INSTITUTE AND FACULTY OF ACTUARIES

EXAMINERS' REPORTS

September 2019

Subject CM1A - Actuarial Mathematics

Introduction

The Examiners' Report is written by the Chief 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.

Mike Hammer
Chair of the Board of Examiners
September 2019

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

1. CM1 provides a grounding in the principles of modelling as applied to actuarial work - focusing particularly on deterministic models which can be used to model and value known cashflows as well as those which are dependent on death, survival, or other uncertain risks.

2. Please note that different answers may be obtained to those shown in these solutions depending on whether figures obtained from tables or from calculators are used in the calculations but candidates are not penalised for this. However, candidates may lose marks where excessive rounding has been used or where insufficient working is shown.

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

1. The comments that follow the questions concentrate on areas where candidates could have improved their performance. Where no comment is made, the question was generally answered well by most candidates. The examiners look most closely at the performance of the candidates close to the pass mark and the comments therefore often relate to those candidates.
2. This was a new large subject which was broadly a merging of the old CT1 and CT5 subjects. To an even greater extent than in April, there appeared to be a large number of ill-prepared candidates who had underestimated the quantity of study required for the new larger subject. However, given this is a new subject, it is difficult to compare the performance of candidates in this diet with those in previous years.

C. Pass Mark

The Pass Mark for this exam in combination with CM1B was 55

Q1

An income protection insurance contract pays an income to the policyholder [½]
while that policyholder is deemed as being 'sick'. [½]
The definition of sickness will be carefully specified in the policy conditions. [½]

If the policyholder recovers, the cover under the policy usually continues, so that subsequent bouts of qualifying sickness would merit further benefit payments. [1]

Such policies are usually subject to a deferred period (e.g. three months) of continuous sickness that has to have elapsed before any benefits start to be paid, and during which no benefit is payable. [1]

Premiums for these policies would normally be regular (e.g. monthly) or single premium [½]

Premiums would typically be waived during periods of qualifying sickness. This means that premiums would not be paid at the same time as benefits are payable. [1]

Off-period [½]
Benefit linked to salary [½]
Benefit can be converted to lump-sum on permanent disability [½]
Term of policy (e.g. ceases at retirement) [½]
[½ each]
[Marks available 7, maximum 4]

This question was generally poorly answered. Many candidates did not seem able to distinguish between income protection contracts and other health-based contracts e.g. critical illness.
Even candidates who identified the correct policy type appeared to struggle to make enough points (e.g. deferred periods, waiver of premiums were mentioned by few candidates)

Q2

Develop a well-defined set of objectives which need to be met by the results of the data analysis. [1]
Identify the data items required for the analysis. [1]
Collection of the data from appropriate sources. [1]
Processing and formatting data for analysis, e.g. inputting into a spreadsheet, database or other model. [1]
Cleaning data, e.g. addressing unusual, missing or inconsistent values. [1]
(Also ensure that legal requirements / professional guidance requirements are satisfied) [1]
[Marks available 6, maximum 5]

Many candidates scored well on this question although a significant minority of candidates failed to score any marks at all. Some candidates wasted time in describing the whole data analysis process.

Q3

(i)

The probability that, of two lives aged 40, one particular life dies first and the death occurs between 5 and 22 years from now (i.e. between age 45 and 62). [2]

(ii)

$$
\begin{aligned}
{}_{5|17}q^{1}_{40:40} &= \tfrac{1}{2} \times {}_{5|17}q_{40:40} \\
&= \tfrac{1}{2} \times \left[{}_{5}P_{40:40} (1 - {}_{17}P_{45:45}) \right] \\
&= \tfrac{1}{2} \left({}_{5}p_{40}^{2} - {}_{22}p_{40}^{2} \right)
\end{aligned}
$$

[1½]

$$
\begin{aligned}
\text{and } {}_{t}p_{x} &= e^{-\int_0^t \mu_{x+s} ds} \\
&= e^{-\int_0^t 0.01 ds} \\
&= e^{-0.01t}
\end{aligned}
$$

[1]

$$
\begin{aligned}
\Rightarrow {}_{5|17}q^{1}_{40:40} &= \tfrac{1}{2}\left[(e^{-0.05})^2 - (e^{-0.22})^2 \right] \\
&= \tfrac{1}{2}[0.9048374 - 0.6440364] \\
&= 0.13040
\end{aligned}
$$

[1½]

