INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORT

April 2017

Subject CT5 – Contingencies
Core Technical

Introduction

The Examiners' Report is written by the Principal Examiner with the aim of helping candidates, both those who are sitting the examination for the first time and using past papers as a revision aid and also those who have previously failed the subject.

The Examiners are charged by Council with examining the published syllabus. The Examiners have access to the Core Reading, which is designed to interpret the syllabus, and will generally base questions around it but are not required to examine the content of Core Reading specifically or exclusively.

For numerical questions the Examiners' preferred approach to the solution is reproduced in this report; other valid approaches are given appropriate credit. For essay-style questions, particularly the open-ended questions in the later subjects, the report may contain more points than the Examiners will expect from a solution that scores full marks.

The report is written based on the legislative and regulatory context pertaining to the date that the examination was set. Candidates should take into account the possibility that circumstances may have changed if using these reports for revision.

Luke Hatter
Chair of the Board of Examiners
July 2017

A. General comments on the *aims of this subject and how it is marked*

1. The aim of the Contingencies subject is to provide a grounding in the mathematical techniques which can be used to model and value cashflows dependent on death, survival, or other uncertain risks.

2. CT5 introduces the fundamental building blocks of all life insurance and pensions actuarial work.

3. Credit is given to students who produce alternative correct numerical solutions. In the case of descriptive answers credit is also given where appropriate valid points are made which do not appear in the solutions below.

4. In questions where definitions of symbols and then formulae are requested, a different notation system produced by a student to that used by the Examiners is acceptable provided it is used consistently, is relevant and is properly defined and used in the answer.

5. Students should note that for long questions reasonable credit is given if they can describe the right procedures although to score high marks reasonably accurate numerical calculation is necessary.

B. General comments on *student performance in this diet of the examination*

1. In general this paper was done less well than previous recent papers although well prepared students managed to score very reasonable marks. Most questions were straightforward and capable of being answered in the allotted time. The questions that gave most difficulty were 4, 6, 7 and 8.

2. Detailed solutions are given below together with commentary from the examiners which we hope will be of assistance.

C. Pass Mark

The Pass Mark for this exam was 60.

Solutions

Q1

$${}_{2.75}p_{77.4} = {}_{0.6}p_{77.4} \times {}_{2}p_{78} \times {}_{0.15}p_{80}$$

$$= \frac{p_{77}}{{}_{0.4}p_{77}} \times {}_{2}p_{78} \times {}_{0.15}p_{80}$$

$$= \frac{p_{77}}{(1-0.4q_{77})} \times {}_{2}p_{78} \times (1-0.15q_{80})$$

$$= \frac{(1-0.036696)}{(1-0.4\times 0.036696)} \times \frac{6953.536}{7615.818} \times (1-0.15\times 0.053303)$$

$$= 0.88550$$

[3]

> Straightforward and generally done well.

Q2 The death benefit in year 19 is 631 × 19 = 11,989. [½]

Profit emerging per policy in force at the start of the year is:

$([{}_{18}V + P]\times 1.045) - (11,989\times 0.015) - ([1-0.015]\times {}_{19}V)$ [2]

$= ([17,095+631]\times 1.045) - (11,989\times 0.015) - (0.985\times 18,510) = 111.49$ [½]

[Total 3]

> This question was done less well. The main issue was the correct use of the traditional reserve movement formula which many students failed to recall.

Q3 (a) $${}_{12}p_{73} = \frac{l_{85}}{l_{73}} = \frac{3385.2479}{7403.0084} = 0.45728$$ [½]

(b) $${}_{10|}a_{56} = v^{10} \times \frac{l_{66}}{l_{56}} \times \left(\ddot{a}_{66} - 1\right)$$ [1]

$$= 0.67556 \times \frac{8695.6199}{9515.104} \times 10.896$$

$$= 6.727$$

(c)

$$A_{64:\overline{10|}} = A_{64} - v^{10} \times \frac{l_{74}}{l_{64}} \times A_{74} + v^{10} \times \frac{l_{74}}{l_{64}}$$

$$= 0.51333 - \left(0.67556 \times \frac{7150.2401}{8934.8771} \times (0.65824 - 1) \right)$$

$$= 0.69809$$

[1½]

[Total 3]

Straightforward and generally done well. Quite a few students valued a Term Assurance in (c) by omitting the final survival factor.

