

INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

16th September 2021

Subject CM1B – Actuarial Mathematics
(Paper B)

Time allowed: 2 Hours (14.30 - 16.30 Hours)

Total Marks: 100

- Q. 1)** An online shopping website wants to start ‘brick and mortar’ operations. For that purpose, the Board of the company wants to open five stores in key locations within the country. Based on the success of these five stores, a decision will then be taken to expand the number of stores further. It is estimated that each store will require INR 3 crores worth of investment at the outset. The Company will fund its initial investment by borrowing at a rate of 8% p.a.

The running cost of each store would be about INR 1 lakh per month (which will be due at the end of the month) with an expected inflation of about 5% p.a. (with the inflation rate being applied monthly from the second month onwards). The stores are expected to earn revenue worth INR 10 lakhs, INR 7 lakhs, INR 5 lakhs, INR 4 lakhs and INR 2 lakhs respectively, by the end of the first month. The management has an optimistic view regarding the growth of the industry and expect that the revenue from each store will grow at a rate of 15% p.a. (with the growth rate being applied monthly from the second month onwards).

The Board has asked the management to assess the project using five distinct project appraisal metrics.

The current risk-free interest rate in the country is 6.5% p.a. It is recommended that this rate be used for accumulation/discounting in the calculation of the project appraisal metrics. All calculations need to be done by compounding on a monthly basis.

- i) The text above mentions annual rates for inflation, borrowing rate, accumulation rate and growth rate. Calculate the equivalent monthly rate for each of these. (2)
- ii) Calculate the five project appraisal metrics by projecting cashflows associated with this project for a period of five years. (you are expected to show all calculations as per first principles and not derive solutions using Microsoft Excel shortcuts which exist for some of these appraisal value metrics) (16)
- iii) A recommendation has been made to the management that the accumulation should be done using the interest rate that the Company earns by investing in equity and other market instruments. This is about 9% p.a. It has also been recommended that the Company should use a discount rate that makes appropriate allowance for the perceived risk of this investment. Discount rate commensurate with the riskiness of this project has been determined to be 16% p.a. Re-calculate the project appraisal metrics expected to be affected by these recommendations. (5)
- iv) The Board considers internal rate of return as a key decision metric. Based on the information provided in scenario (iii) above and the internal rate of return of this project, comment on whether the Board should proceed with this investment? (3)
- v) The debt of INR 3 crores per store is to be paid back by making equal annual instalments in arrears. Develop a schedule of payments clearly showing the interest component and capital repayment component for each instalment. If any annuity function is used in the calculations, then the workings should also show how the annuity function has been calculated. (8)

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- Q. 2)** A with-profits endowment assurance with a 20-year policy term is to be issued to Amit aged exactly 42 years. The basic sum assured is INR 5,00,000 and the company expects to declare simple reversionary bonuses as 3% of the sum assured each year. Bonuses will vest at the end of each policy year and the sum assured plus all accrued bonuses till date will be paid

out upon survival to the end of the policy term or immediately on earlier death. The contract will be subject to level annual premiums payable at the start of each year. The insurance company uses the following basis for the calculation of its premiums:

Mortality:	AM92 Select (provided in the Microsoft Excel sheet)	
Interest:	4% p.a. effective	
Expenses	Initial:	INR 850 per policy
	Regular:	Incurred at the start of each policy year except the first year. These are INR 100 per policy at the start of second policy year and subject to an inflation rate of 1.25% p.a. thereafter.
	Claim:	These are INR 500 on death and INR 300 on maturity, and subject to an inflation of 1.25% p.a. from next day after the policy inception date.
Commission	Initial:	40% of the first year's premium
	Renewal:	5% of each subsequent annual premium and incurred at the same time as receipt of the premium.

- i) Calculate the annual premium for this contract. (Hint: You may use the goal-seek functionality of Microsoft Excel) (25)
- ii) Calculate the annual premium for this contract assuming an interest rate of 5%. (4)
- iii) Comment on the results of (i) and (ii) above. (1)
- iv) The life insurer is considering setting bonus rates to be super-compound reversionary bonus where a bonus rate of 3% applies on sum assured and 5% on the accrued bonuses. Calculate the accrued bonus at the end of each year. (5)
- v) The company is reviewing the assumptions being used and intends to set the expense inflation assumption based on the real-yield available on index-linked Government bonds. The current prevailing real yield based on market benchmarks is 2% p.a. Given the scenario as per part (ii) above, what expense inflation assumption should be used by the company to obtain real yield of 2% p.a.? (4)
- vi) There is great demand in the market for non-participating products. The company intends to launch a non-participating savings product which pays initial sum assured immediately on death or upon survival to end of the term. Using the assumptions for part (ii) above and same annual premium, calculate the initial sum assured that may be offered under this product and comment on your results. (6)

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- Q. 3)** Alex invests his money in an investment fund and his returns are linked to the performance of the fund. The fund is managed such that the one-year return for each year reflects 70% of the total return on ABC Equity Index and 30% of the total return on ABC Bond Index.

You have been provided with the value of the ABC Equity Index and ABC Bond Index over the past 10 years.

- i) 10 years ago, Alex invested INR100,000 in the fund and since then has invested INR50,000 every 2 years. Calculate the current value of his investments. (6)

- ii)** For each of the two indices, calculate the force of interest equivalent to a constant force of interest earned by the investment fund over the period. (3)
- iii)** The fund manager has decided to introduce an annual management charge based on the performance of the fund in the year. A minimum charge of 1% p.a. each year, and is increased to 1.5% if the returns earned by the fund over the year are in excess of 10%. This charge is applied at the end of each year on the value of investment (i.e. post investment earnings for the year). Further, a service tax of 14% also applies on the value of these charges and are deducted from the value of the fund. What would the value of Alex's investments be if this policy was introduced by the company 10 years ago? (5)
- iv)** Alex is currently aged 50. He plans to retire by age 60 and would like to receive a fixed income of at least INR 100,000 per year at end of each year for 20 years post retirement. Assuming a discount rate of 6% p.a. applicable on payments post retirement and no mortality, how long does Alex have to continue his contribution of INR50,000 every two years to achieve this. Assume that the fund earns the same force of interest as in part (ii) in future, Alex makes the first additional payment of INR50,000 at age 50 years exact and ignore charges as described in part (iii). (7)

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