

# INSTITUTE AND FACULTY OF ACTUARIES



## EXAMINATION

7 October 2016 (pm)

### Subject CT5 – Contingencies Core Technical

*Time allowed: Three hours*

#### ***INSTRUCTIONS TO THE CANDIDATE***

1. *Enter all the candidate and examination details as requested on the front of your answer booklet.*
2. *You must not start writing your answers in the booklet until instructed to do so by the supervisor.*
3. *You have 15 minutes of planning and reading time before the start of this examination. You may make separate notes or write on the exam paper but not in your answer booklet. Calculators are not to be used during the reading time. You will then have three hours to complete the paper.*
4. *Mark allocations are shown in brackets.*
5. *Attempt all 13 questions, beginning your answer to each question on a new page.*
6. *Candidates should show calculations where this is appropriate.*

***Graph paper is NOT required for this paper.***

#### ***AT THE END OF THE EXAMINATION***

*Hand in BOTH your answer booklet, with any additional sheets firmly attached, and this question paper.*

*In addition to this paper you should have available the 2002 edition of the Formulae and Tables and your own electronic calculator from the approved list.*

- 1** A whole life assurance policy provides a benefit of 100,000 payable immediately on the death of a male life who is now aged 45 exact.

Calculate, showing all your workings:

- (a) the expected present value of this policy.  
(b) the variance of the value of this policy.

Basis:

Mortality AM92 Ultimate  
Rate of interest 4% per annum

[4]

- 2** A 10-year unit-linked policy has the following profit vector:

$(-50, -10, -10, 5, 5, 5, -3, 15, 40, 60)$

Reserves are set up to zeroise future negative cash flows on the following basis:

Basis:

Mortality The probability of death at each age is a constant 0.25% per annum  
Rate of interest 1.5% per annum

Determine the revised profit vector.

[4]

- 3** A pension scheme provides the following benefits:

- a pension of two-thirds of Final Pensionable Salary on ill-health retirement, where Final Pensionable Salary is the average pensionable salary over the 3 years before retirement.
- a lump sum immediately on death before retirement of four times pensionable salary in the year before death.

Normal Pension Age is age 65.

A life aged 42 exact has pensionable salary in the previous year of 100,000.

- (i) Calculate, showing all your workings, the present value of the ill-health retirement pension for this life.

Basis: Pension Scheme Table in the Formulae and Tables for Examinations [2]

- (ii) Write down an expression for the value of the lump sum death benefit for the same life using commutation functions. [2]

[Total 4]

4 Calculate, showing all your workings:

(a)  ${}_{10|5}q_{65}$ .

(b)  $\ddot{a}_{[30]:15}^{(12)}$ .

Basis:

Mortality AM92  
Rate of interest 4% per annum

[4]

5 Describe how a life insurance company uses risk classification to manage the probability of making a loss from selling its products.

[6]

6 (i) Show, using the method of Uniform Distribution of Deaths, that:

$${}_{2.5}q_{80.75} = \frac{10}{117}$$

[3]

(ii) Calculate, showing all your workings,  $\ddot{a}_{80:\overline{4}|}$ .

Basis:

Mortality  $l_x = 110 - x$  for all  $x$   
Rate of interest 5% per annum

[3]

[Total 6]

7 A life insurance company writes policies that provide income during periods of disability.

(i) Draw the transition state model for these policies labelling your diagram carefully.

[5]

(ii) Describe two examples of selection that might apply for these policies.

[2]

[Total 7]

- 8 (i) Describe one advantage and one disadvantage of using single figure indices to summarise and compare mortality levels. [2]

The table below shows an extract from a study of mortality for a country and a given sub-population:

<i>Age</i>	<i>Country</i>		<i>Sub-population</i>	
	<i>Population</i>	<i>Number of deaths</i>	<i>Population</i>	<i>Observed mortality rate</i>
40–44	834,561	3,510	123,978	0.0029
45–49	779,862	3,153	116,853	0.0033
50–54	750,234	3,620	102,800	0.0051

- (ii) Calculate, showing all your workings, the Standardised Mortality Ratio for the sub-population, using the country as the standard population. [4]
- (iii) Comment on what the value of the Standardised Mortality Ratio shows about the sub-population. [2]

[Total 8]

- 9 A life insurance company issues a 35-year with-profits endowment assurance policy to a life aged 30 exact. The sum assured of 125,000 plus declared reversionary bonuses are payable at the end of the year of death or on maturity.

Level premiums of 3,090 are payable annually in advance for 35 years or until earlier death.