Q4 Under a non-unitised accumulating with-profits (AWP) contract, the basic benefit takes the form of an accumulating fund of premiums with a discretionary annual bonus interest determined by the insurance company each year. [1]

If the accumulating fund at time *t* is denoted by F_t, the simplest form of an AWP contract follows the following recursive formula: $F_t = (F_{t-1} + P)(1+g)(1+b_t)$ where P is the annual premium, g is the guaranteed annual interest and b_t is the discretionary annual bonus interest declared for year *t*. [1]

The discretionary bonus interest will reflect both the returns achieved on the underlying assets over the period plus any additional profits made on the contract in this time. [1]

It is unusual for any guaranteed rate to be applied to AWP in modern conditions (other than the degenerate case where $g = 0$). [1]

The regular bonus interest under AWP can be reduced so as to retain profit for subsequent deferred payment as a terminal bonus payable on death or survival. [1]

With the simple AWP contract, the bonus interest would distribute profits net of all expenses and other costs incurred. [1]

[Max 4]

This question was answered very poorly. Most students failed to understand the features of an AWP and either left the question unanswered or gave an answer of a traditional with – profit contract which was not asked for and thus failed to score marks.

Q5

Age Band	***City A*** *Actual Deaths*	***City B*** *Actual Deaths*	*Total Deaths*	*Total Exposed*	*(i)**	*(ii)***
20–29	230.0	312.5	542.5	450000	562.5	301.4
30–39	654.5	555.8	1210.3	675000	1154.3	582.7
40–49	1608.0	1342.5	2950.5	775000	2774.5	1427.7
50–59	3465.0	3030.0	6495.0	450000	6817.5	2886.7
60–69	4271.0	5460.0	9731.0	225000	9828.0	5406.1
TOTAL	10228.5	10700.8	20929.3	2575000	21136.8	10604.5

* City B expected deaths using Total Exposed and City B mortality rate

** City B expected deaths using Total mortality rate and City B exposure

[4 for table values]

Directly Standardised mortality rate = $\dfrac{21136.8}{2575000} = 0.008208$ [½]

Indirectly Standardised mortality rate = $\dfrac{20929.3}{2575000} \times \dfrac{10700.8}{10604.5} = 0.008202$ [1½]

[Total 6]

Generally well answered.

Q6 The present value is:

$$= 0.01 \times 10 \times \left[\begin{array}{l} \left[\sum_{t=0}^{10} \left(30000 \times \frac{z_{54.5+t}}{s_{53}} - 1000 \right) \times \frac{r_{54+t}}{l_{54}} \times v^{t+0.5} \times \bar{a}^{r}_{54.5+t} \right] \\ + \left(30000 \times \frac{z_{65}}{s_{53}} - 1000 \right) \times \frac{r_{65}}{l_{54}} \times v^{11} \times \bar{a}^{r}_{65} \end{array} \right]$$

[5]

Ignoring suffixes and the compound interest factor:

s = salary index, z-average salary factor over 3 years prior to retirement
r = age retirement factor
l = lives factor

and

$\bar{a}^{r}$ = the continuous annuity factor payable for life for the retiree

[2]
[Total 7]

This question was done quite poorly. Despite being asked not to use commutation factors many students did rather than develop the formula model above.

It was noted that some students interpreted the second paragraph of the question to mean – "age retirement is not permitted before age 60". Their summation expressions therefore started with $t = 6$, rather than $t = 0$. This approach was given full credit.