Alternative solution:

$$
\int_5^{22} {}_{t}p_{40}\, {}_{t}p_{40} \mu_{40+t} dt
$$

[2]

$$
= \int_5^{22} e^{-0.02t} 0.01 dt
$$

$$
= \frac{1}{2}\left[e^{-0.02t} \right]_{22}^{5}
$$

[1]

$$
= \frac{1}{2}\left(e^{-0.1} - e^{-0.44} \right) = 0.13040
$$

[1]

[Marks available, maximum 6]

Part (i) was answered well. Part (ii) was answered well by the strongest candidates but others struggled to make much headway. In questions such as these, it is helpful to remember the integral form of joint lives probabilities as this can be the a quicker way to solve the problem without the need to remember specific formulas

A common error, using the first methodology above, was to exclude the '½' factor.

Q4

Properties include:

- Size/volume, not only does big data include a [½]
    - very large number of individual cases, but each [½]
    - might include very many variables, [½]
    - a high proportion of which might have empty (or null) values - leading to sparse data; [½]

[Maximum 1½]

- Speed/velocity, the data to be analysed [½]
    - might be arriving in real time at a very fast rate - [½]
    - for example, from an array of sensors taking measurements thousands of times every second; [½]

- variety, big data is [½]
    - often composed of elements from many different sources [½]
    - which could have very different structures - [½]
    - or is often largely unstructured [½]

[Maximum 1½]

- reliability/veracity, given the above three characteristics [½]
    - we can see that the reliability of individual data elements might be difficult to ascertain [½]
    - and could vary over time (for example, an internet connected sensor could go offline for a period) [½]

[Marks available 7, maximum 5]

Generally poorly answered except by the strongest candidates.

Q5
(i)
(a)
Equation of value at time 0 is [1]

$$P \times \ddot{a}_x = A_x$$

(b)
Prospective reserve at time is given by [1]

$${}_tV_x^P = A_{x+t} - P \times \ddot{a}_{x+t}$$

(c)
Retrospective reserve at time t is given by [1]

$$\frac{(1+i)^t}{{}_tp_x}\left(P \times \ddot{a}_{x:\overline{t}|} - A^{1}_{x:\overline{t}|}\right)$$

(ii)

$$\begin{aligned}
{}_tV_x^P &= A_{x+t} - P \times \ddot{a}_{x+t} \\
&= A_{x+t} - \underbrace{P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times {}_{t|}\ddot{a}_x}_{\left[\frac{1}{2}\right]} \underbrace{- P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times \ddot{a}_{x:\overline{t}|} + P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times \ddot{a}_{x:\overline{t}|}}_{\left[\frac{1}{2}\right]} \\
&= P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times \ddot{a}_{x:\overline{t}|} - P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times \underbrace{\left(\ddot{a}_{x:\overline{t}|} + {}_{t|}\ddot{a}_x\right)}_{\left[\frac{1}{2}\right]} + A_{x+t} \\
&= P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times \ddot{a}_{x:\overline{t}|} - \frac{l_x}{l_{x+t}} \times (1+i)^t \times P \times \underbrace{\ddot{a}_{x+t}}_{\left[\frac{1}{2}\right]} + A_{x+t} \\
&= P \times \frac{l_x}{l_{x+t}} \times (1+i)^t \times \ddot{a}_{x:\overline{t}|} \underbrace{- \frac{l_x}{l_{x+t}} \times (1+i)^t \times \left(\underbrace{A_x}_{[0.5]} - \frac{l_{x+t}}{l_x} \times v^t \times A_{x+t}\right)}_{\left[\frac{1}{2}\right]} \\
&= \underbrace{\frac{l_x}{l_{x+t}} \times (1+i)^t \times \left(P \times \ddot{a}_{x:\overline{t}|} - \underbrace{A^{1}_{x:\overline{t}|}}_{[0.5]}\right)}_{\left[\frac{1}{2}\right]} = {}_tV_x^R
\end{aligned}$$

[4]
[Total 7]

> *Part (a) was well answered although many candidates included an endowment assurance expression within the formula for the retrospective reserve rather than a term assurance. This caused problems when trying to manipulate part (b).*
>
> *A valid alternative approach to part (b) was to start directly from the premium equation.*

