



Subject: Pricing & Reserving
for Life Insurance
Products 1

Chapter: Unit 3

Category: Practice
Questions

1. CT5 September 2011 Q5

On 1 January 2001, a life insurance company issued a number of 30-year endowment assurance policies that pay £100,000 at maturity, or £50,000 at the end of the year of earlier death to lives then aged 35 exact. Premiums are payable annually in advance.

The company uses the following basis for calculating premiums and reserves:

Mortality AM92 Select

Interest 4% per annum

Initial commission 50% of the premium payable in the first policy year

Initial expenses £300 paid at policy commencement date

Renewal expenses 2.5% of each premium from the start of the second policy year

(i) Write down the recursive relationship between the gross premium reserves at successive durations of these policies, defining all symbols used. [4]

(ii) Show that the annual premium for each policy is approximately £1,803. [4]

There were 385 policies in force on 1 January 2010. During 2010, there were three actual deaths, actual interest earned by the company was 5% and expenses were as expected.

(iii) Calculate the profit or loss made by the company from both mortality and interest in respect of these policies for the year 2010 based on the formula stated in (i) above. [10]
[Total 18]

2. CT5 April 2012 Q2

Under a policy issued by a life insurance company, the death benefit payable at the end of year of death is a return of premiums paid without interest. A level premium of £3,000 is payable annually in advance throughout the term of the policy.

For a policy in force at the start of the 12th policy year, you are given the following information:

Reserve at the start of the policy year £25,130

Reserve at the end of the policy year per survivor £28,950

Probability of death during the policy year 0.03

Expenses incurred at the start of the policy year £90

Rate of interest earned 4% per annum

Reserves given above are immediately before payment of the premium due.

Calculate the profit/loss expected to emerge at the end of the 12th policy year per policy in force at the start of that year. [3]

3. CT5 April 2012 Q15

A life insurance company issues a three-year term assurance policy to a male life aged 57 exact under which level premiums are payable annually in advance throughout the term of the policy or until earlier death. The sum assured is £150,000 payable at the end of year of death.

The company uses the following assumptions to calculate the premium for this policy:

Rate of interest on cash flows 6% per annum

Mortality AM92 Select

Initial expenses £350

Renewal expenses £50 per annum on the second and third premium dates

Initial commission 15% of first premium

Renewal commission 2.5% of the second and third years' premiums

Risk discount rate 6% per annum

(i) Write down the gross future loss random variable at the outset of the policy. [5]

(ii) Calculate the office premium using assurance and annuity functions, setting the expected value of the gross future loss random variable to zero. [4]

(iii) Derive the office premium using a discounted cash flow projection, assuming no withdrawals and using the same profit criterion as in part (ii). [6]

(iv) Without further calculation explain the effect of:

(a) setting up reserves within the calculation of part (iii).

(b) having set up the reserves in part (a), increasing the risk discount rate to 8% per annum. [2]

[Total 17]

4. CT5 September 2012 Q4

(i) Explain what is meant by the following in the context of life insurance policies:

(a) gross premium prospective reserve

(b) gross premium retrospective reserve [4]

(ii) State the conditions necessary for gross premium prospective and gross premium retrospective reserves to be equal. [3]

[Total 7]

5. CT5 April 2013 Q12

A life insurance company issues whole life assurance policies to lives aged 50 exact for a sum assured of £75,000 payable at the end of the year of death. Premiums are payable annually in advance.

- (i) Calculate the annual gross premium for each policy using the basis below. [4]
- (ii) Calculate the minimum annual gross premium that the company should charge in order that the probability of making a loss on any one policy would be 10% or less. [6]

Basis:

Mortality AM92 Select

Interest 6% per annum

Initial commission 100% of the annual gross premium

Initial expenses £325

Renewal commission 2.5% of each annual gross premium excluding the first

Renewal expenses £75 per annum at the start of the second and subsequent policy years

[Total 10]

6. CT5 September 2013 Q13

A whole life assurance policy was issued to a life aged x exact for a sum assured of S payable at the end of year of death. A premium of P is payable annually in advance until death.

The following expense assumptions were used to derive the gross premium payable on the policy:

Initial commission $a\%$ of the annual premium

Initial expenses B

Renewal commission $c\%$ of each annual premium excluding the first

Renewal expenses D per annum at the start of the second and subsequent policy years

Claim expenses $e\%$ of the sum assured.

Let tVx represent the gross premium reserve on this policy at duration t .

Write down an equation linking the gross premium reserve at the beginning and the end of:

- (a) the first policy year
 (b) the t th policy year where $t > 1$

[3]

7. CT5 September 2013 Q22

At the beginning of 2004, a life insurance company issued a number of 20-year “special” endowment assurance policies to male lives then aged 40 exact. Each policy provides a death benefit of £75,000 payable at the end of year of death and a maturity benefit of £150,000.

Premiums on each policy are payable annually in advance for the term of the policy, ceasing on earlier death.

