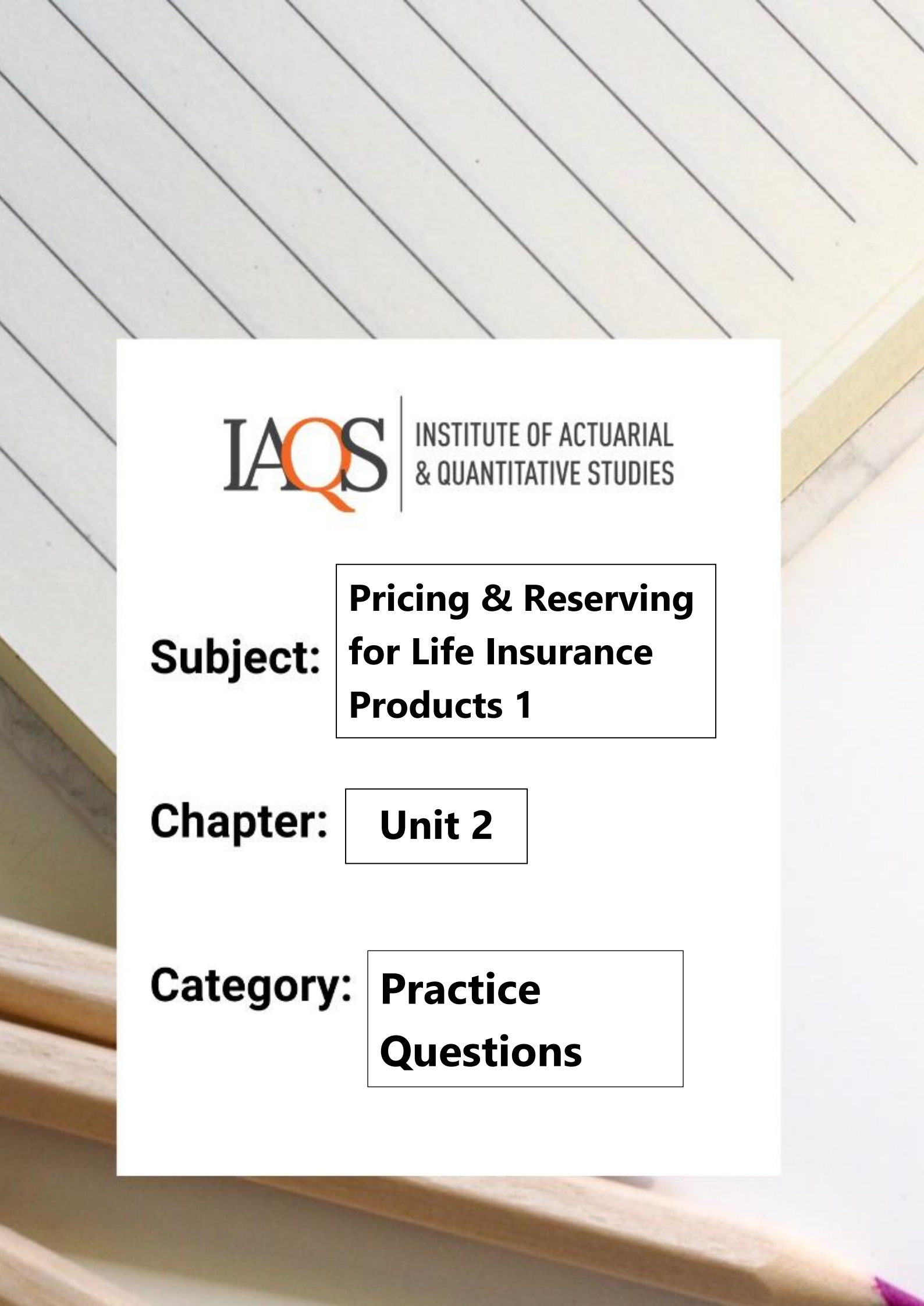

INSTITUTE OF ACTUARIAL & QUANTITATIVE STUDIES

Subject: Pricing & Reserving for Life Insurance Products 1

Chapter: Unit 2

Category: Practice Questions

1. CT5 September 2006 Q10

A life insurance company is reviewing the 2005 mortality experience of its portfolio of whole life assurances.

You are given the following information:

Age exact on 1 Jan 2005	*Sum assured in force on 1 Jan 2005* £	*Reserves at 31 Dec 2005 of policies in force on 31 Dec 2005* £
69	500,000	175,000
70	400,000	150,000

There were 2 death claims during 2005 arising from these policies as follows:

Date of issue of policy	*Age exact at issue of policy*	*Sum assured* £
1 Jan 1980	45	12,000
1 Jan 1982	46	10,000

All premiums are payable annually on 1st January throughout life.

Sums assured are payable at the end of the year of death.

Net premium reserves are held, based on mortality of AM92 Ultimate and interest of 4% per annum.

(i) Calculate the mortality profit or loss for 2005 in respect of this group of policies. [8]

(ii) (a) Calculate the amount of expected death claims for 2005 and compare it with the amount of actual claims.

(b) Suggest a reason for this result compared with that obtained in (i). [4]
[Total 12]

2. CT5 April 2008 Q12

A life assurance company issues the following policies:
• 10-year term assurances with a sum assured of £50,000 where the death benefit is payable at the end of the policy year of death
• 10-year pure endowment assurances with a sum assured of £50,000 payable on maturity

For the term assurance and pure endowment policies, premiums are paid annually in advance.

The company sold 5,000 policies of each type to lives then aged 50 exact. During the first policy year, there were five actual deaths from each of the two types of policies written.

(i) Assuming each type of policy was sold to a distinct set of lives (i.e. no life buys more than one type of policy).

(a) Calculate the death strain at risk for each type of policy at the end of the second policy year of the policies.

(b) During the second policy year, there were ten deaths from each of the two types of policy written. Calculate the total mortality profit or loss to the company during the second policy year.

Basis:
Interest 4% per annum
Mortality AM92 Ultimate for term assurance and pure endowment
Expenses Nil

(ii) The company now discovers that 5,000 lives had bought one of each type of policy.

(a) State whether the mortality profit or loss calculated would now be higher, lower or unchanged to that calculated in (i)(b).

(b) State whether the variance of the benefits paid out by the company in future years would be higher, lower or unchanged to that in (i). Explain your answer by general reasoning. [3] [Total 14]

3. CT5 April 2010 Q12

On 1 January 2005, a life insurance company issued 1,000 10-year term assurance policies to lives aged 55 exact. For each policy, the sum assured is £50,000 for the first five years and £25,000 thereafter. The sum assured is payable immediately on death and level annual premiums are payable in advance throughout the term of this policy or until earlier death.

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

Mortality AM92 Select
Interest 4% per annum
Expenses Nil

(i) Calculate the net premium retrospective reserve per policy as at 31 December 2009.

(ii) (a) Explain your numerical answer to (i) above.

(b) Describe the main disadvantage to the insurance company of issuing this policy.

(c) Give examples of how the terms of the policy could be altered so as to remove this disadvantage.

There were, in total, 20 deaths during the years 2005 to 2008 inclusive and a further 8 deaths in 2009.

(iii) Calculate the total mortality profit or loss to the company during 2009.

4. CT5 September 2012 Q7

On 1 January 2007, a life insurance company sold a large number of 30-year pure endowment policies to lives then aged 35 exact. The sum assured under each policy is £125,000 payable on maturity. Premiums are payable annually in advance throughout the term of the policy.

There were 3521 pure endowment policies still in force on 1 January 2011 and 8 policyholders died during 2011.

Calculate the total mortality profit or loss to the life insurance company during 2011 assuming the company calculates net premium reserves on the following basis:
Mortality AM92 Select

Interest 4% per annum
Expenses Nil

5. CT5 September 2014 Q11

A life assurance company has issued whole of life assurance policies over a number of years. Premiums on these policies are payable annually in advance and the sums assured are payable at the end of the year of death.