A simple bonus, expressed as a percentage of the sum assured, is added to the policy at the end of each year. The death benefit does not include the bonus relating to the policy year of death.

The following basis is used to price this policy:

Mortality	AM92 Select
Rate of interest	4% per annum
Initial expenses	325 plus 75% of the first annual premium, incurred at the policy commencement date
Renewal commission	2.5% of each premium from the start of the second policy year
Claim expense	375 at the point of claim payment

- Calculate, showing all your workings, the level simple bonus rate that can be supported each year on this policy, using the principle of equivalence. [9]

- 10** A 25-year “double” endowment assurance policy is issued to a group of lives aged 40 exact. Each policy provides a sum assured of 25,000 payable at the end of the year of death or 50,000 payable if the life survives until the maturity date.

Premiums are payable annually in advance throughout the term of the policy or until earlier death.

The following information has been provided:

Number of deaths during the 17<sup>th</sup> policy year: 24  
Number of policies in force at the end of the 17<sup>th</sup> policy year: 5,350

- (i) Calculate, showing all your workings, the profit or loss for the group arising from mortality in the 17<sup>th</sup> policy year. [7]  
(ii) Comment on your result. [2]

Basis:

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

[Total 9]

- 11** A life insurance company issues a joint annuity policy to a male aged 60 exact and a female aged 62 exact. Under the policy:

- an annuity of 50,000 per annum is guaranteed to be payable for a period of 10 years and thereafter for the lifetime of the male.
- on the death of the male, an annuity of 20,000 per annum is payable to the female, if she is still alive. This annuity commences on the monthly payment date next following, or coincident with, the date of his death or from the 10<sup>th</sup> policy anniversary, if later. It is payable for the lifetime of the female.
- all annuities are payable monthly in arrear.

Determine the expected present value of the policy.

Basis:

Mortality PMA92C20 for the male and PFA92C20 for the female  
Rate of interest 4% per annum  
Expenses Ignore

[10]

- 12** A life insurance company issues a 15-year decreasing term assurance policy to a life aged 50 exact. The initial sum assured is 450,000, decreasing by 30,000 at each policy anniversary (the first decrease taking place at the beginning of the second policy year). The death benefit is payable immediately on death.

Level annual premiums are payable in advance for 15 years, ceasing on earlier death.

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

Mortality		AM92 Select
Rate of interest		4% per annum
Expenses	Initial	275 plus 30% of the first premium
	Renewal	5% of all premiums excluding the first plus 68 per annum inflating at 4% per annum compound at the start of the second and subsequent policy years.
	Claim	315 inflating at 4% per annum compound
	Inflation	For renewal and claim expenses, the amounts quoted are at outset of the policy and the increases due to inflation start immediately.

- (i) Write down the Gross Premium Future Loss Random Variable at the start of the policy. Use  $P$  for the annual premium. [4]
- (ii) Calculate, showing all your workings, the premium, using the principle of equivalence. [8]
- (iii) Calculate, showing all your workings, the gross premium prospective reserve after 14 years. [2]
- [Total 14]

- 13** A life insurance company issues a 3-year endowment assurance policy to an unmarried life that offers the following benefits:

- On marriage, a return of 107.5% of total premiums paid.
- On surrender, a return of 50% of total premiums paid.
- On death, a benefit which is given by the formula:

$$10,000 \times (1 + t) \quad t = 0, 1 \text{ and } 2$$

where  $t$  denotes the curtate duration in years since the inception of the policy.

- On survival, 30,000 is payable immediately.

The marriage, surrender and death benefits are payable at the end of the policy year of claim.

Premiums of 9,516 are payable annually in advance throughout the term of the policy or until earlier claim.

The policy ceases on payment of any benefit.

The company uses the following basis to profit test this policy:

Independent force of marriage	15%
Independent force of surrender	7.5% in years 1 and 2 only
Independent force of mortality	1%
Interest earned on cash flows	3.5% per annum
Expenses	1.5% of each premium paid
Reserves	None held

The company assumes that:

- each force of decrement is independent and constant over each year of age.
  - surrenders only occur in policy years 1 and 2.
- (i) Determine for each policy year the dependent rates of mortality, marriage and surrender. [4]
- (ii) Derive the expected cash flows for the policy for each policy year. [7]
- (iii) Calculate, from part (ii) the expected present value of the profit or loss to the company for each policy year and in total. Use a risk discount rate of 4% per annum. [2]
- (iv) Discuss the consequences for the company of the profit vector derived in part (iii). [2]
- [Total 15]

**END OF PAPER**