TRIBHUVAN UNIVERSITY

INSTITUTE OF SCIENCE AND TECHNOLOGY

SCHOOL OF MATHEMATICAL SCIENCES

Bachelor in Mathematical Sciences (B.Math.Sc.)

Course of Study

Code No.: MSAS 351 *Full Mark:* 75

Paper: **Actuarial Models II** *Pass Mark:* 30

Nature: Theory *Credit:* 3

Course Description:

The course is a continuation of Acturial Model-I. This is a grounding in the principles of modeling as applied to actuarial work – focusing particularly on stochastic asset liability models and the valuation of financial derivatives. These skills are also required to communicate with other financial professionals and to critically evaluate modern financial theories.

Learning Objectives:

On successful completion of this subject, a student will be able to:

1. Describe, construct, interpret and discuss the models underlying asset valuations.
2. Describe, construct, interpret and discuss the models underlying liability valuations.
3. Describe, construct, interpret and discuss the models underlying option pricing.

Mode of Delivery:

The course will be taught by lecture (48 hrs), and problem solving and class discussion (24 hrs). The use of spreadsheet software for problem solving will be encouraged.

Contents:

Unit 1 Asset Valuations **8 hrs**

Single and Multifactor Models for Investment Returns:

Multifactor models of asset returns and their types (macroeconomic models, fundamental factor models, statistical factor models), Single index model of asset returns, diversifiable and non-diversifiable risk, Construction of the different types of multifactor models.

Stochastic Models for Security Prices:

Continuous time log-normal model of security prices and empirical evidence for and against the model, Standard Brownian motion, Wiener process, Stochastic differential equations, Ito integral, Diffusion and mean-reverting processes, Statement of Ito's Lemma and its application, Stochastic differential equation for the geometric Brownian motion and Ornstein-Uhlenbeck process.

Unit 2 Asset Valuations (Contd.) **8 hrs**

Models of Term Structures of Interest Rates:

Theory of a term structure of interest rates, Characteristics of models for the term-structure of interest rates, Application of the term structure of interest rates to modeling various cash flows and calculating the sensitivity of the value to changes in the term structure, Risk-neutral approach to the pricing of zero-coupon bonds and interest-rate derivatives for a general one-factor diffusion model for the risk-free rate of interest, The approach using state-price deflators to the pricing of zero-coupon bonds and interest-rate derivatives for a general one-factor diffusion model for the risk-free rate of interest,

Vasicek, Cox-Ingersoll-Ross and Hull-White models for the term-structure of interest rates, Limitations of these one-factor models.

Simple Models for Credit Risk:

Credit event and recovery rate, Different approaches to modelling credit risk (structural models, reduced form models, intensity-based models), Merton model, Two-state model for credit ratings with a constant transition intensity, Jarrow-Lando-Turnbull model for credit ratings, Generalisation of the two-state model to incorporate a stochastic transition intensity.

Unit 3 Liability Valuations **16 hrs**

Ruin Theory:

Aggregate claim process, Cash-flow process for a risk, Poisson process and distribution of inter-event times, and their application, Compound Poisson process and its use, Probability of ruin in infinite/finite and continuous/discrete time, Relationships between the different probabilities of ruin, Effect on the probability of ruin of changing parameter values, Probabilities of ruin by simulation.

Run-off Triangles:

Development factor and use of a set of assumed development factors to project the future development of a delay triangle, A basic chain ladder method for completing the delay triangle using development factors and its application, adjustment of the basic chain ladder method to make explicit allowance for inflation, The average cost per claim method, Bornhuetter-Ferguson method for estimating outstanding claim amounts, Underpinning a run off triangles approach, Value basic benefit.

Unit 4 Option Pricing and Valuations **8 hrs**

Arbitrage and a complete market, Option prices, Factors that affect option prices, options which are not model dependent, Valuation of a forward contract, Upper and lower bounds for European and American call, Put-call parity, Use of binomial trees and lattices in valuing options, Risk-neutral pricing measure for a binomial lattice, Risk-neutral pricing approach to the pricing of equity options, Difference between the real-world measure and the risk-neutral measure, Alternative names for the risk-neutral and state-price deflator approaches to pricing.

Unit 5 Black-Scholes Model **8 hrs**

Black-Scholes derivative-pricing model, and it's applications, Validity of the assumptions underlying, Black-Scholes model, Approach to pricing using deflators and its application in simple models, Binomial and Black-Scholes model, Its equivalence to the risk-neutral pricing approach, Commonly used terminology for the first, and where appropriate second, partial derivatives (the Greeks) of an option price, Value basic benifit.

References

1. *ActEd Study Material Subject CT8*, Actuarial Education Company, 2016.
2. Baxter, Martin & Andrew Rennie, *Financial calculus; An introduction to derivative pricing*, Cambridge University Press, 1996.
3. Panjer, Harry H (ed), *Financial economics: with applications to investments, insurance and pensions*, The Actuarial Foundation, 2001.
4. Elton, Edwin J, Martin J Gruber, Stephen J Brown et al, *Modern portfolio theory and investment analysis* (8th edition), John Wiley, 2010.
5. Hull, John C, *Options, futures and other derivatives* (7th edition), Prentice Hall, 2008.

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