BACHELOR OF SCIENCE IN ACTUARIAL SCIENCE WITH IT

1.0 INTRODUCTION

The discipline that applies mathematical and statistical methods to assess risk in the insurance and finance industries. Actuaries are professionals who are qualified in this field through education and experience.

Actuarial science includes a number of interrelating subjects, including probability, mathematics, statistics, finance, economics, financial economics, and computer programming. These problems involve analyzing future financial events especially where future payments involve certain or uncertain timing. Historically, actuarial science used deterministic models in the construction of tables and premiums. The science has gone through revolutionary changes during the last 30 years due to the proliferation of high speed computers and the union of stochastic actuarial models with modern financial theory

In Kenya, therefore, there is a great need to keep up with global professional trends hence the need for a BSc. program in Actuarial science, which provides broad training in the basic mathematics underlying operations of private, social insurance and employee benefit plans.

2.0 OBJECTIVES

The Actuarial Science degree programme is designed to provide broad training in the basic Mathematics underlying the operations of private and social insurance and employee benefit plans.

3.0 ENTRY REQUIREMENTS

To be admitted into the degree of Bachelor of Science in Actuarial Science, candidates must meet the minimum university and School of mathematics and Actuarial Science entry requirements. In addition to meeting the minimum university and School of Mathematics and Actuarial Science admission requirements, candidates for the degree of Bachelor of Science in Actuarial Science must have passed Mathematics with a minimum grade of B at K.C.S.E., or an Equivalent qualification.

4.0 DURATION AND STRUCTURE

(a) To be considered for the award of the degree of Bachelor of Science in Actuarial Science, a candidate shall normally have enrolled for courses over a period of not less than four academic years.

(b) The courses will be offered in units, in which a course unit is defined as a one-hour lecture or two hours tutorial or three hours practical session per week per semester.

(c) Students will take a maximum of 48 units in each year of study. Students wishing to take more than 48 units will require senate approval.

(d) In the first year, students will take 42 units from the department of Mathematics and Applied Statistics, and 4 units from the common University IT courses. In second year, students will take 33 core units from the department, and a further 9 units from the elective courses offered by the department. The remaining four units will be taken from among the IT courses offered as University common courses.

(e) In the third and fourth years of study, students will take the core units, plus an additional unit from the elective units offered by the department.

5.0 EXAMINATIONS

i. The University and School of Mathematics and Actuarial Science common examinations regulations shall apply

ii. Examinations shall be held at the end of the semester in which the courses are taught.

iii. A written report for a product shall constitute 70% and oral examination shall constitute 30% of the total marks.

COURSE DISTRIBUTION

FIRST YEAR

FIRST SEMESTER

SAC 101:	Principles of Actuarial Science	3C
SAC 103:	Mathematical Modeling	3C
SAC 105:	Micro Economics	3C
SAS 101:	Descriptive Statistics	3C
SAS 103:	Introduction to Probability Theory	3C
SMA 100:	Basic Mathematics	3C
SMA 101:	Analytic geometry	3C
SCS 101:	Introduction to Computers (IT)	3C
SCS 103:	Programming in Pascal (IT)	3C

SECOND SEMESTER

SAC 102:	Fundamentals of Actuarial Mathematics I	3C
SAC 104:	Linear Models and Forecasting	3C
SAC 106:	Macro Economics	3C
SAS 102:	Probability and Distribution Theory I	3C
SAS 104:	Programming Methodology	3C
SMA 102:	Calculus I	3C
SMA 103:	Linear Algebra I	3C
SCS 114:	Introduction to Spreadsheets and Database (IT)	3C
SCS 116:	Programming in C (IT)	3C

SECOND YEAR

FIRST SEMESTER

SAC 201:	Financial Mathematics I	3C
SAC 203:	Fundamentals of Actuarial Mathematics II	3C

SAS 201:	Sample Surveys	3E
SAS 203:	Economic Statistics	3C
SAS 205:	Statistical computing I	3C
SMA 200:	Calculus II	3C
SMA 201:	Linear Algebra II	3E
SMA 202:	Vector Analysis	3C
SCS 202:	Object Oriented Programming in Java I (IT)	3C
SCS 203:	Information Systems Analysis and Design (IT)	3C

SECOND SEMESTER

SAC 202:	Life Testing Analysis	3C
SAC 204:	Theory of Interest	3E
SAC 206:	Actuarial Mathematics I	3C
SAC 208:	Risk Theory	3C
SAC 210:	Investment and Asset Management I	3C
SAS 204:	Demography and Social Statistics	3C
SAS 202:	Principles of Statistical inference	3E
SMA 206:	Algebraic Structures	3E
SMA 207	Calculus III	3E
SMA 208:	Analysis	3E
SCS 211:	Visual Basic Programming (IT)	3C
SCS 212:	Database Systems (IT)	3C

THIRD YEAR

FIRST SEMESTER

SAC 301:	Methods of Actuarial Investigations I	3C
SAC 303:	Actuarial Mathematics II	3C
SAC 305:	Pension Mathematics	3C
SAC 307:	Financial Economics I	3E

SAS 303:	Estimation Theory		3E
SAS 305:	Stochastic Processes I		3C
SAS 307:	Theory of Sampling Techniques		3E
SAS 309:	Time Series Analysis		3E
SAS 311:	Statistical Demography I		3E
SAS 313:	Principles of Econometrics		3E
SMA 300:	Real Analysis I		3E
SMA 301:	Ordinary Differential Equations I		3C
SMA 305:	Numerical Analysis I		3E
SCS 301:	Data Structure and Algorithms	(IT)	3C
SCS 308:	Object Oriented Programming in C++	(IT)	3C

SECOND SEMESTER

SAC 300:	Financial Mathematics II		3C
SAC 302:	Methods of Actuarial investigations II		3C
SAC 304:	Actuarial Life Contingencies I		3C
SAS 302:	Mathematical Methods		3E
SAS 304:	Test of Hypotheses		3C
SAS 306:	Statistical Modeling		3E
SAS 308:	Analysis of Experimental designs I		3E
SAS 310:	Stochastic Decision Models I		3E
SAS 312:	Statistical Computing II		3C
SAS 314:	Research Methodology		3C
SMA 303:	Complex Analysis I		3E
SMA 312:	Operation Research I		3E
SCS 318:	Design and Analysis of Algorithms	(IT)	3C
SCS 324:	Statistical Analysis with SPSS	(IT)	3C

THIRD SEMESTER

SAS 317:	Industrial Attachment	3C

FOURTH YEAR

FIRST SEMESTER

SAC 401:	Mathematics of Demography & Graduation	3E
SAC 403:	Actuarial Life Contingencies II	3C
SAC 405:	Investment and Asset Management II	3E
SAC 407:	Principles of Financial Management	3C
SAC 409:	Project in Actuarial Science	3C
SAC 411:	Theory of Business decisions	3E
SAC 415:	Survival Analysis	3C
SAS 401:	Further Distribution Theory	3E
SAS 403:	Non Parametric Methods	3C
SAS 405:	Analysis of Experimental Designs II	3E
SAS 411:	Stochastic Decision Models II	3E
SAS 417:	Statistical Demography II	3E
SAS 419:	Econometric Models I	3E
SMA 405:	Partial Differential Equations I	3C
SMA 420:	Operation Research II	3E
SCS 409:	IT and Society	3C

SECOND SEMESTER

SAC 402:	Statistical Modelling II	3E
SAC 404:	Computational Finance	3C
SAC 406:	Risk and Credibility Theory	3C
SAC 408:	Risk Mathematics	3E
SAS 402:	Bayesian Inference and Decision Theory	3C
SAS 408:	Multivariate Methods	3C
SAS 418:	Applied Population Analysis	3E
SAS 420:	Applied Demography	3E
SAS 422:	Econometric Models II	3E
SAS 424:	Applied Econometrics	3E
SAS 426:	Statistical Computing III	3E

SAS 432:	Health Indicators	3E
SMA 402:	Measure Theory	3E
SMA 414:	Fourier Analysis	3E
SMA 429:	Operation Research III	3E
SCS 433:	Advanced Database Systems	3C
SCS 437:	Information Systems Applications	3C

6.0 COURSE DESCRIPTION

SAC 101: PRINCIPLES OF ACTUARIAL SCIENCE

Basic principles of insurance; classes of insurance; risks and insurance. Theory of interest rates; basic compound interest functions; equations of value; annuities certain; nomial and effective rates of interest; discounted cash flow terminology and methods of investment appraisal. Concepts of decremental rates and other indices; determination of exposed to risk by the census method; gradation methods and applications. Elementary principles of life contingencies; value and premiums for annuities and assurances on one or more lives.

SAC 102: FUNDAMENTALS OF ACTUARIAL MATHEMATICS I

A description of data collection suitable for examining past experience, calculation of exposed to risk and the derivation of decrement rates; monitoring actual against expected experience; methods of graduating experience rates; mortality variation with respect to social, economic and regional factors, and the development of mortality experience during the 20^{th} century, heterogeneity within a population; the main standard mortality tables and the adjustment to have regard to current and prevented future experience; risk classification, undermining and allowing extra mortality risk. **Pre-requisite SAC 101, SMA 102**

SAC 103: MATHEMATICAL MODELLING

Introduction to modeling of dynamic processes, using difference equation, curve fitting; continuous dynamic systems; modeling by differential equations; application to rent – life situations, in finance, economics and ecology.

SAC 104: LINEAR MODELS AND FORECASTING

Review of Linear algebra; Review of statistical results; Regression models, simple regression models, assumptions of linear models; ordinary least squares estimates (OLSE), residuals, statistics of (LSE). Statistical inference;-maximum likelihood estimates. Prediction and forecasting

SAC 105: MICRO ECONOMICS

Economics as a science, the scope of economics. Introduction to micro economics. Demand and supply analysis, effects of controls on prices and supply; classicity of demand and supply, production factors, cost analysis. Utility theory and consumer behaviour. Analysis of insurance problems in terms of utility. Market forms and income distribution, general equilibrium theory. The theory of firms.

SAC 106: MACRO ECONOMICS

Introduction to Macro Economics and the role of government in Economics, public sector, finance and taxation. National Income measures; the circular flow of income; the multiplier and accelerator; aggregate demand and supply. Government fiscal policy and its effects. Government monetary policy and its effects. The money supply and credit creation by banking systems. The major factors affecting unemployment, inflation, economic growth. Monetarist and Keynesian approaches. International trade, exchange rates and the balance of payments.

Pre-requisite SAC 105

SAS 101: DESCRIPTIVE STATISTICS

Nature of Statistics; Uses of Statistics; types of data; sources of data. Methods of data collection. Exploratory data analysis; data displays, charts and diagrams, frequency distributions; tables; graphical displays, scatter plots, frequency graphs. Summary statistics; measures of location and

dispersion, skewness and kurtosis. Correlation: linear correlation and rank correlation. Regression: simple linear and non-linear regression models. Index numbers. Elements of time series.

SAS 102 - PROBABILITY AND DISTRIBUTION THEORY

Review of probability. Special continuous distributions: Gamma, chi-square, Weibull, beta, Cauchy. Bivariate probability distributions; The joint probability law, marginal and conditional distributions, stochastic independence, conditional expectations and regression. The Bivariate normal distribution. Joint and marginal distributions of more than two random variables. Distribution of functions of two or more random variables; The Distribution function technique, moment generating function technique, variable transformation technique.

SAS 103 INTRODUCTION TO PROBABILITY THEORY

Probability: axioms of probability, conditional probability and independence, Bayes theorem. Random variables and probability distributions; the probability distribution function; distribution of a function of random variables. Expectations and moment generating functions. Standard probability distributions: uniform, exponential, normal, Bernoulli, binomial, geometric, negative binomial, hypergeometric, Poisson; the Poisson and normal approximation to the binomial.

SAS 104: PROGRAMMING METHODOLOGY

Principles of computer organisation. Information storage. bits, bytes, words, ordinary and floating point representation of numbers. Character codes. Structured programming using high level language e.g. Pascal, fortran 77, C; programme structure. Abstract data types. Mathematical expressions and operations. Logical expressions and operations. Control structures. Functions. Procedures. Report and display design, Library procedures.

SMA 100 BASIC MATHEMATICS

Series: Arithmetic and geometric series. Systems of linear equations. Sets: operation on set. Venn diagrams. Trigonometric functions, their graphs and inverses, conversions from degrees to radians and vice versa. Addition, multiple angle and sectors formulae, trigonometric identities and equations, sine and cosine rule, standard trigonometric formulae. Algebra: Surd, logarithms and indices, equations and inequalities.

Remainder theorem and its application. Permutations and combination.

Binomial theorem and its geometric representations, complex numbers modulus, arguments, de Moivre's theorem, applications. Roots of complex numbers:

Hyperbolic function: properties, graphs.

SMA 101 ANALYTICAL GEOMETRY

The straight line: Equations of a straight line; gradient of a straight line.

Circle: equation of a circle radius r and centre at the origin and centre at (h,k).

Comics sections: Parabola, ellipse and hyperbola.

Polar coordinates: Relation between vector polar and polar coordinates; graphs of polar equations, polar equations of comic sections.

Parametric equation of lines, circles, parabolas, ellipse and hyperbolas.

SMA 102 CALCULUS I

Limits of functions, continuity, and uniform, continuity. Differentiability of functions properties of derivatives: sums, product, quotients, chain rule-algebraic, logarithmic trigonometric, implicit differentiation. Higher order derivatives: Small changes, rates of change, maxima, minima. Equations of tangent, and normals, kinematic integration, introduction to ant derivatives and their applications.

SMA 103 LINEAR ALGEBRA I

Vectors and scalars: algebraic and geometric properties in $\Re^3$, magnitude and directions and applications and applications such as force, displacement, velocity and rotation. Operations: On vectors such as addition, scalar multiplication, dot and cross products, and linear combination, vector proof of theorems in geometry.

Extension to $\Re^n$: scalar products, formulae for length and angle, Schwartz and triangular inequalities, and planes and lines in $\Re^3$. Vector space over $\Re$:

Subspace, spanning sets, linear independence, bases and dimension, direct sums and intersection of subspace, linear mapping and their matrices with respect to the standard basis, range and null space, nullity and echelon form, rotations and reflections in $\Re^2 and \Re^3$, and application to linear equations, matrix. Multiplication, inverse mappings and their matrices.

YEAR TWO

SAC 201: FINANCIAL MATHEMATICS I

Cash flow models for financial transactions, compound interest and discounting; present values and accumulation of streams of payment, normial and effective rates of interest and discounts through standard compound functions; solving equations of value for implied rate of interest; discounted cash flow techniques in product appraisal, consumer credit, capital redemption contracts and annuity certain. **Pre-requisite SAC 102**

SAC 202: LIFE TESTING ANALYSIS

Models of survival analysis, modeling random and non random censuring and transaction; parametric estimation of life distributions; Non – parametric methods of Kaplam and Meir, proportional hazard models with covariates; Grouped data; time dependant data and covariates.

SAC 203: FUNDAMENTALS OF ACTUARIAL MATHEMATICS II

The single decrement model and calculations based on it; the stationary population model; present values and accumulations of stream of payments based on a single decrement model; equation of value for payments based on a single decrement model; annuity and assurance commutation functions and their relationships; assurance and annuity contracts; product pricing, reserving, surrender values, emergence of profit. **Pre-requisite SAC 102.**

SAC 204: THEORY OF INTEREST

Measurement of simple and compound interest; accumulated and present value functions, annuities, yield rates, amortization. Schedules and sinking funds; bonds, securities and related funds; Application to morgages and bonds.

SAC 206: ACTUARIAL MATHEMATICS I

Accumulation functions, interest, time value of money, compounding periods, cash flow, models, equations of value, annuities certain, continuous time applications, life table, elements of contingent probabilities from life tables, contingent payments, fundamentals of survival models, laws of mortality, expectation of life, elementary survival contracts, premium for elementary survival controls. **Pre-requisite SAC 102, SAC 203.**

SAC 208: RISK THEORY

Individual and collective risk models, models for short terms, models for long – term, application of risk theory to actuarial problems, risk factors; health, habits, morals; occupations, geographical and demographic and their effects; the financial effects of risk factors.

SAC 210: INVESTMENT AND ASSET MANAGEMENT I

Principles underlying legislation, regulations and taxation, valuation of assets and portfolios, capital projects, risk control techniques and performance monitoring.

SAS 201 SAMPLE SURVEYS

Uses, scope and advantages of sample survey: types of survey: survey organisation; sample survey design. Purposive, probability and quota sampling. Simple random sampling; stratified sampling; systematic sampling; multistage sampling and pps selections. Estimation of means, totals and proportions; variance calculations. Sampling error. Sources of error; no response. Management of surveys. **Pre-requisites: SAS 101, SAS 102, SAS 103.**

SAS 202: PRINCIPLES OF STATISTICAL INFERENCE

Meaning of statistics, objectives of statistical investigation. Statistical decision problems, basic concepts of inference. Role of normal distribution in statistics. Random samples, use of random

number tables. Inference about population means: point and interval estimates, simple one sample and two sample tests. Linear regression and correlation analysis. Analysis of variance. Analysis of frequency data. Simple nonparametric tests.

Pre-requisites: SAS 101, SAS 102

SAS 203: ECONOMIC STATISTICS:

Gross domestic product, index numbers, retail price index, consumers' price index, product index; balance of payments and trade statistics.

SAS 204 DEMOGRAPHY AND SOCIAL STATISTICS:

Demography: Scope, uses and sources of demographic and socio-economic data; methods of enumeration; demographic concepts and measures; current and cohort methods of description and analysis; rates and ratios; standardisation; construction of life tables. Measurement of fertility, mortality and nuptiality. Determinants of age structure and the intrinsic growth rate. Survey data; interpretation of demographic statistics, tests of consistency and reliability.

Social Statistics: Nature of social statistics; sources of social statistics; conceptual problems; validity and reliability concepts; definitions and classifications. Measurement problems in social surveys; socio-economic indicators. Studies in the integration of social statistics. **Co-requisite; SAS 201**

SAS 205: STATISTICAL COMPUTING I

Types of problems computers can solve. General structure of installation; mainframe versus stand alone micro computers; networking; operating systems, compiler systems and utilities. Computer graphics. Statistical packages and libraries. Role of computers in data bases. Survey applications. Simulation: random and pseudo random numbers; generation of uniform variates; outline of tests, mention of physical devices for uniform generators; generation of variates from standard distributions e.g. normal, exponential etc. **Pre-requisites: SAS 104, SAS 102, SAS 201**

SMA 200 CALCULUS II

Integration: techniques of integration, definite integrals. Fundamental theorem of Calculus. Applications: areas under curve, length of an arc, plane and surface areas, volumes of solids of revolutions. Improper integral. **Pre-requisite: Calculus I.** The mean value theorem. Indeterminate Forms and L Hospital's Rule. Extending the mean value Theorem to Taylor's Formular. Estimating Approximation Errors. Quadrate Approximations. Rolle's theorem Lagrange's theorem. Applications infinite series; convergence tests. Integrals and their convergence.

SMA 201 LINEAR ALGEBRA II

Field axioms. Vector spaces over an arbitrary field. Linear mapping and their matrices with respect to an arbitrary basis, the change of basis. Conjugation of eigenvectors theorem. Invariant subspaces. Quadratic forms.

SMA 202 VECTOR ANALYSIS

Vector Algebra: Scalars and vectors; types of vectors; addition and subtraction; multiplication and division by a scalar; position vector of point of division, scalar (or dot) product; vector (or cross) product scalar triple product; vector triple product; vector product of vectors; reciprocal vector triads; applications of vector algebra.

Vector Calculus: differential vector calculus; applications of differential geometry and mechanics; integral calculus; Riemann, line, vector line, double, surface and volume. Gradient of a scalar function; Divergence of a vector; curl of a vector.

Stoke's and Green's theorems: orthogonal curvilinear coordinates; contra variance and covariance.

SMA 207 CALCULUS III

Differential and integral calculus of functions of several variables; Taylor's theorems in functions of several variables; stationary points; Lagrange's multipliers; implicit function theorem. Double and triple integrals.

SMA 208: ANALYSIS

Theory of sets, Real numbers – field structure and order, Bounded and unbounded sets, suprema and infima, Completeness in the set of real numbers, functions and relations; Limits of functions; Types of discontinuities; Open sets; Closed sets.

SMA 209: NUMERICAL ANALYSIS II

Multipoint iterative formulae.

Newton's method in 2 variables, 3 variables; Improved Newton's method, roots. Zeros of polynomials, divided difference, Taylor's, Langrange's and Newton's method.

Interpotation: Polynomial interpotation; Discrete least squares approximation. Orthogonal polynomials and least squares approximations. Rational approximation of functions. The Fourier approximation, Construction of minimax rational polynomial approximations.

YEAR THREE

SAC 300: FINANCIAL MATHEMATICS II

Introduction to asset types and securities markets; valuation of securities, effect of income and capital gains tax, interest and discount. Forces of interest; yield curves, discounted mean terms, matching and immunization. Investment risk, stochastic interest and discount interest rate models; risk and return theory; market models; portfolio theory, capital asset pricing model; random walk model. **Pre-requisite SAC 201**

SAC 301: METHODS OF ACTUARIAL INVESTIGATIONS I

Capital redemption policies; determination of the rate of interest in a given transaction. Valuation of securities; effect of income and capital gains taxes. Cumulative sinking funds; yield curves; discounted mean terms; matching and immunization; consumer credit. Introduction to stochastic interest models.

SAC 302: METHODS OF ACTUARIAL INVESTIGATIONS II

Decremental rates and other indices; analysis of data and derivation of exposed to risk formulae; calculation of mortality, sickness and other decremental rates, including multiple decremental rates; graduation methods and their applications; tests of graduation; features of principal tables in common use; national vital statistics and population projection; applications outside insurance, national social security and pension schemes. **Pre-requisite SAC 301**

SAC 303: ACTUARIAL MATHEMATICS II

Multi – state and multiple decrement models; problems of emerging costs; present and accumulated values allowing for decrements; equation of value problems for single life; unit sickness functions; introduction to functions involving more than one life; introduction to valuation of pension fund benefits and contribution; and profit testing of insurance products. **Pre-requisite SAC 203, SAC 205.**

SAC 304: ACTUARIAL LIFE CONTINGENCIES I

Construction of mortality, sickness, multiple decrement and other similar tables from graduated data; determination and use of probability and monetary functions based thereon. Values and premiums of annuities and assurances on one or more lives; determination of policy values, surrender values and paid-up policy values; values of and premiums for multiple life annuities and assurances; reversionary annuities and compound status. Use of stationary population model.

Pre-requisite SAC 206

SAC 305: PENSIONS MATHEMATICS

Principles of pension funds. Mathematical models for; retirement income, retiree medical benefits, disability benefits and survivor benefits. Computer applications, simulation. Guarantees and options. Principles of pension valuation; actuarial cost methods, asset valuation methods, actuarial assumptions, gain and loss analysis.

SAC 307: FINANCIAL ECONOMICS I

Utility theory, stochastic dominance, risk assessment; mean response portfolio theory; multifactor models of asset returns; stochastic asset models; valuation of futures and options; Black – scholes - analysis and arbitrange free pricing.

SAS 302: MATHEMATICAL METHODS

Number systems, errors, interpolation, finite differences. Numerical Solution of non-linear equations, Newton Raphson Method. Approximation of functions. Taylor's series, least squares. Matrix algebra, determinants, eigenvalues and vectors. Numerical solution of a system of linear equations; numerical evaluation of eigenvalues and eigenvectors. Solution of first and second order ordinary differential equations. Difference equations, Special functions; gamma, beta. Laplace transformation and applications. solution of second order partial differential equations; separation of variables, use of Laplace transforms. Fourier series.

SAS 303: ESTIMATION THEORY

Properties of point estimators; sufficient statistics, the factorisation criterion; complete statistics; Minimum variance unbiased estimators; Cramer-Rao, inequality; fisher information; efficient estimators; Maximum likelihood estimators and their properties; interval estimation, Least squares estimation in linear models: Simple linear model, the general linear model. Weighted least squares; interval estimation in linear models. **Pre-requisite: SAS 102, SAS 103**

SAS 304: TESTING HYPOTHESES

Concepts of statistical hypothesis and statistical test; optimal tests, Neyman Pearson lemma; properties of tests; unbiasedness, consistency; confidence sets and tests; generalised likelihood ration tests; tests for correlation and regression, general linear hypotheses. **Pre-requisite; SAS 303**

SAS 305: STOCHASTIC PROCESSES I

Stochastic process, definition and examples. Bernoulli process: probability model, waiting times. Poisson process; probability model, waiting times. Markov chains: discrete time Markov chains, holding times, stationary distributions, classification of states. Birth and death processes, stationary distributions. Queuing models: deterministic approximations, examples of queuing

systems, application to arrival and departure processes, heavy traffic etc. **Pre-requisite: SAS 102, SAS 103**

SAS 307: THEORY OF SAMPLING TECHNIQUES

Review of general principles of survey design. Populations and sampling frames. Simple random sampling; properties of estimates, determination of sample size. Ratio and regression estimation. Stratification, optimality considerations. One-stage and two-stage cluster sampling. Systematic sampling. Multistage designs. Criteria for choosing sampling designs. **Pre-requisite: SAS 201.**

SAS 308: ANALYSIS OF EXPERIMENTAL DESIGNS I

General principles: randomisation, replication, blocking, covariates, orthogonality, balance, logical control or error, sequential design. Estimation of treatment contrasts and their precision, treatment structure; comparison with a control. some common designs: completely randomised design, randomised complete block design, rationale for blocking; Latin squares, rationale, randomisation, analysis; relative merits of designs. Introduction to factorial experiments: 2^2 and 2^3 designs; calculation and interpretation of effects and interactions. Incomplete block designs, optimality criteria. Crossed and nested block structures. **Pre-requisite: SAS 304**

SAS 309: TIME SERIES ANALYSIS AND FORECASTING

Stationary time series, removal of trend and seasonal differences, moments and autocorrelations. Simple autoregressive and moving average models, moments and autocorrelations, the conditions of stationarity; invertibility. Mixed (ARMA) models and the AR representation of MA and ARMA models. Fitting and testing time series models. Forecasting, methods of forecasting, scientific forecasting basic forecasting models, forecasting criteria. Model building and identification. Series used as examples: simulated series, stock market prices etc. **Pre-requisite: SAS 304**

SAS 310: STOCHASTIC DECISION MODELS I

Aims and scope of stochastic modelling, decisions under risk, decision trees, decisions under uncertainty. Markov decision processes, dynamic programming models; linear programming

solution of the Markovian decision problem. Queuing models. Types of queues; roles of Poisson and exponential probability models; queues with combined arrivals and departures; queues with priorities for service. Traffic flow models. Inventory models, practical stock systems; types of inventory; scheduling policies; storage models. Simulation models, role of random numbers; simulation experiments; Monte Carlo calculus and variance reduction techniques, simulation as estimation, control variates, antithetic variates, stratified and importance sampling; choice of sampling size. Analogue simulation systems e.g. queues, inventories, traffic networks, storage systems. **Pre-requisite: SAS 305**

SAS 311: STATISTICAL DEMOGRAPHY I

Simple models of population growth; analysis of mortality using life tables, model life tables, continuous and multiple decrement formulations, statistical properties of life table estimators, proportional hazards and multistate life tables. Stable and stationary populations and their use for estimation of demographic parameters. Continuous formulation of population dynamics equation; solutions of renewal equation. Discrete formulation of population of projects. Parity progression ratios. Mathematical models for fertility and mortality schedules. Quantitative models of nuptiality; models of reproductivity and measurement of fecundability. Analytic and simulation approaches to reproductivity and household structure. Sources of demographic data. **Pre-requisite: SAS 221**

SAS 312: STATISTICAL COMPUTING II

Data structures, arrays and their implementation, strings; application and implementation of stacks, queues, linked lists, trees and graphs. Survey applications, questionnaire design; data processing; data editing and correction; editing and imputation principles; Writing of edit specifications, use of an edit specifications, use of an edit package. Tabulation, table design, writing of a table specification; use of a tabulation package. Application of statistical packages (e.g. GLIM, SPSS, etc) in statistical data analysis. Writing programs to implement numerical algorithms. Application of numerical analysis software packages such as NAG. Simulation of simple deterministic and stochastic systems; simulation of inventory and stock control systems, queuing systems, traffic networks etc. **Pre-requisite: SAS 222**

SAS 314: RESEARCH METHODOLOGY

Meaning of Research, objectives, Types, Approaches, significance, Research Methods versus methodology, the research process. Qualities of a good research; Defining the research problems; Definition selecting the problem, Techniques involved.

Research Design; meaning, need for a research design, Features of a good design, Types of research designs; Basic principles of Experimental designs.

Methods of Data collection; primary and secondary data, processing and Analysis of Data. Use of computers in data handling.

Meaning and Interpretation, Techniques of interpretation; steps of report writing. Layout of a Research report, Types of reports, oral presentation.

SAS 317: INDUSTRIAL ATTACHMENT

Students are attached to Relevant Government Ministries, Kenya Bureau of Standards (KBS), Insurance Companies or any related industrial institutions for a period of three months during the intercession between end of the second semester of year 3 and beginning of first semester of year 4. Students will be assessed by University staff who will visit them at site. This will constitute 50% of the final grade. At the end of the attachment students write a report which they present to the department; this constituting 50% of the final grade.

SMA 300 REAL ANALYSIS I

Uniform continuity: Countable sets

Sequences – Limits point of a sequence, convergence,; Limit superior and limit inferior, monotonic sequence; Cauchy's general principle of convergence; series with positive terms, partial sums, tests of convergence,; comparison test, Cauchy's root test; D'Atembert's ratio test and integral test. Series with alternate terms, absolute and conditional convergences.

Metric Spaces – Definition and examples. Topology on metric spaces, Riemann Integrals, Exponential, trigonometric and logarithmic functions.

SMA 301 ORDINARY DIFFERENTIAL EQUATIONS I

First order equation and applications, second order equations; Homogenous equations with constant coefficients; Equations with variable coefficients; non-inverse differential operators; Applications.

SMA 303 COMPLEX ANALYSIS I

The Complex plane; Basic topological concepts; series; functions of complex variables, limits and continuity. Connected spaces; Regions in C; Differentiability of complex functions; Holomorphic functions, angle-preserving mappings, Biholomorphic mappings. Modes of convergence; Power series; Exponential and trigonometric functions; Polar co-ordinates, roots of unity. Logarithmic functions. Integration over real intervals, path integral, primitives; The Cauchy's Integral Theorem and Cauchy's integral formula; Power series development of holomorphic functions. Cauchy – Taylor's representation theorems.

SMA 305 NUMERICAL ANALYSIS III

The Algebraic Eigenvalue problem:

The eigenvalue: properties of eigenvalues and eign – vectors - similar matrices. Properties of real symmetric matrices – diagonalisation theorem, quadratic forms. Power method: theory of the method, origin shifts, deflation with order reduction: The symmetric eigenvalue problem. Reduction to tri-diagonal form; plane rotation matrices; Householder's orthogonal transformation matrices. Householder's method of reducing A to tri diagonal form: Given's methods of reducing. A to tri diagonal form. Calculation of the eigenvectors: method of inverse

iteration. The non-symmetric eigenvalue problem: reduction to Hessenberg form; the Householder method. The QR algorithm; application to upper Hessenberg matrices.

SMA 312 OPERATION RESEARCH I

Formulation of linear models; convex analysis in E" Elasticity; Duality; Graph fundamentals; Classical transportation model.

YEAR FOUR

SAC 401: MATHEMATICS OF DEMOGRAPHY AND GRADUATION

Collection of demographic statistics, series of errors and their corrections measures of mortality and fertility. Construction of life tables from large databases such as census data. Analysis of experience data. Estimation of mortality and other decremental rates. Graduation methods and their applications; moving weighted average, Bayesian, parametric and smooth – function interpolation methods; statistical considerations; two – dimensional graduation; tests of graduation.

SAC 402: STATISTICAL MODELLING II

Analysis of the general linear model; model building model selection and validation, variable selection; stepwise and best subset regression. Modeling under prior and additional information, ridge regression. Modeling of non-normal data. Treatment of outliers in regression models. Robustness, graphical techniques. Generalised linear models, measurement of association in two – way tables; log – linear and other models for contingency tables; logif, probif, categorical data, score tests, case studies. **Pre-requisite SAS 306**

SAC 403: ACTUARIAL LIFE CONTINGENCIES II

Reserves for financial contracts; design of unit-linked products; profit-testing methods; pension fund functions, service tables, salary scales, scheme design, type of benefits offered; values of and contributions for sickness and disability benefits; pension benefits; benefits depending on marital status, widows and orphans benefits; collective and reversionary approaches; valuation of liabilities under life policies; analysis and distribution of surplus. Introduction to the stochastic approach to life and other contingencies. **Pre-requisite SAC 304**

SAC 404: COMPUTATIONAL FINANCE

Computational methods in finance and financial modeling; interest rate models and interest rate derivatives; derivative securities; Black-scholes theory; no-arbitrange and complete markets theory; Hull and White models; Health – Jarrow – Morton models; Hedging and immunization, the stochastic differential equations and martingale approach, multinomial tree and Monte Carlo methods, the partial differential equations approach, finite difference methods.

SAC 405: INVESTMENT AND ASSET MANAGEMENT II

Interest, rate risk; immunization; duration analysis; cash flow matching; fundamental theorem of asset pricing; term structure of interest rate models**. Pre-requisite SAC 210, SAC 304**

SAC 406: RISK AND CREDIBILITY THEORY

Loss Distributions: Statistical models - Poisson, binomial, normal, gamma, lognormal, loggamma, Pareto, generalised pareto distributions; compound distributions - negative binomial, beta, compound Poisson. Statistical inference for loss distributions - point and interval estimation; hypothesis testing; simulation; model building and testing.

Risk Theory: Individual risk models for a short term; collective risk models over an extended period; ruin theory, applications.

Credibility Theory: Introduction to credibility theory and experience rating; theory of insurance premiums, economics of uncertainty.

SAC 407: PRINCIPLES OF FINANCIAL MANAGEMENT

Objective of financial management. The annual financial statements; content, interpretation and application for planning and control. Budgets as a management tool. The time value of money, risk and return. Company structure and financing.

Basic principles of taxation. Different types of taxation. The role of the main institutions in financial markets. Basic principles of group accounts. Calculation and use of accounting ratios. Limitations of company accounts.

