

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

May 2025

**CM1 - Actuarial Mathematics for Modelling
(Paper B)**

Time allowed: 1 Hours 45 Minutes

Total Marks: 100

- Q.1)** Maria Inc. is planning to launch a new term plan named Titan plus. This plan covers the loan amount taken by policyholders from the bank. Under this plan, sum assured which is equal to the outstanding loan amount will be payable on death to the policyholder. No other benefits are available under this plan. The plan has a fixed premium term as well as policy term of 20 years. The pricing head Mr. Erwin has been tasked with the pricing of this product.

Below are the assumptions to be used for the pricing:

Mortality rate: 50% of the rates provided in the input sheet.
 Fixed renewal expenses: 1000 starting from 1st policy year and inflating by 5% every year.
 Interest rate: 7 % p.a.

You may assume that the expenses are incurred at the start of every policy year. No commission is payable on this product. You may also assume that there are no surrenders during the policy term and that deaths occur at the end of the policy year. The company uses a risk discount rate of 13% p.a. to calculate the expected present value of profits.

The company does not hold any reserves against the policy.

- i) For a loan amount of 1,00,00,000 prepare the annual loan schedule assuming a loan interest rate of 7% p.a. and a loan term of 20 years. You may assume the level loan instalments are paid at the end of every year and instalment is paid prior to policyholder's death. (6)
 - ii) Mr. Levi who is aged 35 years last birthday wishes to purchase the policy with premium of 7,500. Calculate the profit margin for this policy. (13)
 - iii) The company now decides to hold prospective reserves against the policy. The company uses the following assumptions for calculating prospective reserves:
 - a) Renewal expenses: 10% higher than assumed for pricing with no change in inflation.
 - b) Interest rate: 6% p.a.

All other assumptions remain the same as pricing. Calculate the prospective reserves at the end of every year for the above policy using the premium from (ii). (8)
 - iv) Calculate the revised profit margin after allowing for reserves as obtained in (iii) in the calculation. You may assume the same premium and risk discount rate as in (ii) (7)
 - v) Comment on the impact on the profit margin of allowing for reserves in the calculation (3)
- [37 Marks]**

- Q.2)** Bond A is a government bond which is priced at 95 as of 1st January 2021. The bond has 10 years left to maturity and pays a bi-annual coupon of 6% p.a. every 1st July and 1st January.

Bond B is a corporate bond which is priced at 85 as of 1st January 2021. The bond has 10 years left to maturity and pays a quarterly coupon of 7% p.a. every 1st of April, July, October and January.

The redemption price as well as the face value of both the bonds is 100 and you may assume that the coupon due on 1st January 2021 has already been reflected in the price.

- i) Calculate the nominal effective yield for Bond A. (4)
- ii) Calculate the nominal effective yield for Bond B. (4)

- iii)** Based on the inflation index provided, calculate the real effective yield for Bond B. (3)

Bond C is a 10-year zero coupon government bond currently priced at 60 with redemption at 100.

Mr. Rubin is an investment analyst. He is trying to arrive at a suitable discount rate to calculate the price of a share. He estimates that the risk discount rate will be the difference in the real yield of Bond B and the nominal yield of Bond A added to the yield of Bond C.

- iv)** Calculate the discount rate in % rounded to 2 decimals. (2)

Mr. Rubin uses a discounted cashflow model to arrive at the price for a company Anthrax Inc. Under this method, the price is derived as the discounted value of all future dividends and the terminal value at the risk discount rate. The share is currently priced at 96.

The dividends are projected by the following formula: $3 + 10\% * b$; where b are the projected earnings for the year as provided in the table. The dividends are paid at the end of the year. The terminal value of the share after 30 years will be determined by the equity index provided.

- v)** Calculate the share price as per the above model for Anthrax Inc. (6)

- vi)** Without performing any further calculations, specify with reason the impact on the calculated share price of Anthrax Inc. due to the following:

- a)** Increase in the projected earnings of the company. (2)

- b)** If the nominal yield of Bond B is used to calculate the risk discount rate instead of the real yield. (3)

- c)** The dividends are paid in the middle of the year. (2)

Mr. Mustaine has taken a loan of 1,00,00,000. The loan is repayable at the end of 20 years along with the interest at 6% p.a. effective. Mr. Mustaine has a business that generates 5,00,000 at the end of every year. He also expects extra profits at the end of every 5 years due to the market cycle with the last extra profit being at the end of the 15th year. The extra profits will be earned in addition to the above income and will be three times the above income Mr. Mustaine invests the above proceeds in a deposit.

- vii)** Calculate the minimum annual effective yield that Mr. Mustaine needs to earn so that the loan amount at the end of 20 years is repaid. (9)

[35 Marks]

- Q.3)** Harkonnen Pvt. Ltd. wants to prepare a month wise decrement table for a single life using the mortality rate provided in the input sheet. The year wise surrender rates have been provided in the input sheet as well. During the first year, the surrender can only occur at the end of the year.

However, from 2nd year onwards, the surrenders will occur on a monthly basis. You may assume a constant force of decrement to calculate the monthly decrements for both death and surrenders. You may also assume that there are 12 months in a year and all months have the same number of days. The deaths occur at the end of every month and surrenders occur after death.

- i)** Prepare the monthly decrement table for a life aged 35 last birthday for 3 years. (10)

The company has a term plan with a policy term of 10 years. Currently, the company has 1,00,000 policies with all lives aged 40 last birthday. All policies have a single premium which has been received at the outset and have a fixed sum assured of 10,00,000 each. The company holds reserves using prospective method at the end of every year.

Following are the assumptions used for reserving:

Mortality rate: 110% of the rates provided in the table.

Interest rate: 5% p.a.

Surrenders: NIL

You may assume all deaths occur only at the end of the year and there are no expenses or maturity benefit under the policies.

- ii) Calculate the expected death strain for every year. (10)
- iii) Using the data for actual deaths, calculate the mortality profit for every year. (5)
- iv) Without performing any further calculations, comment on the impact of mortality profit due to the following:
 - a) Increase in the no. of actual deaths.
 - b) Increase in the expected mortality rate. (3)

[28 Marks]
