept of a filter, root characteristic equation of time series, Estimation of the mean and the autocovariance

The Wold Decomposition and Partial Correlation: Partial autocorrelation, AR process, MA process, ARMA processes, Calculation of the ACVF, Prediction of an ARMA Process, conintegrated time series, ARIMA time series

Random Walk: Concept and properties of discrete random walks and random walks with normally distributed increments, both with and without drift

Multivariate Autoregressive Model: Concept

Forecasting: Introduction, univariate procedures, multivariate procedures, comparative review of forecasting procedures, prediction theory
Identification, Estimation and Diagnosis of a time series: Criteria for choosing between models, diagnostic tests applied to residuals

Reference:


ASTD 510: Generalized Linear Models Credit-3

Prerequisite for CT4 & CT6

Generalized linear models: exponential family of distributions; Properties of distributions in Exponential family, Component of GLM, Random systematic link function


Inference: sampling distribution for scores, sampling distribution for maximum likelihood estimators, Confidence intervals for model parameters, adequacy of a model, sampling distribution for log-likelihood statistic, log-likelihood ratio statistic (deviance), assessing goodness of fit, hypothesis testing;

Multiple Regression: maximum likelihood estimation, log-likelihood ratio statistic;

Models for binary responses: probability distributions, generalized linear models, general logistic regression, maximum likelihood estimation and log-likelihood ratio statistic, other criteria for goodness of fit, least square methods; Multinomial distributions; Nominal logistic regression models; Ordinal logistic regression models;
Models for Count Data: probability distributions, log-linear models, maximum likelihood estimation, Hypothesis testing and goodness of fit

References:

ASTD 513: Bayesian Inference, Decision Theory and Theory of Games  Credit-3
Prerequisite for CT6

Bayesian Inference:
Bayesian theorem; prior ignorance; likelihood; odds ratio; Bayes factor; Bayesian inference for discrete random variable; Bayes theorem for binomial distribution with discrete prior; Bayesian inference for continuous random variable; Bayesian inference for normal mean; Bayesian inference for difference between means; Comparing Bayesian and frequentist inference for proportion and mean, Loss function, Risk functions, related problems

Decision Theory:
Fundamental concept of decision theory; action space; Bayes decision rule and related examples, Role of sufficient statistics; James-Stein estimator; Minimax rule

Game theory: finite and infinite games; zero sum games; two person zero sum games; pay off matrix; maximum and minimum criterion of optimal solution of a game; dominance property;

References:
Optional Courses:

ASTD 514: Advanced Multivariate Statistical Analysis       Credit-4

- Comparisons of several multivariate means: paired comparisons and a repeated measures design; comparing mean vectors from two populations;
- Comparison of several multivariate population means (one-way MANOVA); simultaneous confidence intervals for treatment effects; two-way multivariate analysis of variance;
- Profiles analysis; repeated measures designs and growth curves;
- Multivariate linear regression models: the classical linear regression model; least squares estimation;
- Inferences about regression model; inferences from the estimated regression function; model checking;
- Multivariate multiple regression; comparing two formulations of the regression model; principal components
- Factor analysis
- Canonical correlation analysis
- Discrimination and classification
- Cluster analysis

Text Books:

ASTD 515: Linear Models       Credit-3

- Simple and multiple regression models;
- Point estimation in the general linear model,
- Projection operators,
- Estimable functions and generalized inverses;
- Tests of general linear hypotheses; Diagnostics and Remedial Measures.
- Power;
- Matrix Approach of the general linear model
- Quadratic Forms and Their Distributions,
- General Linear Models, General Framework,
- Least Squares,
- Properties of Estimators,
- Gauss-Markov Theorem,
- Analysis of variance (ANOVA)
- Analysis of covariance models (ANOCOVA)
- Interval Estimates of Parameters, Testing of Hypothesis, Diagnostics and Remedial Measures
• Generalized Least Squares,
• Extra Sums of Squares,
• Estimation and Hypothesis Testing for Full Rank and Less than Full Rank Models, Model Selection Criteria,
• fixed, random, and mixed effects model;
• Correlation;
• methods for simultaneous inference;
• residual analysis and checks of model adequacy

Text:


References:


ASTD 516: Econometrics Credit-3

1. **Multicollinearity**: nature, detection, consequence and remedy of multicollinearity
2. **Autocorrelation**
3. **Heteroscedasticity**
4. **Model Specification**: Consequences of under and over specification, model selection criteria

5. **Estimation and application of Cobb-Douglas production function**
6. **Simultaneous equation models**:
   • Simultaneous equation bias
   • Inconsistency of OLS estimations
   • Types and rules of identification
   • Estimation of simultaneous estimation methods: Methods of indirect least square (ILS) and two stage least square (2SLS)

7. **Non-Linear regression:**
• Least Square Estimation,
• Estimating the Parameter: Response surface methodology, Semilogarithm
• Time series Econometrics: Stationarity, Unit roots and co-integration, Spurious regression, Dynamic Econometrics model, Distributed lag models.

8. Panel Data Models:
• Fixed Effects
• Random Effects
• Dynamic Model

References: