

# INSTITUTE AND FACULTY OF ACTUARIES



## EXAMINATION

19 April 2017 (am)

### 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** Calculate  ${}_{2.75}p_{77.4}$  assuming a Uniform Distribution of Deaths.

Basis:

Mortality PMA92C20 [3]

**2** Under a 20-year policy issued by a life insurance company, the benefit payable on death, at the end of the year of death, is a return of premiums paid without interest.

A premium of 631 is payable annually in advance, throughout the term of the policy.

The following information is available for a policy in force at the start of the 19<sup>th</sup> year:

Reserves at the start of the year,  ${}_{18}V$ : 17,095

Reserves at the end of the year per survivor,  ${}_{19}V$ : 18,510

Probability of death during the year: 0.015

Rate of interest earned: 4.5% per annum

Determine the profit which is expected to emerge at the end of the 19<sup>th</sup> year for each policy in force at the start of that year. Ignore expenses and all decrements other than death. [3]

**3** Calculate:

(a)  ${}_{12}p_{73}$ .

(b)  ${}_{10|}a_{56}$ .

(c)  $A_{64:\overline{10}|}$ .

Basis:

Mortality AM92

Rate of interest 4% per annum

[3]

**4** Describe the principal features of a non-unitised accumulating with-profits contract.

[4]

5 A small country has just two major cities A and B of approximately equal size.

The following statistics are available for the two cities in relation to the working population:

<i>Age Band</i>	<i>City A</i>		<i>City B</i>	
	<i>Exposed to Risk</i>	<i>Observed Mortality Rate</i>	<i>Exposed to Risk</i>	<i>Observed Mortality Rate</i>
20–29	200,000	0.00115	250,000	0.00125
30–39	350,000	0.00187	325,000	0.00171
40–49	400,000	0.00402	375,000	0.00358
50–59	250,000	0.01386	200,000	0.01515
60–69	100,000	0.04271	125,000	0.04368

Calculate:

- (a) the directly standardised mortality rate for City B
- (b) the indirectly standardised mortality rate for City B

using the combined population of both cities as the standard population. [6]

6 A pension scheme provides an age retirement pension of 1% of Final Pensionable Salary for each year of service. Final Pensionable Salary is defined as the average Pensionable Salary over three years before retirement less 1,000.

Age retirement in normal health follows the principles in the Pension Scheme Table for age retirement functions in the Formulae and Tables for Examinations.

A life is aged 54 exact with 10 years of past service and pensionable salary in the previous year of 30,000.

Set out the expected present value of the past service part of this life's pension in a formula not using commutation functions. Define all symbols used. [7]

7 (i) Describe, in the context of underwriting for life insurance, the following selection processes:

- (a) adverse selection
- (b) spurious selection

[5]

(ii) Describe an example of each selection process in part (i).

[2]

[Total 7]

8 (i) Describe in words the difference between the functions  $(\bar{IA})_{x:\overline{n}|}$  and  $(\bar{IA})_{x:\overline{n}|}$ . [2]

(ii) Determine, showing all your working,  $(\bar{IA})_{x:\overline{15}|}$ .

Basis:

Force of mortality  $\mu_x = 0.02$  for all  $x$

Force of interest 3%

[5]

[Total 7]

9 An assurance policy provides a benefit of 1 payable immediately on the death of the last survivor of a male life aged 55 exact and a female life aged 50 exact.

Determine:

(i) the expected present value of this policy. [4]

(ii) the variance of the present value of this policy. [4]

Basis:

Force of mortality Male life – a constant force of 0.03

Female life – a constant force of 0.02

Force of interest 4%

[Total 8]

10 A special joint-life deferred annuity policy provides the following benefits:

- 20,000 payable immediately on each death at any age
- a pension payable monthly in advance after 10 years at a rate of 10,000 per annum if both lives are alive and 5,000 per annum if only one life is alive

Premiums are payable monthly in advance until the first death for a maximum of 10 years.