You are given the following information relating to a group of policies within the portfolio of whole of life assurance policies

Age exact on 1 January 2013	*Sums assured in force on 1 January 2013*	*Reserves held on 31 December 2013 for policies in force at that date*
69	£740,000	£371,000

During 2013, there was 1 death claim (on a policy which was issued on 1 January 2000 for a sum assured of £15,000) arising from this group of policies.

(i) Calculate the mortality profit or loss for 2013 to the company in respect of this group of policies assuming net premiums are held on the following basis:

Mortality AM92 Ultimate
Interest 4% per annum

(ii) Calculate the amount of expected death claims in 2013 for this group of policies.

(iii) Compare your answer in part (ii) with the amount of actual claims and comment on your answer with reference to your answer in part (i) above.

6. CT5 September 2014 Q9

A life aged 60 exact purchases a special deferred term assurance policy for an overall term of 20 years.

Under this policy a sum assured of £100,000 is paid on death but only on death from age 65 exact up to the end of the term. On death between age 60 and 65 the benefit is equal to the total premiums paid without interest.

All payments on death are made at the end of the year of death. An annual premium paid in advance is payable for the full 20 year term.

Calculate the annual premium payable.

Basis:
Mortality AM92 Ultimate
Interest 4% per annum
Expenses Ignore

7. CT5 April 2016 Q2

(i) State the two conditions under which the net premium prospective reserve will equal the net premium retrospective reserve.

(ii) Describe two reasons why these conditions are unlikely to hold in practice.

8. CT5 April 2016 Q6

An endowment assurance pays a sum assured of 10,000 immediately on death or on survival to the end of the term of the policy.

(ii) Calculate, showing all your workings, the premium payable continuously for a life aged 40 exact for an endowment assurance with a term of 20 years. [4]

Basis:
Mortality $\mu x = .01$ for all x
Rate of interest 5% per annum

9. CT5 September 2017 Q4

Explain why a life insurance company will need to set up reserves for the level premium conventional whole life assurance contracts it has sold.

10. CT5 April 2018 Q5

On 1 January 2010, a life insurance company issued single life annuities to policyholders then aged 65 exact.

Each annuity is for 30,000 payable annually in arrears.

At the beginning of 2017, there were 5650 policyholders alive and during 2017, 80 policyholders died.

The company calculates its reserves using the following basis:
Mortality PMA92C20
Interest 4% per annum
Expenses Ignore

(i) Calculate the mortality profit or loss for these annuities for the year 2017.

(ii) Comment on your answer in part (i).

11. CT5 April 2018 Q3

A life aged 50 exact purchases a single-premium temporary annuity. The annuity pays 7,500 annually in arrears for a term of 10 years, ceasing on death, if earlier.

Calculate the reserve for the annuity at the end of the first policy year, using the net retrospective method and the following basis:

Mortality AM92 Select
Interest 4% per annum
Expenses Ignore

12. CT5 April 2018 Q10

A life insurance company sells a special deferred annuity policy to a life aged 60.75 years exact (i.e. 60 years and 9 months). The policy is funded by quarterly premiums in advance ceasing at age 65 (no premium is payable at age 65 exact).

The benefits under the policy are as follows:
• At age 65, an annuity of 12,000 a year is payable half-yearly in advance. Payment is guaranteed for five years and then continues to the age of 75 when it reduces to 10,000 a year under the same payment method until the death of the policyholder.
• At age 75, an additional lump sum benefit of 10,000 is payable. The annuity then reduces to 10,000 a year, ceasing on the death of the policyholder.

Determine that the quarterly premium is approximately 9,030.

Basis:
Mortality PFA92C20 (assume the uniform distribution of deaths method)
Rate of Interest 4% per annum
Expenses Ignore

13. CT5 April 2017 Q11

On 1 January 2000 a life insurance company issued a number of 20-year pure endowment policies to a group of lives aged 40 exact. In each case, the sum assured was 60,000 and premiums were payable annually in advance throughout the term or until earlier death.

On 1 January 2016, 18,230 policies were still in force. During 2016, 86 policyholders died, and no policy lapsed for any other reason.

