

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

November 2025

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

Time allowed: 1 Hours 45 Minutes

Total Marks: 100

Q. 1) Hashira Ltd. is launching a new Unit Linked Insurance Product. Following are the features of this product:

- A higher of the Sum Assured or Unit Fund value at the end of the year is payable on death
- The bid value of the unit fund is payable on surrender and maturity of the policy
- Annual premiums are payable at the beginning of year until the end of the policy term
- The company deducts an allocation charge as per the data provided from the premium.
- The company also deducts a fixed annual policy fee of INR 1,000 and an annual maintenance charge of 0.5% of the Unit Fund value
- The bid offer spread is 0.5% applicable on allocated premium

Assume that the fixed policy fee is deducted at the start of the year right after the allocation charges. Annual maintenance charge is deducted at the end of the year.

Mr. Muzan, who is aged 40 years old wishes to purchase a policy with a Sum Assured of INR15,00,000 and an Annual premium of INR 100,000. The policy term is 15 years.

- i) Prepare a projection of the Unit Fund Value for the entire policy term showing all the components and charges for Mr. Muzan. You may assume that the Unit Fund growth rate is at 10% p.a. (8)

The company uses the following assumptions for profit testing the product:

- Mortality Rate: 80% of the rates provided in the sheet
- Initial Expenses: INR 10,000
- Renewal Expenses (from 2nd year): INR 3,000
- Commission: Same as allocation charges
- Interest on Non-unit Fund: 6% p.a.
- Surrenders: As provided in the sheet

You may assume that surrenders only occur at the end of the year after the deaths. Expenses are incurred at the start of the year. The company currently does not hold any non-unit reserves.

- ii) Calculate the profit signature for the policy as well as the Expected Present Value (EPV) of Profits using a risk discount rate of 13% p.a. (13)

Wisteria Ltd. feels that the company is incurring losses due to paying out the excess death benefits from the non-unit fund. The pricing head Mr. Giyu suggests that the company should explicitly deduct additional “mortality charges” through the unit fund account. These additional mortality charges will be deducted at the end of each year only after deduction of all other charges in the unit fund account. The mortality charges will be applied on the Sum at risk which is defined as the excess of the fixed sum assured over the fund value at the end of the year, if any. No mortality charge is deducted if the Fund Value is higher than the fixed Sum Assured. The same fund value used for calculation of mortality charge should be used for calculation of death outgo.

The charge will be calculated by multiplying the mortality charge rate with the above excess. The mortality charge rates used for arriving at these additional mortality charges are 90% of the mortality rates provided in the sheet

iii) Prepare the revised projection for the Unit Fund Value. (5)

iv) Calculate the revised profit signature and the EPV of profits. (5)

The company now decides to hold a non-unit reserve against this policy. The company zeroes the non-unit reserve every year. The company uses the same basis for the calculation of the non-unit reserve as profit testing in iv) with one change.

Non-Unit Reserve is computed based on 5% p.a. interest rate. All other charges and assumptions remain the same.

v) Calculate the non-unit reserve at the end of every year. (5)

vi) Calculate the revised profit signature and EPV using assumptions as in iv) after incorporating the non-unit reserve from v) components in profit testing. (5)

[41]

Q. 2) The Rothschild Group is planning to start a new bank in Judea. The group will have to invest INR 100 crores upfront to start the bank. Additionally, the bank will incur a cost of 20 crores towards acquiring the required infrastructure for the bank. The initial investment of 100 crores will be invested in a risk-free asset earning 3% p.a. to meet regulatory capital requirements. This interest at the end of the year will be transferred by the bank to the Group i.e. the amount invested in the bank will always be 100 crores. The bank will have running costs of salaries and rent as provided in the sheet. These expenses will be incurred at the start of the year.

The bank expects customers to deposit and withdraw money from their deposit accounts every year as per the data provided. The deposits from the customers are made at the start of the year and withdrawals are made at the end of the year. The bank will pay interest on the deposit balance to the customers at the end of the year. The bank uses balance of the deposits at the start of the year for the calculation of interest amount payable. The bank will also give out 80% of all the deposit balance at the start the year as loans. The bank charges a loan interest which is 2% p.a. more than the interest it pays on the deposits. The bank will receive this interest at the end of the year. You may assume that the deposit balance at the start of the year also includes the additional deposits made for the year.

