

INSTITUTE OF ACTUARIES OF INDIA
EXAMINATIONS

February 2025

CM1 - Actuarial Mathematics (Paper A)

Time allowed: 3 Hours 15 Minutes

Total Marks: 100

Q1. For a term assurance contract with a fixed term, how will the annual premium change as the age at entry increases from ages 25 and above?

- a. It will increase
- b. It will decrease
- c. It will stay the same
- d. Insufficient information to answer

[1 mark]

Q2. Arrange the annual premium calculated using the same basis for the following policies issued to the same person with the same sum assured in a descending order: (I) A whole life assurance (with a premium paying term of 10 years); (II) A 10-year term assurance; (III) A 10-year endowment assurance.

- a. I > II > III
- b. III > I > II
- c. II > I > III
- d. III > II > I

[2 mark]

Q3. What will be the value of the prospective reserve at time n for a n year term assurance cover, that pays S at the end of year of death, provided death occurs during the term of the contract?

- a. S
- b. 0
- c. $S/(1+i)$
- d. 1

[1 mark]

Q4. Which of the following can be classified as a direct expense?

- a. Board of directors' remuneration
- b. Postal charges
- c. Renewal commission
- d. Office rent

[1 mark]

Q5. Female mortality is observed to be lower than male mortality at all ages. Which contract will have a higher reserve (assume the same benefits are payable under both contracts and the same premiums are paid): (I) A whole life assurance issued to a 45-year old male; (II) A whole life assurance issued to a 45-year old female?

- a. I
- b. They will have the same value
- c. II
- d. Insufficient information to answer

[1 mark]

Q6. Calculate the single premium payable by a 45 years old man for a 20-year endowment assurance policy that pays 1,000,000 on maturity or at the end of year of earlier death. Expenses of 5,000 are incurred at the start of each year and a claim expense of 1,000 is incurred at the time of paying the claim. Assume mortality as per AM 92 Select Table and interest rate of 6% p.a.

- a. 539,214
- b. 387,057
- c. 539,350
- d. 386,877

[2 marks]

Q7. Calculate the annual premium (payable in advance for a maximum of 20 years or until earlier death) by a 45 years old man for a whole life assurance policy that pays 1,000,000 at the end of year of death. Expenses of 5,000 are incurred at the start of each year while the policy is in-force. Assume mortality is as per AM 92 Ultimate Table and interest rate of 4% p.a.

- a. 26,839
- b. 26,862
- c. 19,638
- d. 19,663

[3 marks]

Q8. Amy invested X amount in a fixed deposit for 10 years returning compound interest. It yielded 5% per annum and returned an amount of INR 40,722.37 at the end. What was the initial amount X that was invested?

- a. 31,444.74
- b. 2,500.00
- c. 1,497.37
- d. 25,000.00

[2 marks]

Complete the following table; i has been provided in the first row and d in the second.

	Value of...?			
Base variable	δ	i	v	d
i	A	4.50%	D	F
d	B	C	E	6.10%

Answer the following questions based on the table given above.

Q9. The correct values of A & B are –

- a. 4.50% and 5.75%
- b. 2.84% and 2.89%
- c. 4.40% and 5.92%
- d. 4.40% and 6.29%

[2 marks]

Q10. The correct values of C & F are –

- a. 6.40% and 4.21%
- b. 6.50% and 4.31%
- c. 6.10% and 4.50%
- d. 6.50% and 4.10%

[2 marks]

Q11. The correct values of D & E are –

- a. 0.95694 and 0.94251
- b. 0.95694 and 0.93900
- c. 0.95500 and 0.93900
- d. 0.96699 and 0.94400

[1 mark]

Q12. You are told that $i = 6.0\%$. What is the present value of an annuity paying INR 1,500 annually in arrears forever?

- a. 25,000.00

- b. 1,500.00
- c. 1,415.09
- d. 30,000.00

[2 marks]

Shariq receives the following quarterly dividend payouts from his invested equity over the next 10 years–

- INR 120 for 5 years (Year 1 to 5)
- INR 230 for 3 years (Year 6 to 8)
- INR 400 for 2 years (Year 9 & 10)

Further, he sells his shares for INR 20,000 at the end of the 10th year and receives the amount as a lumpsum.

Assumption: interest rate of 12% convertible quarterly and no taxes.