(i) Calculate the profit or loss from mortality for this group for the year ending 31 December 2016.

Basis:
Mortality AM92 Select
Rate of interest 4% per annum
Expenses Ignore

(ii) Comment on your answer in part (i).

14. CM1A April 2019 Q10

(i) Define the term "prospective reserve" when used for a life insurance contract.

(ii) State the conditions necessary for the prospective reserve to equal the retrospective reserve.

A life insurance company issues a whole life assurance with sum assured S to a life aged exactly x. Annual premiums, payable annually in advance, are paid throughout the policy term. The benefit is payable immediately on death and there are no expenses.

(iii) Demonstrate that the prospective reserve is equal to the retrospective reserve at time t, assuming that the conditions referred to in part (ii) are met.

15. CM1A April 2019 Q13

On 1 January 2002 a life insurance company issued the following policies:

• Identical 25-year without profit endowment assurances each with a sum assured of £200,000 payable at the end of the policy term or at the end of year of death if earlier. Premiums are payable annually in advance throughout the term or until earlier death. The policies were issued to lives aged 35 exact.

• Identical level whole life annuities, each payable annually in advance at a rate of £10,000 per annum, issued to lives aged 65 exact.

An extract from the company's records gives the following information for 2018 in respect of these policies:

Policy type	*Endowment assurance*	*Annuity*
Number of policies in force on 1 January 2018	15,203	12,352
Total annual premium for in-force policies as at 1 January 2018	82,774,000	–
Number of policyholder deaths during 2018	46	746

There were no other exits in 2018.

(i) Calculate the mortality profit for the year ended 31 December 2018 in respect of:
(a) endowment assurances
(b) annuities.

Basis:
Mortality - Endowment assurances AM92, Annuities PMA92C20

Interest rate 4% per annum
Expenses Ignore

(ii) Discuss your answers in part (i).

16. CM1A September 2019 Q5

A life office issued a whole of life assurance contract to a life aged x exact with a sum assured of 1 payable at the end of the year of death.

Level premiums of P are payable annually in advance, ceasing on death. Ignore expenses.

(i) Using standard actuarial notation, write down:
(a) The equation of value at time 0.
(b) An expression for the prospective reserve at duration t years, denoted by ${}_tV_x^P$.
(c) An expression for the retrospective reserve at duration t years, denoted by V_x^R.

Assume that the basis used to calculate both the prospective and retrospective reserves is the same as that used to calculate the premium, P.

(ii) Show that the prospective and retrospective reserves are equal at time t.

17. CM1A April 2021 Q10

On 1 January 2011, a life insurance company planned to issue the following two policies to lives then aged 45 exact:

- a 15-year without-profit endowment assurance with a sum assured of S payable on maturity or immediately on earlier death, and with premiums of P payable annually in advance

- a 15-year temporary life annuity payable annually in advance purchased with a single premium of $50,000.

The annual annuity payments were calculated to be exactly sufficient to pay the premiums for the endowment assurance as they fell due.

(i) Calculate P and S.

The policies were actually issued with S = $90,000 payable under each endowment assurance policy and an annual premium of P = $4,450.

On 31 December 2020, there were 550 policies still in force. During 2020, there were six deaths with no other decrements taking place.

(ii) Calculate the mortality profit for the calendar year 2020.

(iii) Comment on your numerical result obtained in part (ii).

Basis:
Mortality: AM92 Ultimate
Interest: 4% p.a.
Expenses: Ignore

18. CM1A September 2021 Q9

A life insurance company issues 30-year pure endowment assurance policies to a group of lives aged exactly 30. Each policy provides a sum assured of $50,000 payable on survival to the end of the term. Premiums on the policy are payable annually in advance for 30 years or until earlier death.

There were two deaths during the 25th policy year and the number of policies in force at the end of that year was 315. There were no exits other than death during the year.

(i) Calculate, showing all working, the mortality profit or loss arising in the 25th policy year.

(ii) Comment on your result obtained in part (i).

Basis:
Mortality: AM92 Ultimate
Interest: 4% p.a. effective
Expenses: None