INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

November 2026

CM2 - Economic Modelling (Paper B)

Time allowed: 1 Hour 45 Minutes

Total Marks: 100

Q.1) A casino called "The Formaggio" has a game called "The Wily Wheel" for its patrons. In this game, a patron throws a marble on a spinning wheel. The wheel has 10 slots numbered 1 through 10 and the marble can land in any one slot. The area of the slots is designed in such a way that the probability of the marble landing in slots 1-3 is 8% each, 4-7 is 15% each, 8-9 is 6% each and that of landing in slot no. 10 is 4%.

Below are the rules of the game

- The patron pays a fixed entry fee of ₹40 per game
- The payout to the patron is the square of the slot number the marble lands
- There is no bias in throwing the marble and the likelihood of the marble landing in any zone is defined as above

i) List the probability of the marble landing in various slots along with the payoff to the patron. Also, calculate the net payoff to the patron for each possibility. Compute the % return relative to the investment by the patron for every possibility. **[3]**

ii) A patron is willing to accept an unfair gamble. Explain, with reasons if the person is risk averse, risk neutral or a risk seeker. Also, describe what the utility function graph of the patron will look like. **[3]**

iii) Using the above probabilities, calculate the mean, standard deviation and variance of the % returns. Also, calculate the following measures of risk for the return earned by the patron:

- Downside semi-variance
- Shortfall probability using a benchmark return of -30% and -50%
- Value at risk (VaR) return levels at 75% and 90% confidence

Expected shortfall below -30% and -50% return levels. **[14]**

Mr. Tai Fung, the owner of the casino, wants to recalibrate his pricing strategy for the game to increase profits and reduce the risk.

iv) Under the current scenario, calculate the probability that the casino makes a profit on a game. **[3]**

v) Calculate the entry fee the casino should charge such that the expected profit to the casino per game is ₹18. **[3]**

vi) Recalculate the probability of the casino making a profit on any given game. Comment on the difference from (iv). Also, without performing any further calculations, comment on the change in the VaR and expected shortfall for the patron. **[6]**

[32 Marks]

Q.2) Konoha Inc. is a company whose shares trade on the stock exchange. A European Call option with a term of 4 years is written on the non-dividend paying share of the company. The current stock price is ₹100 and the strike price of the call option is ₹103. The risk-free continuously compounded force of interest is 5.50% p.a.

It has been observed that the stock moves either 20% upwards in a year or 15% downwards in a year from its current position.

i) Calculate the risk neutral probability of an upward movement and construct a binomial tree for the next 4 years. **[5]**

ii) At each of the terminal nodes at the end of the 4th year, calculate the option payoff value of the European call option. Calculate the risk neutral probability of reaching each terminal node. Calculate the price of the call option at time 0. **[7]**

iii) Calculate the risk neutral probability that the option expires in the money. Explain whether the real world probability of an up-move will be lower or higher than the risk neutral probability along with the reasons. **[4]**

iv) Calculate the expected terminal payoff from the option using the risk neutral probabilities. Compare the expected payoff with the option price calculated in ii and comment on why both are different. **[3]**

v) Explain what a "delta" for an option is and provide the range of the delta of a call option. Comment on how an investor who has sold the call options will create a delta neutral portfolio using shares. Express the no. of shares to be bought/sold as a function of the delta and the no. of call options to achieve a delta neutral portfolio. **[5]**

vi) Consider a special "Knock out" Call option with the same strike price and maturity. In this call-option, if the stock price goes below a certain threshold any time during the term, the option becomes worthless i.e. it gets "knocked-out". The threshold is set at ₹90. Calculate the price of this option at time 0 and comment on the difference in price with the regular call option. **[6]**

[30 Marks]

Q.3) An insurance company sells life insurance policies that are identical in nature. The company has an initial surplus ₹ 10,000,000. The company charges ₹ 10 p.a. as premium for the life insurance policy which has a term of 10 years. You have been provided the number of policies sold each year for the next 10 years. The company derives its annual claim rate based on a distribution. You have been provided 100 simulated values for the next 10 years of the annual claim rate. The sum assured per policy is ₹12,000.

You may assume that the policy is sold at the start of the year and the claim is paid at the end of the year. The claim rate is applicable on the total inforce policies at the start of the year.

i) Tabulate the no. of active policies under each simulation for the next 10 years. Create another table for the no. of deaths every year. **[4]**

ii) Tabulate the surplus process of the insurance company for the next 10 years under all simulations starting from the initial surplus and find the probability of ruin at the end of the 10th year. The company defines ruin as a situation when the total surplus as on date becomes negative. **[5]**

iii) Repeat the above process of calculation of ruin probabilities with an initial investment of ₹7,500,000. Comment on the difference from (ii). Plot a year-wise chart depicting the probability of ruin at the end of every year. **[5]**

iv) The regulator of the country is proposing a new regulation. As per the regulation, the company will have to define ruin when the Surplus at time t i.e. Required Surplus is less than 1. The required surplus is calculated by multiplying a factor to the total inforce sum assured at time t. The proposed factor is 0.5%. Calculate the probability of ruin under this new definition at the end of the 10th year. Assume the initial surplus as in (ii). **[3]**

The regulator has scrapped the above proposed plan. Ruin will now be defined as before. Mr. A, the Chief Actuary wants to revisit the premium charged for the policies.

v) Calculate the lowest premium per policy p.a. such that the probability of ruin at the end of 10 years is not greater than 21%. Assume initial surplus same as (ii). **[4]**

Mr. B, the Marketing Head believes that the company should keep the premium unchanged from before by exploring reinsurance arrangements. The reinsurance arrangement is Quota share where the reinsurance shares 10% of both the claims and the premium.

vi) Calculate the expected surplus at the end of the 10th year with the reinsurance arrangement. Also, calculate the probability of ruin at the end of the 10th year. Comment on the difference from (ii). **[10]**

vii) The company is considering investing the surplus at the end of the year in a debt instrument which pays a fixed return. Without performing any further calculation, explain with reason what will happen to:

a) The expected surplus at the end of the 10th year

b) The premium, if the company recalculates the premium such that the probability of ruin is unchanged from (ii) **[4]**

viii) Describe the general shape of the yield curve. Explain what is meant by an inverted yield curve. **[3]**

[38 Marks]

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