Q6
(i)

$$v(1) = \frac{1}{1.04} = 0.961538$$ [½]

$$v(2) = \frac{1}{1.04 \times 1.05} = 0.915751$$ [1]

$$v(3) = \frac{1}{1.04 \times 1.05 \times 1.06} = 0.863916$$ [1]

$$v(4) = \frac{1}{1.04 \times 1.05 \times 1.06 \times 1.07} = 0.807398$$ [½]

$$\text{Then price} = 4\left(v(1) + v(2) + v(3) + v(4)\right) + 100v(4) = 94.9342$$ [½]

Find i such that: [1]

$$94.9342 = 4a_{\overline{4}|} + 100v^4$$
$$Try\ i = 5\% \qquad RHS = 96.4540$$
$$Try\ i = 5.5\% \qquad RHS = 94.7423$$
$$i = 0.05 + \left(\frac{96.4540 - 94.9342}{96.4540 - 94.7423}\right) \times 0.005$$
$$= 5.444\%\ \text{pa}$$ [1½]

(ii)
The forward rates are increasing with term. [1]
The gross redemption yield is a weighted average of those increasing rates. [1]
It is therefore lower than the 1-year yield forward rate $f_{3,1}$. [1]
[Total 10]

Part (i) was answered well although some candidates did not appreciate the need to calculate the price of the bond in order to calculate the gross redemption yield.
Part (ii) was poorly answered by marginal candidates as this calls for a good understanding of how gross redemption yield relates to forward rates. Note that marks are available for apparently obvious observations e.g. 'forward rates are increasing with term'.

Q7
(i)
Let P denote the level annual premium.
Then, we have:

$$P \times \ddot{a}^{4\%}_{45:\overline{20}|} = (20{,}000 - 2{,}000) \times A^{4\%}_{45} + 2{,}000 \times (IA)^{4\%}_{45}$$

$$\Rightarrow \quad P = \frac{18{,}000 \times 0.27605 + 2{,}000 \times 8.33628}{13.780}$$

$$= 1{,}570.50$$

[2]

We need the reserve at the end of 2018 (i.e. at time 17), when the lives are age 62. [1]
The benefit on death in 2019 (i.e. year 18) is (20,000−2,000) + 18×2,000=54,000. [1]
Thus, the reserve at time 17 is given by:

$${}_{17}V = 52{,}000 \times A_{62} + 2{,}000 \times (IA)_{62} - P \times \ddot{a}_{62:\overline{3}|} = 37{,}121.06$$

[2]

Benefit on death during 2018 is 52,000, so that we have $DSAR = SA - {}_{17}V = 14{,}878.94$. [1]

Then, we have:

$EDS = 378 \times q_{61} \times 14{,}878.94 = 50{,}668.77$ where $q_{61} = 0.009009$ [1]

and $ADS = 4 \times 14{,}878.94 = 59{,}515.76$ [½]

Hence, mortality profit for 2018 is $EDS - ADS = -8{,}846.99$. [½]

(ii)
For a whole life assurance policy early deaths lead to losses for the company. [1]
A loss has arisen here as there were more deaths than expected.
Actual deaths = 4 compared with expected deaths of 0.009009 x 378 =3.4054 [2]

[Total 12]

Generally answered well. Common errors in part (i) included calculating the reserve for the wrong time period and/or calculating the wrong death benefit for that period.

Q8

(i)

Is there a Capital gain?

$$i^{(2)} = 2\left(1.08^{1/2} - 1\right) = 7.846\%$$ [1]

$$\frac{D}{R}(1-t) = \frac{9}{1.1} \times 0.85 = 6.955\%$$ [1]

$$i^{(2)} \geq \frac{D}{R}(1-t) \Rightarrow \text{Capital gain}$$

And so loan will be assumed to be redeemed as late as possible since that is worst case scenario for the investor. [1]

Working per £100 nominal

$$\text{Price} = 0.85 \times 9a_{\overline{25}|}^{(2)} + 110v^{25} \quad \text{at } 8\%$$

$$= 83.264 + 16.062$$ [1]

$$= £99.326 \text{ per £100 nominal} = £993,260 \text{ for whole loan}$$ [1]

(ii)

(a)

Price paid is P per £100 nominal where:

$$99.326 = 0.85 \times 9a_{\overline{10}|}^{(2)} + Pv^{10} \quad \text{at } 8\%$$ [1½]

$$\Rightarrow P = \left(99.326 - 52.339\right) \times 1.08^{10} = £101.441 \text{ per £100 nominal}$$

$$= £1,014,410 \text{ for whole loan}$$ [1½]