Show that the monthly premium payable for a male life aged 55 exact and a second female life aged 50 exact is approximately 1,114.

Basis:

First life mortality PMA92C20

Second life mortality PFA92C20

Rate of interest 4% per annum

Expenses Ignore

[9]

- 11** 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. [7]

Basis:

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

- (ii) Comment on your answer in part (i). [2]  
[Total 9]

- 12** A life insurance company issues a 30-year with-profits endowment assurance policy to a life aged 35 exact. The sum assured is 100,000 together with any attaching bonuses and is payable immediately on death.

Level premiums are payable monthly in advance, ceasing on maturity or on the policyholder's death if earlier.

Simple annual bonuses are added at the end of each policy year. The death benefit does not include any bonus relating to the policy year of death.

The company calculates the premium on the following basis:

Mortality	AM92 Select
Rate of interest	4% per annum
Expenses	
Initial	325
Renewal	70 at the start of the second and subsequent policy years and payable until death
Claim	275 on death
Commission	
Initial	70% of the total premium payable in the first policy year
Renewal	2.5% of the second and subsequent monthly premiums
Bonuses	Simple bonus of 2.5% of basic sum assured per annum

- (i) Show that the monthly premium for this policy is approximately 292. [9]

As at the end of the 28<sup>th</sup> policy year, the total actual past bonus additions to the policy have followed the assumptions stated in the premium basis above.

(ii) Calculate the gross prospective policy value at the end of the 28<sup>th</sup> policy year.

Policy value basis:

Mortality	AM92 Ultimate	
Rate of interest	4% per annum	
Expenses		
Renewal	85 at the start of each policy year and payable until death	
Claim	300 on death	
Commission		
Renewal	2.5% of the monthly premiums	
Bonuses	Simple bonus of 2.75% of basic sum assured per annum	[6]
		[Total 15]

**13** A life insurance company issues a 3-year unit-linked endowment assurance policy to a male life aged 60 exact. The details are:

- Level premiums of 9,000 per annum are payable yearly in advance throughout the term of the policy or until earlier death.
- 80% of the premium is allocated to units in the first policy year and 100% in the second and third policy years.
- A policy fee of 25 is deducted from the annual premium before the allocation to units.
- The units are subject to a bid-offer spread of 5%.
- An annual management charge of 1.5% of the bid value of the units is deducted at the end of each policy year.
- Management charges are deducted from the unit fund before death, surrender and maturity benefits are paid.
- If the policyholder dies during the term of the policy, the death benefit of 125% of the bid value of the units is payable at the end of the policy year of death.
- On maturity, 100% of the bid value of the units is payable.
- The policyholder may surrender the policy at any time during the first and second policy years.

- On surrender, the bid value of the units less a surrender penalty is payable at the end of the policy year of exit as follows:

<i>Year</i>	<i>Penalty</i>
1	600
2	300

The company uses the following assumptions in carrying out profit tests of this contract:

Rate of growth on assets in the unit fund	4.5% per annum in year 1 4.0% per annum in year 2 3.5% per annum in year 3
Rate of interest on non-unit fund cash flows	2.0% per annum
Mortality	AM92 Select
Initial expenses	220
Renewal expenses	75 per annum on the second and subsequent premium dates
Initial commission	30% of first premium
Renewal commission	1.5% of the second and subsequent years' premiums
Rate of expense inflation	2.0% per annum
Risk discount rate	6.5% per annum

For renewal expenses, the amount quoted is at the commencement of the policy, and the increases due to inflation start immediately.

The company assumes that the force of decrement due to surrender is:

- 0.1 in policy year 1.
- 0.05 in policy year 2.

It also assumes that each force of decrement is independent and constant over each year of age.

- (i) Determine for each policy the dependent rates of mortality and surrender. [4]
- (ii) Calculate the profit margin for the policy. [11]

The company now assumes that there are no surrenders.

- (iii) Calculate the expected present value of profit for the policy. [4]
- [Total 19]

**END OF PAPER**