SAC 408: RISK MATHEMATICS

Classical approaches to risk including the insurance principle and the risk-reward trade-off. Risk models, review of probability, Bachelier and Lundburg models of investment and loss aggregation. Fallacy of time diversification and its generalization. Loss distribution, geometric and Brownian motion and the compound poisson process. Modeling of individual losses which arise in a loss aggregation process. Distributions for modeling size loss; statistical techniques for fitting data. Credibility theory. Economic rationale for insurance, problems o adverse selection and moral hazard. Utility theory, ruin theory, capital asset pricing model, Black-Scholes option pricing model. Application of risk theory.

SAC 409: PROJECT IN ACTUARIAL SCIENCE

This course will consist of several seminars designed to encourage independent research work and to encourage the student to take an overall view of the different specialized problems in Actuarial Science. Students are expected to undertake a research project on a subject of their own choice. The complete project will be written up in a report and submitted for assessment and grading. There will also be an oral and visual presentation of the completed project at the end of the course. There will be no written examination in this course.

SAC 411: THEORY OF BUSINESS DECISIONS

Applications of linear programming in business decision making, shadow prices and their use in schemes of decentralization. Expected utility, decision rules for problems involving risk, with applications to insurance and investment problems. Random processes, information structures, trees and sequential decisions, uncertainty analysis; Bayes and minimax solutions of games against nature and zero – sum two person games. Organizations considered as games and as teams, survey of information organization theory. Markov models in business management, consumer behaviour; selecting a portfolio of credit risks.

SAC 415: SURVIVAL ANALYSIS

Survival function; hazard function; cumulative hazard function; censoring; Kaplan-Meier survival curve; parametric and non-parametric representation of the survival and hazard distributions. Two – sample and k – sample tests; proportional hazard models; accelerated failure time models; models for grouped survival data; inclusion of covariates – cox's P.H. model; application of model checking; competing risks – extensions of cox's model.

SAS 401: FURTHER DISTRIBUTION THEORY

Independence of x and s^2 in normal samples. Order statistics: joint and marginal distributions, distribution of median and range, studentized range, exact moments of order statistics. Multinomial trials and the multinomial distribution. Multinormal distribution: pdf and mgf non-singular case, mean vector and covariance matrix; marginal and conditional distributions; linear transformations; quadratic forms in normal vectors, distribution theory, independence of two quadratic forms, independence of linear and quadratic forms. Convergence and limit theorems: convergence in distribution; central limit theorem for i.o.d random variables and extensions; weak law of large numbers; strong law of large numbers. **Pre-requisites: SAS 102, SAS 302**

SAS 402: BAYESIAN INFERENCE AND DECISION THEORY

Elements of decision theory: Statistical games; the no data problem. Loss and regret mixed actions, the minimax principle, Bayes actions; decision with sample data; decision rules, risk function, Bayes decision rules.

Bayesian inference: Problems associated with classical approach; Bayes' approach: prior and posteri distributions; specification of prior distributions; Bayesian estimation, properties of Bayes' estimators; Bayesian tests and confidence sets; examples of situations where Bayesian and classical approaches give equivalent or nearly equivalent results.

Sequential methods: Sequential probability ratio test; Stein fixed width confidence intervals.
Pre-requisite: SAS 304

SAS 403: NONPARAMETRIC METHODS

Nonparametric inference, simple one-sample tests; order statistics, empirical distribution function, ranks and runs; general nature of nonparametric tests, allocation of scores, confidence intervals; efficiency and robustness considerations; dealing with tied observations. Goodness of fit tests. General two-sample and c-sample problems; linear rank tests; Wilcoxon's rank sum test; use of rank sum procedures for assessing symmetry and in analysis of variance; Friedman test, two-sample tests of dispersion. Measures and tests for association; analysis of contingency tables; Kendall's t, Spearman's rank correlation; coefficient of concordance. Efficiency of nonparametric procedures.

Pre-requisite: SAS 304

SAS 405: ANALYSIS OF EXPERIMENTAL DESIGNS II

Review of experimental and statistical objectives. General 2^n design, confounding of one or more effects, partial confounding: fractional replication; block compositions. Factors at 3 levels; 3^2 and 3^3 experiments with and without confounding, estimation of effects. Split plot designs. Incomplete block designs: nature and need for incomplete blocks; types of designs, balanced designs, balanced incomplete block design, intra and inter block analysis; partially balanced incomplete blocks - two associate classes only. Youden squares; lattice designs; relative merits

of designs. Planning of experiments; choice of design, economic considerations, treatment design; experimental design. Determination of optimum plot/block size and shape. **Pre-requisite: SAS 308**

SAS 408: MULTIVARIATE METHODS

Practical examples of multivariate data; summarising multivariate data, mean vectors and covariance matrices, correlation matrix. Sampling from the multinormal, MLE's and tests for the mean vector; simultaneous confidence intervals; test of structural relationship. Testing equality of two population means. MLE's of partial and multiple correlations and tests; testing for complete independence; canonical correlations and variates, test of canonical correlation and reduction in dimensionality. Classification into one of two populations. Calculation and interpretation of principal components. Elements of multivariate analysis of variance, one-way grouping and two-way grouping without interaction. **Pre-requisites: SAS 304, SAS 401**

SAS 411: STOCHASTIC DECISION MODELS II

Dynamic programming and heuristics. Project scheduling; probability and cost considerations in project scheduling; project control. Reliability problems; replacement and maintenance costs; discounting; group replacement, renewal process formulation, application of dynamic programming. Critical path analysis. Queuing theory in practice, obstacles in modelling queuing systems; data gathering and testing; queuing decision models; cases studies. Game theory, matrix games; minimax strategies; saddlepoints; mixed strategies; solution of a game. Behavioural decision theory, descriptive models of human decision making; the use of decision analysis in practice **Pre-requisite: SAS 310**

SAS 417: STATISTICAL DEMOGRAPHY II

Dynamics and Projections: Population growth theory; stable and semi-stable populations; relations between demographic processes and the age structures; the nature and patterns of variation in fertility and nuptiality.

