



INSTITUTE OF ACTUARIAL
& QUANTITATIVE STUDIES

Subject: Pricing & Reserving
for Life Insurance
Products

Chapter:

Category: Assignment
1 questions

1. i) Define the constant force of mortality.

ii) Calculate the constant force of mortality applicable to a life aged between 55 and 56 exact. (Basis: AM92 Tables)

2. Calculate the value of $1.75 p 40.75$ using AM92 Ultimate mortality and assuming that:

- i) Deaths are uniformly distributed between integer ages.
- ii) Force of mortality is constant between integer ages.

3. Calculate ${}_{1.4}q_{54.5}$ using the method of Uniform Distribution of Deaths (UDD) and the ELT15 (males) mortality table.

4. A man aged 45 years exact buys a 20-year endowment assurance policy that pays Rs. 50,000 on maturity. The man pays a premium of Rs. 1,577 at the beginning of each year throughout the policy term, or until death if that happens first. On death during the policy term, all premiums paid till the date of death are returned to the nominee without any interest at the end of the year of death.

Calculate the expected present value of the benefits payable under this policy assuming mortality rate of AM92 Select and interest rate of 4% p.a.

5. By considering a term assurance policy as a series of one year deferred term assurance policies, show that

$$\bar{A}_{x:n|}^1 = \frac{i}{\delta} A_{x:n|}^1$$

6. A Life insurance company issues 20 year pure term single premium insurance policies. On 1 January 2015 it sold 10,000 such policies to females aged 45 years exact. The Sum Assured under the policy is INR 5,000,000 and the death benefit is paid at the end of year of death.

As at Jan 2015 the company uses the following basis for calculating premium and net premium reserves:

Interest rate: 4% per annum

Mortality: AM92 Ultimate

Expenses and commission: Nil

i) Calculate the total single premium collected at start of January 2015.

During the year the company experiences 10 deaths. The Appointed Actuary at the end of the year revises the reserving basis and changes the interest rate to 6% per annum and the mortality rate for female policies equal to AM92 Ultimate with a two year set back.

ii) Calculate the total mortality profit or loss arising during the year for the life insurance company.

7. A life insurance policy promises to pay a benefit of Rs.50,000 at the end of policy-year of death to a life now exactly aged 50 years, provided that death occurs after attaining the age of 60 years. Calculate the expected present value of death benefit assuming that the effective annual interest rate is 6% p.a. and mortality rates are based on 100% of AM92 Ultimate table.

8. A life aged 65 years exact buys a single premium whole life assurance policy, which pays a death benefit of Rs 100,000 at the end of year of death. Mortality follows a select table with a one-year select period and the following values are provided
 $q_{[65]} = 0.75 \cdot q_{65}$ Also: $A_{65} = 0.5412$ and $A_{66} = 0.5591$

Calculate the single premium to be paid.

Assume an interest rate of 8% per annum and zero expenses.

9. A life insurance company is planning to issue an immediate annuity of Rs. 120,000 payable annually in arrears to a life aged 70 exact.

- i) Calculate the single premium such that the expected present value of loss is 0.
- ii) Given the premium calculated in (i) above, calculate the probability that the present value of loss is positive.
- iii) Calculate the least premium such that the probability that the present value of loss is positive does not exceed 5%.

Bases: Mortality: PMA92C20

Interest: 4% per annum.

10. A continuous whole life annuity is issued to a Life aged x .

- i) Write down the notation for the annuity and that for the expected present value of this annuity.
- ii) Calculate the Standard deviation of the present value of the benefits given the following
 - Constant force of interest of 4%.
 - Constant force of mortality.
 - Expected present value of the benefit is 16.

11. A life Insurance company sells the following set of policies on 1st January 2007.

-- 10,000 regular premium term assurance policies with a policy term of 25 years, to male lives then aged 40 years exact. The level sum assured under the policy is Rs. 2,500,000 and is paid at the end of year of death. Annual premiums are paid annually in advance.

-- 10,000 single premium immediate annuity policies to male lives then aged 50 years exact. An annual annuity payment of Rs. 250,000 is paid on survival at the end of every policy year.

As on 31st December 2016, out of 10,000 term insurance policies only 8,500 are in-force, whereas 9,900 of immediate annuity policies are in-force.

- i) Explain, what can be the possible reasons of difference between the counts of in-force policies for the two types of products as on 31st December 2016, given the same count of policies originally issued.

The company calculates the net premium reserves for above products, using the following assumptions:

Mortality - AM92 Ultimate for the term assurance and PMA92C20 for immediate annuity and interest rate of 4% per annum.

ii) Calculate the total reserves in-force for the above portfolio as at 31st December 2016.

iii) As part of the annual regulatory submission, the company has to develop an analysis of surplus report. List the possible sources of surplus for a Life Insurance company.

During the last year, i.e. 1st January 2016 to 31st December 2016, 5 deaths have happened in the term assurance portfolio, whereas only 4 deaths have happened in the annuity portfolio. Also, there has been no other form of decrement seen during the year.

iv) Calculate the mortality profit for the period 1st January 2016 to 31st December 2016, for the combined portfolio.

12. Calculate:

i) $s_{55:\overline{10}|}$

ii) $a_{[40]:\overline{20}|}^{(4)}$

Basis: Mortality AM92

Rate of interest 6% per annum

13. A group of lives all aged 45 years exact have bought a life insurance policy of 20 year policy term providing the following benefits:

i) Rs.100,000 is payable at the end of the year of death, if death occurs during the term of the policy

ii) Rs.200,000 is payable on the maturity date of the policy in respect of those lives who survive the policy term.

The premiums are payable annually in advance for 15 years.

Calculate the mortality profit during the 13th policy year if

i) the number of in force policies at the end of 13th policy year is 195 and ii) number of deaths during 13th policy year is 4.

Basis - Mortality AM92 Ultimate;
Interest Rate 4% per annum

14. A life office issues identical deferred annuities to each of 100 women aged 63 years exact. The benefit is Rs.5000 per annum payable continuously from a woman's 65th birthday, if still alive at that time, and for life thereafter.

i) Write down an expression for the random variable for the present value of future benefits for one policy at outset.

ii) Calculate the total expected present value at outset of these annuities.

Basis: Mortality: PFA92C20
Interest: 4% per annum

iii) Calculate the total variance of the present value at outset of these annuities, using the same basis as in part (ii).

15. Write a recursive equation relationship between the reserve at the start of the year and the reserve at the end of the year assuming level annual premium P payable in advance for the following benefit structures:

a) A death benefit of S payable at the end of the year of death. A guaranteed benefit of X payable at the end of every month which doubles from the second month. This benefit is payable at the fixed durations to all policies in force at the start of the year.

b) A death benefit of S payable at the end of the year of death. A survival benefit of R payable in the middle of the year.