(i) Calculate the annual gross premium for each policy using the following premium basis: [4]

Mortality AM92 Select

Interest 4% per annum

Initial commission 25% of the first annual premium

Initial expenses £400

Renewal expenses £45 per annum at the start of the second and subsequent policy years

(ii) Determine the gross premium reserve for each policy in force at the end of the eighth policy year and for each policy in force at the end of the ninth policy year, using the same basis as above. [6]

At the beginning of 2012, there were 625 policies in force. Actual experience for this portfolio of business during 2012 was as follows:

Number of deaths 3

Interest earned 4.5%

Expense incurred per policy in force at beginning of policy year £45

(iii) Derive, using the recursive relationship between the opening and closing reserves, the profit/loss from this portfolio of business in 2012 separately from:

- mortality
- interest
- expenses [4]

[Total 14]

8. CT5 April 2014 Q11

On 1 January 2008, a life insurance company issued a number of without profit endowment policies maturing at age 60 to lives then aged 40 exact. The sum assured is payable at the end of year of death or on survival to the end of the term and level premiums are payable annually in advance throughout the term of the contract.

Premiums and reserves on each policy are both calculated on the following basis:

Mortality AM92 Select

Interest 4% per annum

Initial commission 60% of the first premium

Renewal commission 6% of each annual premium excluding the first

- (i) Calculate the annual office premium per £1,000 sum assured for each policy. [2]
- (ii) Calculate the gross premium prospective reserve per £1,000 sum assured for each policy in force at 31 December 2012. [2]

9. CT5 April 2015 Q6

A life aged 55 exact purchases a 3-year term assurance with sum assured of £150,000 payable if death occurs during the term of the policy. Level premiums of £900 are payable annually in advance throughout the term of the policy or until earlier death. The death benefit is payable at the end of the policy year of death.

Calculate the expected present value of the profit or loss to the office on the contract.

Basis:

Mortality AM92 Select

Interest 3% per annum

Initial expenses £260

Renewal expenses £70 per annum incurred at the start of both the second and third policy year

Assume no reserves are required for this policy. [6]

10. CT5 April 2015 Q9

On 1 January 1999, an insurance company issued a without profit whole life policy to a life aged 45 exact. The sum assured on the policy is £125,000 which is payable at the end of the year of death. Level premiums are payable annually in advance to age 65 or until earlier death.

The company calculated the premium on the following basis:

Mortality AM92 Select

Interest 6% per annum

Initial expenses 75% of the first year's premium, incurred at outset

Renewal expenses 5% of the second and each subsequent year's premium, incurred at the beginning of the respective policy years

Claims expense £325 payable at the end of the year of death

- (i) Show that the annual premium is approximately £1,883. [4]

On 31 December 2013, immediately before the premium then due, the life wishes to surrender the policy. The insurance company calculates a surrender value equal to the gross prospective policy reserve, using the following basis:

Mortality AM92 Ultimate
Interest 6% per annum
Expenses Ignore

(ii) Calculate the surrender value payable by the insurance company. [3]
[Total 7]

11. CT5 September 2018 Q10

A life insurance company issues whole of life assurance policies to lives aged 35 exact for a sum assured of 85,000 payable at the end of year of death. Premiums are payable annually in advance.

(a) Calculate the annual office premium for each policy using the basis below.

(b) Calculate the minimum office premium the company should charge in order that the probability of making a loss on any one policy would be 5% or less.

Basis:

Mortality AM92 Select

Interest 6% per annum

Initial commission 75% of the annual premium

Initial expenses 350

Renewal commission 2.5% of each annual premium excluding the first

Renewal expenses 85 per annum at the start of the second and subsequent policy years.

[10]

12. CM1A April 2022 Q11

A life aged 30 exact purchases a 35-year term assurance policy. Level monthly premiums are payable in advance throughout the duration of the contract, ceasing on death, and the sum assured of \$250,000 is payable immediately on death.

(i) Calculate, showing all working, the monthly premium.

Basis:

Mortality AM92 select

Interest 4% p.a. effective

Expenses - Initial: \$250 plus 60% of the first monthly premium

- Renewal: 3% of the second and subsequent monthly premiums

The insurance company actually charges a premium of \$50 per month.

The company calculates gross premium retrospective reserves, assuming the same basis as in part (i) above but using a rate of interest of 6% p.a. effective.

(ii) Calculate, showing all working, the reserve held for the policyholder at age 55 exact, immediately before the premium then due.

The insurance company is proposing to calculate reserves using the same basis as in part (ii) but adopting a gross premium prospective reserving approach.

(iii) Explain, without performing any further calculations, whether the proposal will result in a higher or lower reserve than that calculated in part (ii).

13. CM1A September 2022 Q8

A life insurance company issues 20-year term assurance policies to lives aged 45 exact. The sum assured of £300,000 is payable at the end of the year of death. Level premiums are payable annually in advance for the term of the policy ceasing on the death of the policyholder if earlier.

The insurance company uses the following assumptions:

Mortality AM92 (select)

Interest 4% p.a. effective

Expenses -

Initial £250 incurred at the outset of the policy

Renewal £50 incurred at the start of the second and each subsequent policy year

Claim £75 incurred when the benefit is paid out

Commission -

Initial 25% of the annual premium

Renewal 1.5% of each annual premium excluding the first

(i) Write down the gross future loss random variable at outset for the policy in terms of K_x , the curtate future lifetime of a life aged x exact.

The company sets the premium such that the expected present value of the gross future loss random variable is equal to 4% of the expected present value of premium income.

(ii) Calculate the gross premium, showing all working.