Q7 Underwriting is the process by which life insurance companies divide lives into homogeneous risk groups by using the values of certain factors (rating factors) recorded for each life. [1]

(a) Adverse selection is characterised by the way in which the select groups are formed rather than by the characteristics of those groups. Any form of selection may also exhibit adverse selection. Adverse selection usually involves an element of self-selection, which acts to disrupt (act against) a controlled selection process which is being imposed on the lives. This adverse selection tends to reduce the effectiveness of the controlled selection. [1]

If prospective policyholders know that a company does not use a particular rating factor, e.g. smoking status, then lives who smoke will opt to buy a policy from this company rather than a company that uses smoking status as a rating factor. [1]

The outcome will be to lessen the effect of the controlled selection being used by the company as part of the underwriting process. The effect of self-selection by smokers is adverse to the company's selection process. [1]

(b) When homogeneous groups are formed we usually tacitly infer that the factors used to define each group are the cause of the differences in mortality observed between the groups. However, there may be other differences in composition between the groups, and it is these differences rather than the differences in the factors used to form the groups that are the true causes of the observed mortality differences. [1]

Ascribing mortality differences to groups formed by factors which are not the true causes of these differences is termed spurious selection. [1]

For example, when the population of England and Wales is divided by region of residence, some striking mortality differences are observed. However, a large part of these differences can be explained by the different mix of occupations in each region. The class selection ascribed to regions is spurious and is in part the effect of compositional differences in occupation between the regions. [1]

[Total 7]

> This question was generally poorly answered. The main issue was that many students just gave bookwork definitions without linking their answer to the underwriting process.

Q8 (i) $(I\bar{A})_{x:\overline{n}|}$ is the expected present value of an increasing endowment assurance on a life aged x for n years whereby the sum assured is 1 in the first year increasing by 1 every full year to n at the end of the term. The death claim is paid immediately on death. The maturity value is paid at the end of the term.

$(\overline{I}\bar{A})_{x:\overline{n}|}$ is similar except that the increase in sum assured from 1 to n is continuous from inception. [2]

(ii)

$$(I\bar{A})_{x:\overline{15}|} = 0.02\times\int_0^1 e^{-.05t}dt + 0.02\times 2e^{-.05}\times\int_0^1 e^{-.05t}dt + 0.02\times 3e^{-.05\times 2}\times\int_0^1 e^{-.05t}dt$$

$$+\ldots+0.02\times 15\times e^{-.05\times 14}\times\int_0^1 e^{-.05t}dt + 15\times e^{-.05\times 15}$$

$$= 0.02\times\int_0^1 e^{-.05t}dt\times\left(1+2e^{-.05}+3e^{-.10}+\ldots..+15e^{-.70}\right)+15e^{-.75}$$

$$= 0.02\times\left(\frac{1-e^{-.05}}{.05}\right)\times\left(\frac{1-e^{-.75}}{(1-e^{-.05})^2}-\frac{15e^{-.75}}{(1-e^{-.05})}\right)+15e^{-.75}$$

$$= 0.4\times 0.04877\times\left(\frac{0.52763}{0.00238}-\frac{7.08550}{0.04877}\right)+7.08550$$

$$= 1.4906+7.0855$$

$$= 8.576 \quad \text{(to 3dp)}$$

[3½ marks lines 1 to 4, 1 mark line 5, ½ mark for result]

In Part (i) some students thought that there was no difference in the symbols depicted but there was clearly an extension of the bar across the top of the symbol in the second case compared to the first.

Part (ii) proved to be the most challenging question on the paper and was consequently very poorly done with few students making progress on this.

Some students actually wrongly calculated $(\overline{IA})_{x:\overline{n}|}$ which has a simpler derivation.

Q9 (i)

$$EPV = \bar{A}_{\overline{55:50}} = \bar{A}_{55} + \bar{A}_{50} - \bar{A}_{55:50}$$

$$\bar{A}_{55} = 0.03 \times \int_0^\infty e^{-0.07t} dt = \frac{3}{7}$$

$$\bar{A}_{50} = 0.02 \times \int_0^\infty e^{-0.06t} dt = \frac{1}{3}$$

$$\bar{A}_{55:50} = \int_0^\infty e^{-0.09t} (0.03 + 0.02) dt = \frac{5}{9}$$

$$\Rightarrow \bar{A}_{\overline{55:50}} = \frac{3}{7} + \frac{1}{3} - \frac{5}{9} = \frac{13}{63} = 0.20635$$

