INSTITUTE AND FACULTY OF ACTUARIES

EXAMINATION

27 September 2017 (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 List the four main categories of costs which are affected by inflation in the context of allocating expenses to life assurance contracts. [2]

2 Describe what is meant by spurious selection, including an example. [3]

3 Calculate ${}_{2.25}q_{85.5}$ using the method of Uniform Distribution of Deaths.

Basis: ELT15 (Males)

[4]

4 Explain why a life insurance company will need to set up reserves for the level premium conventional whole life assurance contracts it has sold. [4]

5 (i) Calculate $\overline{A}_{47:\overline{11}|}$. [3]

(ii) Calculate $\ddot{a}^{(4)}_{[53]:\overline{13}|}$. [2]

Basis: Mortality AM92
Interest 4% per annum

[Total 5]

6 (i) Calculate $\ddot{a}_{40:\overline{4}|}$. [2]

(ii) Derive the value of $A^{1}_{40:\overline{4}|}$, using your result from part (i). [4]

Basis:

From the following life table extract

x	l_x
40	100,000
41	99,200
42	98,100
43	96,700
44	94,700

Interest 5% per annum

[Total 6]

7 A population is subject to two modes of decrement, α and β as defined below:

$\mu_x^{\alpha} = 1/(110 - x)$ for $0 \le x < 110$; and

$\mu_x^{\beta} = 0.03$ for $0 \le x < 110$

You are given that $\int_0^1 te^{-0.03t} dt = 0.490112$

Determine the value of $(aq)_{40}^{\beta}$. [7]

8 A company is about to establish a pension scheme that will provide retirement benefits to its members of n/80ths of final pensionable salary at age 65 or on earlier ill health, where n is the total number of years of service to retirement. Age retirement in normal health follows the principles in the Pension Scheme Table for age retirement functions in the Formulae and Tables for Actuarial Examinations. Final pensionable salary is the average salary in the three years before retirement.

An employee joins the scheme aged 45 exact and is granted exactly 15 years of past service. The employee's salary in the year before joining was 35,000.

(i) Calculate the present value of benefits for this member (including future service). [5]

(ii) Calculate the contribution required, as a percentage of future salary, to fund this benefit. [3]

Basis:

Pension Scheme from the Formulae and Tables for Actuarial Examinations

[Total 8]

9 A special whole life assurance policy is issued on a life aged 50 exact.

Under this policy the sum assured, payable at the end of the year of death, is 1 unit for the first 10 years decreasing to 0.75 units thereafter.

(i) Calculate the expected present value of the benefit. [3]

(ii) Determine the variance of the present value of the benefit. [5]

Basis:

Mortality AM92 Ultimate
Interest 4% per annum

[Total 8]

10 (i) Explain each of the following terms in words, without giving any formulae:

(a) crude mortality rate

(b) directly standardised mortality rate

(c) indirectly standardised mortality rate

(d) standardised mortality ratio

[4]

The following table summarises the mortality experience of a particular region of a country compared to the whole population of the country.

	Regional Group		***Whole Population***	
Age Group	*Number of lives*	*Deaths*	*Number of lives*	*Deaths*
20–34	40,000	42	1,000,000	1,300
35–49	75,000	135	1,600,000	3,200
50–64	35,000	110	900,000	2,500
TOTAL	150,000	287	3,500,000	7,000

(ii) Calculate the value of each of the terms defined in part (i), for the regional group. [5]

[Total 9]

11 A life insurance company issues a large number of 4-year unit-linked endowment assurance policies to lives aged 65 exact. Level premiums are payable annually in advance until maturity or earlier death.

The company has performed a profit test on these policies and the profit vector per policy sold, ignoring surrenders, is as follows:

$$(185.21, -121.52, -5.28, 12.95)$$

(i) Calculate the profit signature per policy sold if negative non-unit fund cash flows are zeroised. [3]

The company now wishes to allow for surrenders in its calculations. It assumes that at the end of the first and second policy years only, 3% of the surviving policyholders will surrender. Surrender values are equal to the bid value of units held (after deduction of the fund management charge) less a surrender penalty of 50.

(ii) Calculate the revised profit signature per policy sold after allowing for surrenders if negative non-unit cash flows are zeroised. [6]

(iii) Calculate the net present value of the revised profit signature in part (ii), using a risk discount rate of 8% per annum. [1]

Basis:

Mortality	AM92 Ultimate
Interest earned on non-unit cash flows	5% per annum fund
Expenses	Ignore

[Total 10]

12 A life insurance company issues a 3-year guaranteed bonus endowment assurance policy to a life aged 62 exact with a basic sum assured of 75,000. The basic sum assured, together with any attaching bonuses, is payable at the end of the year of death or maturity if earlier.

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

Simple annual bonuses are added at the beginning of each policy year (i.e. the death benefit does include any bonus relating to the policy year of death).

The company uses the following basis for carrying out profit tests of this policy:

Mortality		AM92 Ultimate
Withdrawals		Ignore
Interest earned		5% per annum on cash flows
Expenses	Initial	15% of the first premium
	Renewal	5% of subsequent premiums
Bonuses		Simple bonus of 4% of basic sum assured per annum

The company holds net premium reserves for the policy using the following basis:

Mortality	AM92 Ultimate
Interest	4% per annum

(i) Calculate the net premium reserve for the policy at policy duration $t = 1$ and $t = 2$ years immediately before the premium then due. [8]

(ii) Determine the annual premium required for the policy to achieve an internal rate of return of 6% per annum to the company. [9]

[Total 17]

13 On 1 January 2000, a life insurance company issued 25-year increasing term assurance policies to single lives aged 40 exact.

The death benefit, payable at the end of the year of death, was 50,000 in the first policy year and increased at the beginning of each policy year at a rate of 1.92308% per annum compound. The first increase was at the start of the second policy year.

A return of premiums paid, with no interest, is payable on survival to the end of the term of the policy.

Level premiums on the policies are payable annually in advance for 25 years or until earlier death.

The company calculates its reserves on a net premium basis and negative reserves are permitted.

(i) Show that the annual net premium for each policy is approximately equal to 323 using the basis below. [4]

At the start of 2016, there were 1425 policies in force. 10 policyholders died during 2016.

(ii) Calculate the mortality profit or loss to the company during 2016 using the basis below. [7]

After an analysis of surplus investigation by the company, it found that it had made neither a profit nor a loss in 2016 in respect of the policies in part (ii).

(iii) Determine the rate of interest the company earned in 2016. [6]

Basis:

Mortality	AM92 Select
Interest	6% per annum
Expenses	Ignore

[Total 17]

END OF PAPER