Q13. What will be the present value of above payments (i.e. quarterly dividends in arrears, along with the lumpsum payout at the end)?

- a. 14,894.03
- b. 8,677.34
- c. 10,274.43
- d. 4,756.41

[4 marks]

Q14. Shariq now considers investing in a level quarterly annuity payable continuously for 10 years. Assuming he wants to have the same present value of the annuity & lumpsum as mentioned in Q13 through the new arrangement, what will be the amount of the level annuity using the same assumptions as above?

- a. 1,269.51
- b. 437.96
- c. 1250.84
- d. 317.38

[3 marks]

Q15. If you expect uncertainty in the receipt of a future set of payments, how will you allow for this in your present value calculations?

- a. Apply a probability of payment to each cashflow
- b. Increase the discount rate used
- c. Only A
- d. Both A & B

[1 mark]

Q16. Fill in the blanks –

A _____ model is a simplified case of a _____ model. The former has a _____ set of inputs whereas the latter model recognizes the _____ nature of input components.

- a. Deterministic, stochastic, random, fixed
- b. Deterministic, random, fixed, random
- c. Deterministic, stochastic, fixed, random
- d. Stochastic, deterministic, random, random

[2 marks]

Q17. Complete the following definition:

_____ refers to the approach of using a deterministic model along with changing one or more assumptions to see the range of possible outcomes.

- a. Stochastic simulations
- b. Sensitivity Testing
- c. Monte-carlo simulations
- d. Scenario approach testing

[1 mark]

Q18. Fill in the blanks:

At the start of a loan schedule, the amount of _____ contributed as part of the repayment amount is lower than the amount of _____. The reverse scenario occurs at the _____ of the loan schedule payouts.

- a. Capital, interest, end
- b. Capital, loan repayment, end
- c. Interest, capital, middle
- d. Interest, capital, end

[1 mark]

Rihan goes to the bank and agrees on the following payment arrangement –

- Payment will be made annually in arrears
- The first installment is INR 40,000
- Each payment from the second payment reduces by INR 2,000 every year
- Payments go on for 10 years
- Borrowing rate is 6% p.a. effective

Basis the above information, answer the following questions –

Q19. What is the amount of the loan taken by Rihan?

- a. INR 2,17,701
- b. INR 3,33,988
- c. INR 2,46,367
- d. INR 2,35,199

[3 marks]

Q20. What are the interest and capital components of the second payment?

- a. Interest: 14,112; Capital: 25,888
- b. Interest: 25,411; Capital: 12,559
- c. Interest: 12,559; Capital: 25,441
- d. Interest: 11,032; Capital: 24,968

[3 marks]

Q21. How many days will it take for INR 12,500 to accumulate to INR 18,000 at a force of interest of 5% per annum?

- a. 7.287
- b. 7.273
- c. 2,661.90
- d. 0.182

[2 marks]

Q22. You are paying 20 yearly installments of INR 25,000 each against a 11% effective rate loan taken for your sister's education. What is the total amount of interest paid by you over the 20-year period?

- a. INR 500,000.01
- b. INR 300,916.80
- c. INR 199,083.20
- d. INR 320,645.76

[2 marks]

Q23. Preksha goes to the bank to get a loan for her new car. She agrees to pay 1,20,000 per annum in arrears for 5 years at a rate of 10% per annum to settle the loan. What is the flat rate on the loan taken out by her?

- a. 6.38%
- b. 4.84%
- c. 20.00%
- d. Insufficient information to answer the question

[2 marks]

Q24. Shiv and Neha are both aged 60 exact. Upon Neha's death, Shiv will receive a pension of Rs. 30000 per annum payable annually in advance starting from the end of the year of Neha's death till Shiv reaches age 80 years. There will be no payment on or beyond Shiv's 80th birthday in any circumstance. Calculate the EPV of this benefit to Shiv.

Given:

- Shiv's mortality follows PMA92C20
- Neha's mortality follows PFA92C20

Interest rate for all future years is 4% per annum.

- a. 24,837
- b. 29,661
- c. 34,277
- d. 18,046

[4 marks]

Q25. In each of the following circumstances, state whether the calculations should use a money or real rate of interest.

- A. A woman wants to invest lump sum today to get a pension of Rs.1,50,000 per annum for the rest of her life.
- B. A man buys a zero-coupon bond that will provide him with Rs. 10,00,000 in 15 years' time. He is trying to calculate an appropriate purchase price for the bond.
- C. An actuarial student wants to invest an amount of money to buy a car in one year's time, the current price of car is known.