[½ mark for lines 1 and 5, 1 mark each other line – Total 4]

(ii)

$$\text{Variance} = {}^2\bar{A}_{55} + {}^2\bar{A}_{50} - {}^2\bar{A}_{55:50} - (EPV)^2$$

$${}^2\bar{A}_{55} = 0.03 \times \int_0^\infty e^{-0.11t} dt = \frac{3}{11}$$

$${}^2\bar{A}_{50} = 0.02 \times \int_0^\infty e^{-0.10t} dt = \frac{1}{5}$$

$${}^2\bar{A}_{55:50} = \int_0^\infty e^{-0.13t} (0.03 + 0.02) dt = \frac{5}{13}$$

$${}^2\bar{A}_{55} + {}^2\bar{A}_{50} - {}^2\bar{A}_{55:50} = \frac{3}{11} + \frac{1}{5} - \frac{5}{13} = 0.08811$$

$$\text{Variance} = 0.08811 - (0.20635)^2 = 0.04553$$

[2 marks for knowing to square interest – 2 marks for rest]
[Total 8]

A straightforward question of its type – well done by well prepared students

Q10 Value of lump sum death benefit:

$$EPV = 20000 \times \left(\bar{A}_{55} + \bar{A}_{50} \right)$$

$$\bar{A}_{55} = (1.04)^{0.5} \times \left(1 - d\ddot{a}_{55}\right) = 1.019804 \times (1 - 0.038462 \times 17.364) = 0.338724$$

$$\bar{A}_{50} = (1.04)^{0.5} \times \left(1 - d\ddot{a}_{50}\right) = 1.019804 \times \left(1 - 0.038462 \times 19.539\right) = 0.253412$$

$$EPV = 20000 \times \left(0.338724 + 0.253412\right) = 11842.7$$

[3]

Value of deferred annuity:

$$EPV = 5000 \times \left({}_{10|}\ddot{a}_{55}^{(12)} + {}_{10|}\ddot{a}_{50}^{(12)} \right)$$

$$= v^{10} \times 5000 \times \left(\frac{9647.797}{9904.805} \times \left(13.666 - \frac{11}{24}\right) + \frac{9848.431}{9952.697} \times \left(16.652 - \frac{11}{24}\right)\right)$$

$$= 0.67556 \times 5000 \times (12.865 + 16.024)$$

$$= 97581.3$$

[3]

Value of premiums:

Let P be the monthly premium

$$EPV = 12P\ddot{a}_{55:50:\overline{10}|}^{(12)}$$

$$= 12P \times \left(\ddot{a}_{55:50}^{(12)} - v^{10}\, {}_{10}p_{55}\, {}_{10}p_{50}\, \ddot{a}_{65:60}^{(12)}\right)$$

$$= 12P \times \left(16.602 - \frac{11}{24} - v^{10} \times \frac{9647.797}{9904.805} \times \frac{9848.431}{9952.697} \times \left(12.682 - \frac{11}{24} \right)\right)$$

$$= 12P \times (16.144 - (0.67556 \times 0.97405 \times 0.98952 \times 12.224))$$

$$= 98.215P$$

[2½]

Hence monthly premium = (11842.7 + 97581.3) / 98.215 = 1114 nearer whole no.

[½]

[Total 9]

> A straightforward question of its type – well done by well prepared students. The only real issue was in valuing the deferred annuity portion.