Additionally, the bank also charges an account maintenance charge of INR 500 per customer. Also, the bank charges a fee of 0.5% of the withdrawal amount as the withdrawal charges. Both these charges are assumed to be at the end of the year. At the end of 20 years, the group plans to wind up its operations by selling the bank to another group. The bank expects to receive a sum of money which is 5 times its operational income for the 20th year. Operational income is defined as the income earned through interest on loans only.

i) Prepare the cashflows for the bank for the 20-year period. The cashflows must include all the costs, incomes and opening as well as closing balances of the deposits for each year. (8)

ii) Calculate the Net Present Value of the cashflows using a discount rate of 12% p.a. (5)

iii) Calculate the IRR achieved by the group with this project. (4)

iv) Mr. Mayer, the Deputy Chairman of the group has the following suggestions. Without performing further calculations, comment on the impact of the below suggestions on both NPV and IRR:

- a) Reducing the spread between the loan and the deposit interest rate to 1.5%
- b) Giving out only 75% of the deposits as loans instead of 80%
- c) Reducing the withdrawal fee to 0.25% of the withdrawal amount

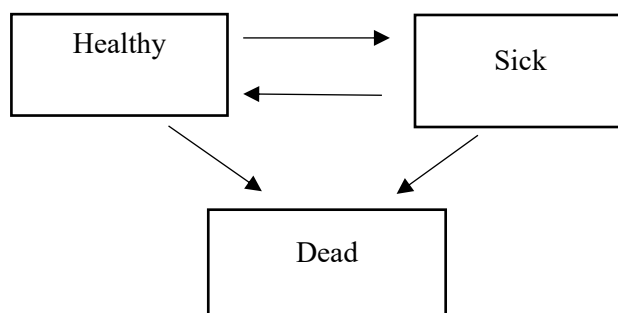
(6)

Mr. Jacob, the Chairman believes the company should wind up by selling after 30 years instead of 20 years i.e. to continue operations for another 10 years. The bank will still be sold to another company at 5 times the operational income of the 30th year.

v) Recalculate the Net Present Value for the project and comment on the change in NPV from (ii).

(6)
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Q. 3) An insurance company offers an insurance product which offers payments to policyholders on sickness and death. The company uses a discrete multiple decrement model to value the benefits under this product. The policyholder starts out in a Healthy (H) state at the start of the policy term. At the end of any given year, the policyholder can be in Healthy (H), Sick (S) or Dead (D) state. A policyholder can move between the states during the year as per the below diagram:



The transition probabilities for any given year are as follows:

- Health to Sick (HS): 0.02
- Health to Dead (HD): 0.0015
- Sick to Dead (SD): 0.003
- Sick to Healthy (SH): 0.95

It is assumed that the transitions happen only at the end of the year. It is also assumed that the transitions from Healthy to sick and Sick to healthy occur first and the transitions to death from both the states happen after.

i) Calculate the decrement table for 10 years assuming there are 100,000 policyholders at the start of the policy. You must show all the probabilities, decrements as well as the number of policyholders in each state at the end of every year.

(9)

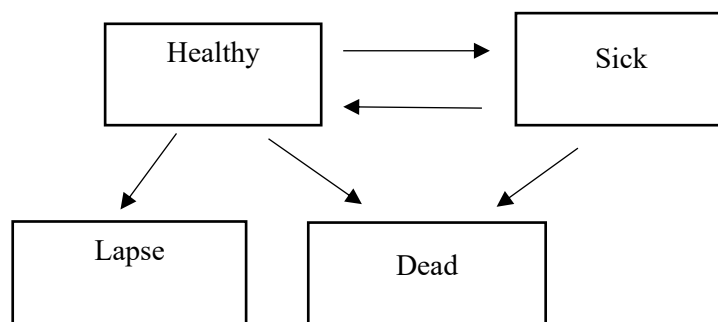
The above product pays out INR 10,000 for every year that the policyholder is sick. This payment is made to policyholders in sick state at the start of the policy year. The product also makes a payment of INR 100,000 on death of the policyholder from any state at the end of the year.

- ii) Calculate the total expected value of both the benefits payable under this product for each year. (6)

The company wants to calculate the premium for this product. The premium will be payable at the start of every policy year. Additionally, the company wants to add a waiver of premium clause to the product. As per this clause, no premiums will be payable by a policyholder who is sick i.e. premiums will only be paid by policyholders in Healthy State. The company also earns an interest of 6% p.a on premiums after payment of sickness benefits.

- iii) Calculate the premium per policy such that the Expected Present Value (EPV) of all profits is 2% of the Expected Present Value of all the premiums. Use a risk discount rate of 12% p.a. (10)

The company wants to add a Lapse (L) state to the model. The revised transition diagram will be as below:



- iv) Without performing further calculations, comment on the impact of inclusion of lapse state on the following: (3)
- EPV of sickness benefits
 - EPV of premium
 - EPV of profits, assuming the premium is unchanged from (iii)
- v) Comment on whether inclusion of the lapse state gives a more “prudent” or a more “realistic” approach to pricing. (2)

[30]