Choose the correct option:

- a. Real, Money, Real
- b. Money, Money, Money
- c. Real, Real, Money
- d. Money, Money, Real

[1 mark]

A marketing company is onboarding new clients in the next few months. This new project requires the company to make an investment of INR 5 Cr at the outset, followed by INR 3 cr three years later in advance. It is expected that the client fees will provide income over a 13-year period starting from the end of the third year. Net income from the project will be received in arrears at a rate of INR 1.8 Cr per annum. At the end of this 15-year period there will be no further income expected to be received.

Q26. What is the discounted payback period for the above set of cashflows, assuming an effective interest rate of 9% per annum?

- a. 6.4 years
- b. 5.1 years
- c. 4.8 years
- d. 8.9 years

[4 marks]

Q27. In which of the below scenarios does capital gains tax have to be paid on a bond held by an investor?

- a. At the end of every year
- b. On a monthly basis as the value of the bond grows
- c. On sale/redemption of the bond
- d. None of the above

[1 mark]

Q28. The force of interest, $\delta(t)$, is a function of time and at any time t , measured in years, is given by the formula: $\delta(t) = 0.08 + 0.002t$. Calculate the seven-year spot rate of interest per annum from time $t=0$ to time $t=7$.

- a. 9.09%
- b. 6.84%
- c. 7.65%
- d. 9.42%

[3 marks]

Q29. Select the odd one out.

- a. Terminal bonus
- b. Interim bonus
- c. Reversionary bonus
- d. Simple bonus

[1 mark]

Q30. Select the odd one out.

- a. Premiums
- b. Expenses
- c. Profits
- d. Benefits

[1 mark]

Q31. $l_x - l_{x+1} = ??$

Which of the below values fits the question marks?

- a. l_{x-1}
- b. q_x
- c. d_x
- d. p_x

[1 mark]

Using the PMA92C20 table for both lives calculate:

Q32. $\mu_{85:75}$

- a. 0.002450

- b. 0.118736
- c. 0.120837
- d. 0.002607

[1 mark]

Q33. ${}_5p_{65:60}$

- a. 1.063649
- b. 0.940160
- c. 0.957538
- d. 0.923097

[2 marks]

Q34. Using Uniform Distribution of Deaths (UDD) and PMA92C20 mortality basis, calculate the value of ${}_{2.5}q_{75.75}$

- a. 0.09344
- b. 0.99218
- c. 0.08404
- d. 0.91596

[3 marks]

Q35. Choose the false statement:

- a. Infant mortality is generally very high
- b. The probability of dying at higher ages above 65 is generally higher than mid-30s.
- c. The accident hump generally occurs during the ages 35 to 45
- d. Number of deaths post age 100 is generally low.

[1 mark]

Q36. Given the force of mortality is 0.040 at all ages, what will the probability that a life aged exact 14 will die before age 20?

- a. 0.213372
- b. 0.078663
- c. 0.220393
- d. 0.786628

[2 marks]

Q37. What is the total benefit payable on death to the following policyholder if he dies at the start of the 10th policy year? Benefits are as below:

- Base sum assured = INR 5,00,000
- Cash bonus payable in hand quarterly = 3% p.a. of SA
- Reversionary bonus attached to sum assured at each policy anniversary (paid as part of death/maturity benefit) = 4% of SA
- Terminal bonus payable on maturity = 20% of SA
- Terminal bonus payable on death = 10% of SA

- a. 7,30,000
- b. 8,30,000
- c. 7,80,000
- d. 9,65,000

[2 marks]

Q38. Consider a 20-year regular premium endowment assurance policy with a sum assured of INR 75,000 payable on maturity (or at the end of the year of earlier death), taken out by a 40-year old.

Expenses are 75% of the first premium and 5% of each subsequent premium, plus an initial expense of INR 250.

Given a gross annual premium of INR 2,200 payable in advance and a gross premium reserve at the end of the 10th policy year of INR 33,642, calculate the gross premium reserve at the end of the 11th policy year.

Assume AM92 Ultimate mortality and 4% pa interest.