Alternative solution

$$\text{Price} = 0.85 \times 9a_{\overline{15}|}^{(2)} + 110v^{15} = 101.44 \quad \text{at } 8\%$$

(b)

Net redemption yield is i where:

R > P→ CGT → worst case scenario redeem as late as possible [½]

$$101.441 = 0.75 \times 9a_{\overline{15}|}^{(2)} + 110v^{15} - 0.35 \times \left(110 - 101.441\right)v^{15} \quad \text{at } i$$

$$i = 7\% \Rightarrow RHS = 101.319$$

$$i = 6\% \Rightarrow RHS = 111.176$$

Interpolating gives $i = 7.0\%$

[2½]

[3]

[Marks available 14, maximum 11]

Part (i) was answered well, although some candidates neglected to test whether there would be a capital gain.

Some candidates did not appreciate that the bond should be assumed to be redeemed as late as possible as that is the worst case scenario for the investor. As the redemption choice is outside the investor's control the investor must assume that it is redeemed at the worst time possible.

In part (b) many candidates struggled to recognise what cashflows were paid/received by each of the two investors and hence failed to formulate the equations of value.

Q9 Let P denote the single premium payable at age 60.

Then, equation of value is given by:

$$P = \underbrace{250+(20{,}000+12\times10)\times\left(a_{\overline{5}|}^{(12)}+\underbrace{v^5\times{}_5p_{60}\times a_{65}^{(12)}}_{\text{PMA92C20}}\right)}_{\text{EPV of benefit payable to husband (including annuity expenses)}}$$
$$+(10{,}000+12\times10)\times\left[\underbrace{v^5\times{}_5p_{60:58}\times a_{65|63}^{(12)}}_{\substack{\text{EPV of reversionary annuity}\\ \text{assuming both lives survive}\\ \text{to end of guaranteed period}}}+\underbrace{v^5\times(1-{}_5p_{60})\times{}_5p_{58}\times a_{63}^{(12)}}_{\substack{\text{but, if husband dies during guaranteed period}\\ \text{then EPV of benefit after end of guaranteed}\\ \text{period is based on single-life annuity for wife}}}\right]$$

[1 for expenses + 2 for benefit to husband + 3 for benefit to wife]

Then, using 4% per annum interest, we have:

$$a_{\overline{5}|}^{(12)}=\frac{i}{i^{(12)}}\times a_{\overline{5}|}=1.018204\times4.4518=4.532841 \qquad [½]$$

using PMA92C20, we have:

$$v^5\times{}_5p_{60}=0.82193\times\frac{9{,}647.797}{9{,}826.131}=0.807013 \qquad [½]$$

using PMA92C20, we have:

$$a_{65}^{(12)}=\ddot{a}_{65}-\frac{12+1}{24}=13.666-\frac{13}{24}=13.124333 \qquad [½]$$

using PMA92C20/PFA92C20, we have:

$${}_5p_{60:58}={}_5p_{60}\times{}_5p_{58}=\frac{9{,}647.797}{9{,}826.131}\times\frac{9{,}775.888}{9{,}881.764}=0.971331 \qquad [½]$$

using PMA92C20/PFA92C20, we have:

$$a_{65|63}^{(12)}=a_{63}^{(12)}-a_{65:63}^{(12)}=\left(\ddot{a}_{63}-\frac{13}{24}\right)-\left(\ddot{a}_{65:63}-\frac{13}{24}\right)=15.606-12.282=3.324 \qquad [1½]$$

using PFA92C20, we have:

$$a_{63}^{(12)} = \ddot{a}_{63} - \frac{13}{24} = 15.606 - \frac{13}{24} = 15.064333$$ [½]

Thus, we have:

$$\begin{aligned} P &= 250 + 20{,}120 \times (4.532841 + 0.807013 \times 13.124333) \\ &\quad + 10{,}120 \times \left[\begin{array}{l} 0.82193 \times 0.971331 \times 3.324 \\ +0.82193 \times \left(1 - \dfrac{9{,}647.797}{9{,}826.131}\right) \times \dfrac{9{,}775.888}{9{,}881.764} \times 15.064333 \end{array} \right] \\ &= 250 + 304{,}301.89 + 29{,}105.91 \\ &= £333{,}657.80 \end{aligned}$$

[1]
[Total 11]

This was a challenging questions and few candidates correctly incorporated all the components required. Marginal candidates would have benefited from breaking down each component of the benefit and the expenses and from showing more detailed working. This would have added greater clarity to their attempts and may well have led to greater marks for some partially correct solutions.