Q11 (i) $P\ddot{a}_{[40]:\overline{20}|} = 60,000 A_{[40]:\overline{20}|}^{\ \ \ 1} = 60,000 v^{20}\ {}_{20}p_{[40]}$

$\Rightarrow P(13.930) = (60,000)(0.45639)(0.94245)$

$\Rightarrow P = 25,807.49 / 13.93 = 1,852.66$

[2]

Mortality profit = Expected Death Strain – Actual Death Strain

$DSAR = 0 - {}_{17}V = -(60,000 A_{57:\overline{3}|}^{\ \ \ 1} - P\ddot{a}_{57:\overline{3}|})$

$= -(60,000 v^3\ {}_3p_{57} - P\ddot{a}_{57:\overline{3}|})$

$= -\{(60,000)(0.88900)(0.98098) - (1,852.66)(2.870)\} = -47,008.34$

[2]

EDS = (q_{56})(18230)(–47,008.34) = (0.005025)(18230)(–47,008.34)

= –4,306,234.24 [1½]

ADS = (86)(–47,008.34) = –4,042,717.24 [1]

Mortality Profit = –4,306,234.24 – (–4,042,717.24) = –263,517
i.e. a loss. [½]

(ii) We expected $18230q_{56}$ = 91.6 deaths. Actual deaths were 86. With pure endowments, the death strain is negative because no death claim is paid and there is a release of reserves to the company on death. In this case, less deaths than expected means this release of reserves is less than required by the equation of equilibrium and the company therefore makes a loss. [2]

[Total 9]

Well prepared students completed this question very satisfactorily.

The main errors were students valuing an endowment assurance rate than a pure endowment or using ${}_{16}V$ instead of ${}_{17}V$.

The conclusion was also not clearly stated in many cases

Q12 (i) If the monthly premium and sum assured are denoted by P and S respectively then:

$$0.975 \times 12P\ddot{a}^{(12)}_{[35]:\overline{30}|} + 0.025P$$

$$= (0.975S + 275)\bar{A}^{\,1}_{[35]:\overline{30}|} + Sv^{30}\,{}_{30}p_{[35]} + 0.025S(I\bar{A})_{[35]:\overline{30}|}$$

$$+325 + 70(\ddot{a}_{[35]:\overline{30}|} - 1) + 0.7 \times 12P \qquad [6]$$

where $(I\bar{A})_{[35]:\overline{30}|} = (I\bar{A})^{\,1}_{[35]:\overline{30}|} + 30v^{30}\,{}_{30}p_{[35]}$ [½]

$$\Rightarrow 0.975 \times 12P\ddot{a}^{(12)}_{[35]:\overline{30}|} + 0.025P$$

$$= (1.04)^{0.5}\left[(0.975 \times 100{,}000 + 275)A^{\,1}_{[35]:\overline{30}|} + 0.025 \times 100{,}000(IA)^{\,1}_{[35]:\overline{30}|}\right]$$

$$+(1 + 30 \times 0.025) \times 100{,}000v^{30}\,{}_{30}p_{[35]} + 325 + 70(\ddot{a}_{[35]:\overline{30}|} - 1) + 8.4P$$

where

$$\ddot{a}^{(12)}_{[35]:\overline{30}|} = \ddot{a}^{(12)}_{[35]} - v^{30}\,{}_{30}p_{[35]}\ddot{a}^{(12)}_{65}$$

$$= \left(\ddot{a}_{[35]} - \frac{11}{24}\right) - v^{30}\,{}_{30}p_{[35]}\left(\ddot{a}_{65} - \frac{11}{24}\right)$$

$$= \left(21.006 - \frac{11}{24}\right) - .30832 \times \frac{8821.2612}{9892.9151}\left(12.276 - \frac{11}{24}\right)$$

$$= 20.548 - 3.249 = 17.299 \qquad [½]$$

$$A^{\ \ 1}_{[35]:\overline{30}|} = A_{[35]:\overline{30}|} - v^{30}\ {}_{30}p_{[35]} == 0.32187 - 0.27492 = 0.04695$$ [½]

$$(IA)^{\ \ 1}_{[35]:\overline{30}|} = (IA)_{[35]} - v^{30}\ {}_{30}p_{[35]}\left(30A_{65} + (IA)_{65}\right)$$

$$= 7.47005 - 0.30832 \times \frac{8821.2612}{9892.9151}(30 \times 0.52786 + 7.89442)$$

$$= 7.47005 - 6.52394 = 0.94611$$

[1]

$$\Rightarrow (0.975 \times 12 \times 17.299 + 0.025)P$$

$$= (1.04)^{0.5}\left[97,775 \times 0.04695 + 2,500 \times 0.94611\right]$$

$$+175,000 \times 0.27492 + 325 + 70 \times 16.631 + 8.4P$$

$$\Rightarrow 202.423P = (1.04)^{0.5}[4,590.536 + 2,365.275]$$

$$+48,111.0 + 325 + 1,164.17 + 8.4P$$

$$\Rightarrow 194.023P = 7,093.563 + 48,111.0 + 325 + 1,164.17 \Rightarrow P = 292.20$$ [½]