- INR 48,396
- INR 50,239
- INR 37,068
- INR 49,927

[4 marks]

Q39. What does the below equation denote?

$$A_{x:\overline{n}|}^1 = \sum_{k=0}^{n-1} v^{k+1} {}_k|q_x \equiv A_x - v^n {}_n p_x A_{x+n}$$

- Term assurance of n years, representing the EPV of benefit payable at end of year of survival
- Term assurance of n years, representing the EPV of benefit payable at end of year of death
- Endowment assurance of n years, representing the EPV of benefit payable at end of year of survival or death
- Whole Life assurance, representing the EPV of benefit payable at end of year of death

[1 mark]

Q40. Calculate $A_{49:\overline{15}|}^1$ using AM92 table and a 4% interest rate.

- 0.566220
- 0.562230
- 0.056223
- None of the above

[2 marks]

Q41. A life insurance company sells 1,000 whole life annuities on 1 January 2025 to policyholders aged 65 exact. Each annuity is for INR 25,000 payable annually in arrear. 5 annuitants die during 2025. The office holds reserves using the following basis:

Mortality PFA92C20

Interest 4% per annum

What is the profit or loss from mortality for this group for the year ending 31 December 2025?

- INR 16,69,690
- INR 200,690
- INR 115,510
- INR 215,600

[4 marks]

Q42. An airline has just purchased a new aircraft for INR 40,00,000. In six months' time, additional cost of INR 6,50,000 will also be spent for immediate insurance and maintenance.

The airline expects to receive an initial revenue for the next five years. An initial revenue of INR 1,15,000 shall be received at end of the first year (start of second year). The revenue is expected to increase at the same percentage at the start of each year with the last increase at the end of the fifth year. An agreement has been made with an investor who will purchase the aircraft from the airline at the end of the sixth year for INR 58,00,000.

Calculate the compound percentage increase in the annual revenue required to earn the company an internal rate of return of 6% per annum effective.

- a. 8.30%
- b. -8.22%
- c. 6.01%
- d. 6.53%

[4 marks]

Q43. Priti purchased a government bond on 1st April of a particular year. The bond pays coupons of 4% p.a. half-yearly in arrears on 30th September and 31st March. The bond will be redeemed at 105% of its purchase price 12 years after the purchase date (on 31st March).

The investor also pays capital gains tax of 40% p.a. on 30th June for any capital gains realized in the previous year.

What is the price for INR 100 nominal of the bond, assuming that the investor achieves a yield of 5% p.a. effective interest?

- a. 105.0000
- b. 94.3588
- c. 68.3484
- d. 91.3568

[3 marks]

Q44. A 15-year term assurance with a sum assured of INR 1 cr payable at end of year of death is issued to a 30-year old female for a level annual premium of INR 400.23 payable in advance. What is the prospective reserve at the end of the 6th year, just before the payment of the 7th premium?

Assumptions: AM92 Ultimate mortality; No age setback; 4% interest

- a. INR 67,650
- b. INR 39,899
- c. INR 65,092
- d. INR 61,018

[3 marks]

A unit-linked policy has the following profit vector:

(-25, -14, -8, 30, 35)

Q45. Calculate the time 0 reserves required to zeroize the losses. Assume a rate of 8% p.a. and $q_x = 0.02$ at each age.

- a. INR 40.01
- b. INR 41.01
- c. -INR 41.01
- d. INR 44.20

[2 marks]

A life insurance company sells with-profits whole life plans to male lives aged 40 years exact. The contracts are unique since they pay INR 13,50,000 at the end of year of death. The company expects to declare reversionary bonus of 3% of sum assured every year, attached on every policy anniversary. If death occurs during the first 20 years, terminal bonus is payable on death and expected to be declared at 20% of already attached reversionary bonuses.

Premiums on each policy are payable annually in advance, ceasing on earlier death. Consider the following assumptions:

- Mortality AM92 Select
- Interest 4% per annum
- Initial expenses INR 4,000
- Renewal expenses INR 450 per annum at the start of the second and subsequent policy years

Answer the below questions basis the above information:

Q46. Given that the policyholder dies during the 20th year, what is the total death benefit that he can expect to receive?

- a. 24,30,000
- b. 22,73,400
- c. 13,50,000
- d. 23,22,000

[2 marks]

Q47. Ignoring the terminal bonus on death, calculate the annual premium payable for this policy.

- a. INR 32,295.24
- b. INR 16,639.47
- c. INR 32,281.51
- d. INR 16,173.10

[4 marks]