Q10

(i)

$$10A(0,6) = 10 \times \exp\left(\int_0^6 \delta(t)\,dt\right)$$ [½]

$$= 10 \times \exp\left(\int_0^4 (0.03 + 0.01t)\,dt + \int_4^6 0.07\,dt\right)$$ [1]

$$= 10 \times \exp\left[\left[0.03t + \frac{0.01}{2}t^2\right]_{t=0}^{t=4} + (0.07 \times 6 - 0.07 \times 4)\right]$$ [1]

$$10\exp(0.20 + 0.14) = 14.0495$$ [½]

(ii)

Present value is given by:

$$\int_4^{10} 5v(t)\,dt \text{ where } v(t) = \exp\left(-\int_0^t \delta(s)\,ds\right)$$ [0.5 for integral + 0.5 for {4 to10}]

Then, for $4 \le t < 6$, we have:

$$\begin{aligned} v(t) &= \exp\left[-\left(\int_0^4 (0.03+0.01s)\,ds + \int_4^t 0.07\,ds\right)\right] \\ &= \exp\left[-\left(\left[0.03s+\frac{0.01}{2}s^2\right]_{s=0}^{s=4} + \left[0.07s\right]_{s=4}^{s=t}\right)\right] \\ &= \exp\left[-\left(0.20+\left[0.07t-0.28\right]\right)\right] \\ &= \exp\left(-0.07t+0.08\right) \end{aligned}$$

[1½]

And, for $t \ge 6$, we have:

$$\begin{aligned} v(t) &= \exp\left[-\left(\int_0^4 (0.03+0.01s)\,ds + \int_4^6 0.07\,ds + \int_6^t 0.09\,ds\right)\right] \\ &= \exp\left[-\left(0.20+\left[0.07\times 6-0.07\times 4\right]\right)+\left[0.09s\right]_{s=6}^{s=t}\right] \\ &= \exp\left[-\left(0.34+\left[0.09t-0.54\right]\right)\right] \\ &= \exp\left(-0.09t+0.20\right) \end{aligned}$$

[1½]

Thus, present value is given by:

$$\begin{aligned} & 5\times\int_4^6 e^{-0.07t+0.08}\,dt + 5\times\int_6^{10} e^{-0.09t+0.20}\,dt \\ &= 5e^{0.08}\times\left[\frac{e^{-0.07t}}{-0.07}\right]_{t=4}^{t=6} + 5e^{0.20}\times\left[\frac{e^{-0.09t}}{-0.09}\right]_{t=6}^{t=10} \\ &= \frac{5e^{0.08}}{0.07}\times\left(e^{-0.28}-e^{-0.42}\right)+\frac{5e^{0.20}}{0.09}\times\left(e^{-0.54}-e^{-0.90}\right) \\ &= 7.6400+11.9547 \\ &= 19.5947 \end{aligned}$$

[2]

(iii)

We need to find i such that:

$$19.5947 = 5\left(\bar{a}_{\overline{10}|}-\bar{a}_{\overline{4}|}\right)$$

[1]

Thus, we have:

$$\left.\begin{array}{lll} \text{try } i=6\% & \Rightarrow & RHS=20.0536 \\ \text{try } i=7\% & \Rightarrow & RHS=18.8112 \end{array}\right\} \Rightarrow i \approx 0.06+(0.07-0.06)\times\frac{20.0536-19.5947}{20.0536-18.8112}=0.0637$$

Hence, to nearest 0.1%, equivalent effective rate of interest is 6.4% per annum. [2]

[Total 12]

Part (i) was answered well. Common errors in part (ii) included • *assuming that a single payment was being valued rather than a continuous payment stream.* • *the force of interest was 0.07 throughout the entire annuity payment.* *Candidates who made an error in part (ii) often used the correct methodology in part (iii) and they were awarded full credit.*

Q11

(i)

All functions are valued at 6% per annum unless otherwise noted.