(ii) Gross prospective policy value (calculated at 4%) is given by:

$$V^{\text{prospective}} = 170,000\bar{A}_{63:\overline{2}|} + (0 + 300)q_{63}v^{0.5} + (2750 + 300)\,p_{63}q_{64}v^{1.5}$$

$$+5500\,{}_2p_{63}v^2 + 85\ddot{a}_{63:\overline{2}|} - 0.975 \times 12P\ddot{a}^{(12)}_{63:\overline{2}|}$$ [4]

where $B = 28 \times 0.025 \times 100,000 = 70,000$ [½]

and

$$\ddot{a}^{(12)}_{63:\overline{2}|} = \ddot{a}^{(12)}_{63} - v^2\,{}_2p_{63}\ddot{a}^{(12)}_{65}$$

$$= \left(\ddot{a}_{63} - \frac{11}{24}\right) - v^2\,{}_2p_{63}\left(\ddot{a}_{65} - \frac{11}{24}\right)$$

$$= \left(13.029 - \frac{11}{24}\right) - .92456 \times \frac{8821.2612}{9037.3973}\left(12.276 - \frac{11}{24}\right)$$

$$= 12.57067 - 0.90245 \times 11.81767 = 1.90582$$ [½]

$$\bar{A}_{63:\overline{2}|} = (1.04)^{0.5} A^{1}_{63:\overline{2}|} + v^2 \, {}_2p_{63} = (1.04)^{0.5}(0.92498 - 0.90245) + 0.90245$$

$$= 0.92543$$

[½]

$$V^{\text{prospective}} = 170,000 \times 0.92543 + 300 \times 0.011344 \times 0.98058$$

$$+3050 \times 0.98866 \times 0.012716 \times 0.94287$$

$$+5500 \times 0.90245 + 85 \times 1.951 - 0.975 \times 12 \times 292.20 \times 1.90582$$

$$= 157323.1 + 3.3371 + 36.1534 + 4963.475 + 165.835 - 6515.50$$

$$= 155,976.39$$

[½]
[Total 15]

Part (i) was generally done well. The main issue was the development of the bonus part of the formula. Part (ii) was generally less well done.

Reasonable credit was given if students showed overall understanding of the processes even if some of the calculations lacked accuracy.

Q13

Annual premium	£9000.00	Allocation % (1st yr)	80.0%
Risk discount rate	6.5%	Allocation % (2nd yr)	100.0%
Interest on investments (1st yr)	4.5%	Allocation % (3rd yr)	100.0%
Interest on investments (2nd yr)	4.0%	B/O spread	5.0%
Interest on investments (3rd yr)	3.5%	Management charge	1.5%
Interest on non-unit funds	2.0%	Surrender penalty (1st yr)	£600
Death benefit (% of bid value of units)	125%	Surrender penalty (2nd yr)	£300
		Policy Fee	£25

	£	*% prem*
Initial expense	220	30.0%
Renewal expense	75	1.5%
Expense inflation	2.0%	

(i) Using $\mu^d_{[x]+t} = -\ln\left(1 - q^d_{[x]+t}\right)$ we have:

x	t	$q^d_{[x]+t}$	μ^s_{x+t}	$\mu^d_{[x]+t}$
60	0	0.005774	0.10	0.005791
61	1	0.008680	0.05	0.008718
62	2	0.010112	0.00	0.010163