Analysis of Fertility and Mortality: Measures of marital and overall fertility; nuptiality and replacement; intermediate fertility variables and models of fertility; construction and interpretation of life tables and other measures of mortality; logit life tables.

Indirect Demographic Estimation: Techniques for estimating demographic parameters from conventional or limited data. **Pre-requisite: SAS 311**

SAS 418: APPLIED POPULATION ANALYSIS

This course is intended to deal with the use of basic demographic concepts and techniques in social, economic, and medical planning and research. Examples of topics to be dealt with include: The use of population projections at national levels; studies of provision of places in higher education; the momentum of population growth in developing countries; the application of regional and local projections in planning housing, schooling etc; manpower planning; household and family structure and composition; impact of contraception and abortion on fertility; the use of survey data in assessing family planning programmes; women's participation in labour force; the impact of breast feeding on fertility and infant mortality; inputs to planning of primary health care; occupational mortality; unemployment and mortality. **Pre-requisites: SAS 311, SAS 417**

SAS 419: ECONOMETRIC MODELS I

General linear model; principles of estimation and testing; maximum likelihood; model specification; autocorrelation in linear models, tests, estimation; stochastic regression, consequences, instrumental variables; lagged variables, explanatory variables, dependent variables, estimation, dynamic models; simultaneous equation systems, structural form and reduced form, estimation. **Pre-requisite: SAS 313**

SAS 420: APPLIED DEMOGRAPHY

Collection of demographic data: Historical development of demographic statistics; stages involved in planning a census; content of census and survey schedules; basic response errors; structure of census organisations; vital registration, types of demographic sample survey; the World Fertility Survey Programme.

Demographic sampling and survey design: Applications of principles of statistical sampling to demographic surveys; types of demographic sample survey designs; questionnaire and schedule design.

Evaluation of family planning programmes: Aims of programmes; methods of evaluation; evaluation of programmes' demographic impact, methods of analysis; case studies.

Report Writing on analysis of demographic data: Evaluation of data; analysis and checking for consistency and convergence of parameters; interpretations of findings; implications for planning and policy formulation; conclusions. **Pre-requisites: SAS 311, SAS 417**

SAS 422: ECONOMETRIC MODELS II

Structural and reduced forms, lagged endogenous variables; identifiability, global and local identifiability, multicollinearity; estimation of simultaneous equation systems, subsystems, and single equations; types of estimators, their asymptotic properties; hypotheses testing, types of tests and their asymptotic properties, testing over-identifying constraints; testing for mispecification. **Pre-requisite: SAS 419**

SAS 424: APPLIED ECONOMETRIC

Econometric model building and testing; Probit and Tobit analysis; use of econometric concepts and techniques in economic and development planning and research; models for plan preparation at the enterprise and national levels; derivation and use of shadow prices in development planning and project scheduling; demand analysis; labour market behaviour; models of unemployment; econometric analysis of inflation; monetarist models; rational expectations and the natural rate hypotheses; models of consumer and investment behaviour; use of the standard computer packages in econometrics including practical exercises; case studies. **Pre-requisite: SAS 419**

SAS 426: STATISTICAL COMPUTING III

Records, files, data bases; types of files; retrieval and updating procedures; use of data bases. Further consideration of hardware e.g. varieties of machine types and peripherals. Network; communication between micro and mainframe computers. Environmental problems. Elements of fault finding; electrical safety; security problems and safeguards; back-up copies; confidentiality. Applications. **Pre-requisite: SAS 312**

SAS 432: HEALTH INDICATORS

Health indicators: Uses and criteria of selection; health policy indicators, social and economic indicators, indicators of provision of health care, health status indicators. Sources of health indicator data. General principles of a health statistics system. Classification of diseases and causes of death. Nutrition surveys.

SMA 402 MEASURE THEORY

Lebseque measure on the real line; Outer lebesque measure; Measurable Functions; Lebesque integral monotone convergence theorem; Fatuou's Lemma; Lebesque Dominated Convergence Theorem; Comparison between lebesque and Riemann integral highlighted.

SMA 405 PARTIAL DIFFERENTIAL EQUATION I

Surface and curves in three dimensions; Simultaneous differential equations of first order methods of solution of orthogonal trajectories of systems of curves on a surface. Pfaffian differential equations, Linear, semi-linear, quasi-linear equations of the first order; Integral surfaces passing through a given curve; Use of methods of Cauchy, Charpit and Jacobi in solving non-linear partial differential equation of the first order.

SMA 414 FOURIER ANALYSIS

Introduction to Fourier expansion on a general interval; half-range expansions; Complex forms orthogonal systems of functions on a compact interval; Bessel's inequality; Approximation theorem Parseval's equality (identity); Riemman-Lebesgue Lemma Dirichlet-Jordan convergence. Applications to infinite series; Ferjer's sums, Ferjer's theorem for convergence of Fourier series; Weierstrass' approximation theorem; Gibb's phenomenon. Differentiation and integral of Fourier series; Physical application of the theory of Fourier integral of functions satisfying Dirichlet's condition on (a,b); Fourier inversion sine and cosine transforms simple applications.

SMA 420 OPERATION RESEARCH II

Optimisation in network, shortest path floyds algorithm critical path method and PERT; Maximal flow, Dynamic programming; Transhipment model; Service tours, vehicle scheduling savings and other heuristic methods – Urban transport planning with emphasis on bus mode; Traffic flows.

SMA 429 OPERATION RESEARCH III

Multi-objective; Goal programming; Utility of decision theory; Markov chains; manpower planning; Rogers population models; Further concepts in economics, e.g. consumer surplus; Pereto optimality; Elements of input-output and cost-benefit analysis Non-Linear Programming Lagrange's multipliers, Kahu-Tucker analysis Quadratic and integer programming (one algorithm each).