<u>Value of Premiums</u>

Let P be the monthly premium, then the value of future premiums is given by

$$=12P\ddot{a}^{(12)}_{[50]:\overline{25|}}=12P\left(\ddot{a}_{[50]}-\frac{11}{24}-\frac{v^{25}l_{75}}{l_{[50]}}\left(\ddot{a}_{75}-\frac{11}{24}\right)\right)$$

$$=12P\left(14.051-\frac{11}{24}-\frac{(0.232999)6879.1673}{9706.0977}\left(7.679-\frac{11}{24}\right)\right)$$

$$=12P\left(14.051-\frac{11}{24}-0.165137\left(7.679-\frac{11}{24}\right)\right)$$

$$=12P(12.400)=148.803P$$

[2]

<u>Value of benefits</u>

$$150000\left(A_{[50]}+0.015(IA)_{[50]}\right)$$

$$=150000(0.20463+0.015\times 4.84789)$$

$$=30,695+10,908=41,603$$

[1½]

Value of Commission

$$12P\left(0.25+0.025\left(\ddot{a}^{(12)}_{[50]:\overline{25|}}-\tfrac{1}{12}\right)\right)$$

$$=12P\left(0.25+0.025\left(12.400-\tfrac{1}{12}\right)\right)=6.6951P$$

[1]

<u>Value of Expenses</u>

Renewal expenses:

Calculating at an interest rate given by

$$1+i'=\frac{1.06}{1.0192308}=1.04$$

i.e. at $i'\% = 4\%$ [1]

$\Rightarrow$ EPV of renewal expenses = $75\ddot{a}^{4\%}_{[50]}$ [½]

Claim expenses:
If we assume first inflation increase occurs at same time as claim is paid (and so claim expense at end of year 1 would be £50 x 1.0192308) then

$EPV \quad = 50A_{[50]} \qquad @4\%$ [1]

So total expenses:

$300 + 75\ddot{a}^{4\%}_{[50]} + 50A^{4\%}_{[50]}$

$= 300 + 75 \times 17.454 + 50 \times 0.32868$

$= 1625.19$ [1½]

Thus, monthly premium is given by

$148.803P = 41,603 + 6.6951P + 1,625.19$

$\Rightarrow P = \dfrac{43228}{142.108}$

$\Rightarrow P = 304.19$

Thus, the monthly premium is approximately £304 (not £303 as shown in question). [½]

(ii)
All functions valued at 4%.
At the end of the 24th policy year the sum assured payable is equal to:
150,000(1+24×0.01) = 186,000 [1]

<u>EPV of future benefits</u>:

$186,000A_{74} + 150,000 \times 0.0075(IA)_{74}$

$= 186,000(0.65824) + 150,000 \times 0.0075(6.50913)$

$= 122,432.64 + 7,322.77 = 129,755.41$ [2]

<u>EPV of Future Premiums</u>:

$$12P\left(\ddot{a}_{74:\overline{1}|} - \left(\frac{11}{24}\right) \times \left(1 - \frac{v\, l_{75}}{l_{74}}\right)\right)$$

$$= 12P\left(1 - \left(\frac{11}{24}\right) \times \left(1 - \frac{6879.1673}{1.04(7150.2401)}\right)\right)$$

$$= 12P\left(1 - \left(\frac{11}{24}\right) \times (1 - 0.92509)\right) = 11.588P = 11.588 \times 304.19 = 3,525$$ [2]

<u>EPV of Commission</u>:

$$12P\left(0.025\ddot{a}^{(12)}_{74:\overline{1}|}\right)$$

$$=12P\left(0.025\ddot{a}^{(12)}_{74:\overline{1}|}\right)=11.588P\times 0.025=0.290P=88.22$$

[1]

<u>EPV of Expenses</u>:

$$125\ddot{a}_{74}+75A_{74}$$

$$=125\times 8.886+75\times 0.65824=1{,}160.12$$

[1]

Therefore, the gross prospective reserve at the end of the 24th policy year is given by:
129,755+88+1,160-3,525=127,478
i.e. £127,478 [1]

[Total 17]

Using the standard approximations, the premium to the nearest £ was £304 rather than the £303 as stated in the question. Allowance was made for candidates who appeared to have an answer of £304 but then spent time trying to adjust this answer. However, few marginal candidates appeared to have been affected. Candidates who used £303 in part (b) were given full credit. Full credit was also given to candidates who assumed the first inflation increase occurred after the first year so that the claim expense at the end of the first year would be £50.
In general part (i) of this question generated clearer attempts by candidates (e.g. when compared to Q9). Attempts to part (ii) were less clear possibly due to time pressure.

END OF MARKING SCHEDULE