The dependent rates of decrement are calculated for each policy year using:

$$(aq)^j_x = \frac{\mu^j}{\mu^d + \mu^s}\left[1 - e^{-(\mu^d + \mu^s)}\right]$$

where *d* denotes mortality and *s* surrender

$\Rightarrow$

$$(aq)^d_{60} = \frac{\mu^d}{\mu^d + \mu^s}\left[1 - e^{-(\mu^d + \mu^s)}\right] = \frac{0.005791}{0.105791}\left[1 - e^{-(0.105791)}\right] = 0.005495$$

$$(aq)^s_{60} = \frac{\mu^s}{\mu^d + \mu^s}\left[1 - e^{-(\mu^d + \mu^s)}\right] = \frac{0.1}{0.105791}\left[1 - e^{-(0.105791)}\right] = 0.094892$$

$$(aq)^d_{61} = \frac{\mu^d}{\mu^d + \mu^s}\left[1 - e^{-(\mu^d + \mu^s)}\right] = \frac{0.008718}{0.058718}\left[1 - e^{-(0.058718)}\right] = 0.008467$$

$$(aq)^s_{61} = \frac{\mu^s}{\mu^d + \mu^s}\left[1 - e^{-(\mu^d + \mu^s)}\right] = \frac{0.05}{0.058718}\left[1 - e^{-(0.058718)}\right] = 0.048560$$ [4]

$$(aq)^d_{62} = \frac{\mu^d}{\mu^d + \mu^s}\left[1 - e^{-(\mu^d + \mu^s)}\right] = \left[1 - e^{-(0.010163)}\right] = 0.010112$$

Multiple decrement table:

x	$(aq)^d_x$	$(aq)^s_x$	(ap)	${}_{t-1}(ap)$
60	0.005495	0.094892	0.899613	1.000000
61	0.008467	0.048560	0.942973	0.899613
62	0.010112	0.000000	0.989888	0.848310

Unit fund (per policy at start of year)

	yr 1	*yr 2*	*yr 3*	
value of units at start of year	0.000	7021.026	15926.629	
alloc	7180.000	8975.000	8975.000	
B/O	359.000	448.750	448.750	
interest	306.945	621.891	855.851	
management charge	106.919	242.538	379.631	
value of units at year end	7021.026	15926.629	24929.099	
				[3]

Cash flows (per policy at start of year)

	yr 1	*yr 2*	*yr 3*	
unallocated premium + pol fee	1820.000	25.000	25.000	
B/O spread	359.000	448.750	448.750	
expenses	2920.000	211.500	213.030	
interest	–14.820	5.245	5.214	
man charge	106.919	242.538	379.631	
extra death benefit	9.645	33.712	63.021	
surrender penalty	56.935	14.568	0.000	
end of year cashflow / profit vector	–601.611	490.888	582.545	
				[4]

probability in force	1	0.899613	0.848310	
discount factor	0.938967	0.881659	0.827849	
expected p.v. of profit	233.56			[1½]
premium signature	9000.000	7602.362	6731.287	
expected p.v. of premiums	23333.649			[1½]
profit margin	1.00%			[1]

(ii) The non unit fund cash flows that change are:

	yr1	*yr2*	*yr3*
extra death benefit	10.135	34.561	-
surrender penalty	0	0	-

Multiple decrement table becomes:

x	$(aq)_x^d$	$(aq)_x^s$	(ap)	$_{t-1}(ap)$
60	0.005774	0	0.994226	1.000000
61	0.008680	0	0.991320	0.994226
62	0.010112	0	0.989888	0.985596

[2]

Revised profit vector (–659.036, 475.472, 582.545) [1]

Revised profit signature (–659.036, 472.727, 574.154) [½]

Revised PVFNP = –618.813 + 416.784 + 475.313 = 273.284 [½]
[Total 19]

This question was done well by those students who had prepared.

Again partial credit was given to students who understood the processes where calculations were not always accurate.

Students should note that the use of the approximation $(aq)_x^d = q_x^d(1 - \frac{1}{2}q_x^s)$ is no longer in the core reading and has been replaced by the force of mortality version.

END OF EXAMINERS' REPORT