INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

29th November 2023

Subject CM1B – Actuarial Mathematics (Paper B)

Time allowed: 1 Hour 45 Minutes (10.15 - 12.00 Hours)

Total Marks: 100

INSTRUCTIONS TO THE CANDIDATES

1. *Mark allocations are shown in brackets.*

2. *Attempt all questions beginning your answer to each question in the template provided.*

3. *Attempt all sub-parts of the question in the template provided only, unless otherwise instructed to do so.*

4. *The working of each part of the question should be on a separate tab (sheet). For example, question 1(i) should be worked out within the tab (sheet) with name 1(i) of worksheet.*

5. *Where possible, summarize your data used & assumptions made (if any) in a separate tab.*

6. *Do save your work in solution template on a regular basis.*

7. *All the detailed guidelines are available on exam screen.*

8. *Please check if you have received complete Question Paper and no page is missing. If so, kindly get new set of Question Paper from the Invigilator.*

Q. 1) A set of Inflation index starting from Jan 2022 to Dec 2038 is given in the data sheet of the template

    i) Calculate the annual effective inflation rate over the previous twelve months for each month starting from January 2023 with index data provided. (4)

An investor purchased INR 10 million nominal of a newly issued 15-year index-linked security on 15th January 2023, at a price of INR 100 per INR 100 nominal. The security paid coupons half-yearly in arrears at a nominal rate of 1.5% per annum and was redeemed at par.

The coupons and the redemption payment of the security were indexed in line with the inflation index values allowing for three-months' time lag.

    ii) Calculate the following, assuming the investor held the security until redemption,

        a) The annual effective money yield. (8)

        b) The annual effective real yield.
        Assume that all months are of equal length of 30 days. (8)

    iii) Has this instrument provided any inflation protection to investor? If yes, assess the inflation protection that has been provided by the security. (6)

[26]

Q. 2) A Life Insurance company has issued a regular premium term assurance contract with initial sum assured of INR 1,00,00,000 and policy term of 30 years. The sum assured increases every policy year by 5% of initial sum assured beginning from the second policy year subject to maximum sum assured of 200% of initial sum assured. The benefit on death is payable at the end of the year of death. The level annual premium of INR 35,000 is payable in advance till the end of the policy term or death whichever is earlier. The contract is issued to the policyholder aged 30 years exact at the time of entry.

The following assumptions are issued by the company to carry out the profit testing:

Mortality Rates	: As given in template.
Interest Rate	: 7% per annum
Initial Expenses	: INR 2,000
Renewal Expenses	: INR 1,000 from the start of second policy year onwards and inflating by 4.50% per annum from the start of the third policy year
Initial Commission	: 30% of annual premium
Renewal Commission	: 10% of annual premium
Risk Discount Rate	: 15% per annum
Reserves	: 105% of total premium paid multiplied by ratio of outstanding policy term to total policy term

    i) Calculate the profit margin of the policy. (24)

    ii) The Marketing Actuary wants to include an option for return of premium option at the end of policy term on survival of policyholder. Calculate the annual premium that will be payable in advance to maintain the same profit margin. (7)

iii) The Appointed Actuary thinks that the reserves might be insufficient and has asked to calculate the reserves as 115% of total premium paid multiplied by ratio of outstanding policy term to total policy term. Calculate the revised profit margin and comment on the results. (5)

[36]

Q. 3) On 1st January 2012, a Life Insurance Company sold a regular premium participating endowment assurance policy to a life aged 30 years for a policy term of 25 years. The basic sum assured under the policy is INR 5,00,000 and an annual premium of INR 15,000 is payable each year in advance during the policy term. The company declares reversionary bonus in each year. Sum assured along with accrued bonus is payable on maturity or on early death. Death benefit is payable only at the end of policy year.

In the "Input" sheet of the template, the details of valuation assumption for expected mortality, expected expenses, inflation and interest rate are given. Inflation is applied on fixed renewal expense starting from 2nd policy anniversary. In the same sheet, actual expenses incurred, the actual reversionary bonus declared and the actual investment return earned by the Company on similar group of policies from the year 2012 to 2022 are also provided. The actual mortality experience was 75% of the expected mortality at all ages during this period.

Any decrement other than death is ignored throughout.

Using the given information on actual experiences,

i) Calculate the Gross premium retrospective reserve of the said policy as at 11th policy anniversary. (19)

From the given information on expected assumptions,

ii) Calculate each of $A^1_{x+t:\overline{n-t}|}$, $A_{x+t:\overline{n-t}|}{}^1$, $\ddot{a}_{x+t:\overline{n-t}|}$ and $\ddot{a}_{x+t:\overline{n-t}|}$ @| inflation adjusted interest rate, recursively backwards from the end of the policy term to the 11th policy anniversary. (11)

iii) Calculate Expected Present Value (EPV) of Premium, EPV of Expenses and EPV of guaranteed benefits (Basic sum assured and already vested bonus) as at 11th policy anniversary using above functions calculated in part (ii). (4)

iv) The Company has decided to pay a terminal bonus of INR 20,000 only to the policyholders who survive till maturity. Find the Internal Rate of Return (IRR) through calculation of net present value, to be earned by a policyholder on the policy, if maturity benefit is calculated as a sum of basic sum assured, already accrued bonus till 2022, future bonus at the rate of 40 per thousand basic sum assured and the terminal bonus as above. (4)

[38]

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