



Subject: PRLI2

Chapter: Unit 1 & 2

Category: Assignment 1

1. A life assurance company issues a deferred post-retirement regular income plan to a life now aged 35 years exact. The policy provides an income of Rs. 50,000 per annum in advance starting on the policyholder's 60th birthday. The income increases by Rs 3,000 each year starting from the 61st birthday.

The policy also provides death benefit, payable immediately on death, which is given by the formula: $10,000 \times (25 - t)$ where $t = 0, 1, 2, \dots, 24$ and t denotes the curtate duration in years since inception of the policy. Death benefit cover ceases at age 60 (i.e., at the end of the deferment period).

The policy is paid for by level monthly premiums payable in advance from the date of issue over the deferment period or until death if happens earlier.

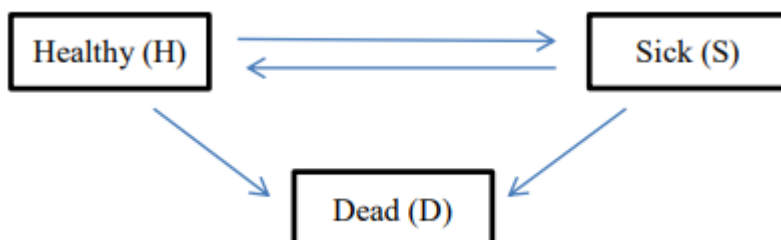
The company uses the following premium basis for the policy:

- Mortality AM92 Select
- Interest 4% p.a.
- Initial commission 30% of the total premiums payable in the first policy year
- Initial expenses Rs.235
- Renewal commission 5% of the 2nd premium and subsequent monthly premiums
- Renewal expense Rs.60 p.a. at the start of the 2nd and subsequent policy years.

The renewal expense is assumed to increase continuously at 4% per annum compound rate from inception of the policy. These expenses are incurred over the deferment period or until death if earlier.

Calculate monthly premium for the policy, show all your workings.

2. A life insurance company uses the following 3 state model, to estimate the profit in respect of a 2 year combined death benefit and sickness policy issued to a healthy policyholder aged exact 50 at inception.



In return for a Single premium of Rs. 25,000 payable at the outset the company will pay the following benefits:

- Rs. 50,000 if the policyholder dies within 2 years, payable at the end of the year of death.
- Rs. 35,000 at the end of each of the 2 years if the policyholder is in a sick state.

Let S_t represent the state of the policyholder at age $50+t$, so that $S_0 = H$ and for $t = 1$ and 2 , $S_t = H, S$ or D . The company uses transition probabilities defined as follows:

$$p_{50+t}^{ij} = P(S_{t+1} = j | S_t = i)$$

For $t = 0$ and 1 the transition probabilities are:

$$p_{50+t}^{HD} = 0.15, \quad p_{50+t}^{SD} = 0.2, \quad p_{50+t}^{SH} = 0.55 \quad \& \quad p_{50+t}^{HS} = 0.2$$

- i) One possible outcome for this policy is that the policyholder is healthy at times 0, 1 and 2. List all possible outcomes and the associated cash flows.
- ii) Calculate the probability of occurrence for each of the possible outcomes.
- iii) Assuming a rate of interest of 8% per annum, calculate the mean and standard deviation of the net present value at time 0 of the profit for the policy.

3. A three-state transition model is as below:

Healthy to ill = σ_x

ill to Healthy = ρ_x

Healthy to Dead = μ_x

ill to Dead = γ_x

Assume that the transition probabilities are constant at all ages with $\sigma_x = 3\%$, $\gamma_x = 6\%$, $\rho_x = 1\%$ and $\mu_x = 4\%$.

A healthy life aged 40 years exact takes out a 20-year sickness contract that provides a premium refund of Rs.15,000 if the insured remains Healthy for the full duration of the contract. From the options provided below, select the expected present value of the premium refund at the beginning of the contract with a force of interest of 5% p.a.

- a) 2,479
- b) 1,265
- c) 1,361
- d) 912

4. An insurer sells a decreasing term insurance policy with a policy term of 15 years and an initial sum assured of Rs.300,000 to lives aged 50 years exact. The sum assured decreases by Rs.15,000 at the start of each year starting from the second policy year. The death benefit is payable immediately on death. Premiums are payable annually in advance throughout the term of policy. The office calculates premium using AM92 Ultimate mortality and interest rate of 4% p.a.; initial expense of

Rs.500, renewal expense of Rs.50 at the start of each year except in the first policy year, and a claim expense of Rs.800.

- i) Using P for the annual premium, write down the future loss random variable for the policy at the start of the term, and also just before the payment of tenth premium, assuming the policy is still in force at that time.
- ii) Calculate the office premium.
- iii) Calculate the gross premium prospective reserve for the policy just before the payment of tenth premium. Also clearly mention the assumption made for reserving basis.

5. ABC Insurance Company is a leading insurance company selling protection business. They sell decreasing term assurance plans where the benefit terms can be customised to the needs of customers.

An individual aged 55 years wants to guarantee an amount of INR 5,000,000 to his family upon his death. He currently invests INR 20,000 per month into an account that earns an interest at 1% per month. ABC Insurance Company sells a decreasing term assurance plan to him with gross premium of INR 5,000 payable monthly and death benefit being calculated as difference between INR 5,000,000 and the balance in the account at the end of the month.

In respect of the insurance plan, ABC Insurance Company has an initial expense of INR 2000 and a renewal expense of INR 50 per month, incurred from beginning of second policy month inflating at 3% p.a. Further, ABC Insurance Company pays a renewal commission of 5% of premium.

Calculate the expected net cash flow for ABC Insurance Company in the 30th month from this contract. You may assume mortality to be 100% of AM92 Ultimate with an age set back of 3 years and assume uniform distribution of deaths over each year of age. You should ignore any interest income.

6. A life insurance company sells an insurance product with a policy term of 5 years that pays benefits to the customer as described below:

- INR 800,000 at the end of the year of death during policy term
- INR 500,000 at the end of the year of withdrawal due to permanent sickness during policy term •
- INR 300,000 upon survival to the end of the policy term
- 60% of the total premiums paid till date at the end of the year upon lapsation

Below assumptions apply:

- Force of mortality = 0.01
- Force of sickness = 0.04
- Force of lapsation = 0.05
- Discount rate of 5% p.a.
- Annual premium of INR 100,000 paid in advance

- i) Calculate the dependent probabilities of death, sickness, lapse and survival.
- ii) Calculate the net present value of the contract ignoring expenses and other charges.

7. An insurer issues a decreasing term assurance combined with an annuity contract to a life aged 30 years exact. Level premiums are payable monthly in advance for a maximum term of 30 years.

On death of the life insured before age 60 years a benefit is paid immediately. The benefit is INR 500,000 on death in the first year of contract, INR 485,000 on death in the second year, INR 470,000 on death in the third year and so on with the benefit decreasing by INR 15,000 each year until age 60 years is attained. No death benefit is payable after age 60 years.

On attaining age 60 years the life receives a whole life annuity of INR 20,000 p.a. payable monthly in arrears.

Calculate monthly premium using the following basis:

Mortality: upto age 60 AM92 Select, Over age 60 PMA92C20

Interest 4% p.a.

Expenses Initial: Rs.850 per policy

Regular: Rs.50 in the first year, inflating at the rate of 4% p.a., assumed to be incurred annually at the start of each year during the deferment period.

Claim expense: 0.75% of each annuity payment

8. An insurance company sells a with-profits product with a sum assured of INR100,000, single premium of INR10,000 and policy term of 10 years to a policyholder aged 30 years exact. Compound reversionary bonus rate for the product is 3% p.a. and are attached on each policy anniversary. Upon death of the life assured during the policy term or upon maturity, the benefit payable is sum assured plus accrued bonuses at the end of the policy year.

i) When calculating reserves, the regulations only require insurance company to hold a reserve in respect of bonus accrued until the valuation date; and make no allowance for future bonuses. Assuming a reserving interest rate of 4.5% p.a. and mortality rate based on 90% of AM92 ultimate table; which of the below most closely reflects the reserve required just after the 8th policy anniversary.

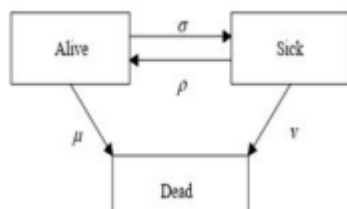
- (a) 119,500
- (b) 116,000
- (c) 116,500
- (d) 114,000

ii) The regulations have changed recently. Under the revised regulations, the insurance companies are required to reserve for future expected bonus declarations as well; and accordingly set an interest rate assumption, which reflects expected real world earnings. Therefore, the company has

revised the reserving basis such that: future bonus rate assumption for reserving remains at 3% p.a. and reserving interest rate is 6.5%. Without performing additional calculations, explain whether this would result in an increase or decrease in reserves.

9. A three-state transition model is shown in the following diagram: Assume that the transition probabilities are constant at all ages with $\mu = 2\%$, $v = 4\%$, $p = 1\%$ and $\sigma = 5\%$.

Calculate the expected present value of a sickness benefit of £2,000 p.a. paid continuously to a life now aged 40 exact and sick, for this period of sickness only, discounted at 4% pa and payable to a maximum age of 60 exact.



- (a) 18,653
- (b) 19,751
- (c) 25,056
- (d) 20,762

10. i) Prove that

$$(Ia)_{n|} = (\ddot{a}_{n|} - nv^n) / i$$

Where i = effective rate of interest p.a. and n = term

ii) Mr Gary is working as an executive in a multinational company. He is planning to start saving for his child's higher education who is currently 8 years old. The expenses for higher education will be incurred after 10 years from now.

The current cost of higher education is INR 30,00,000 which increases with an inflation of 6% p.a.

Mr Gary plans to start the contribution by INR 2,00,000 p.a. immediately. From second year onwards, at the start of each year, he wishes to increase the previous year's contribution by INR X till the 10th year. Assume that the interest earned on the savings is 10% p.a. effective, calculate how much should be the increase per year (i.e. X) so as to meet the fund requirement for higher education of the child at the end of tenth year.