



Society of Actuaries



Canadian Institute of
Actuaries

Exam MLC Models for Life Contingencies

Tuesday,
November 5, 2013
8:30 a.m. – 11:45 a.m.

MLC

INSTRUCTIONS TO CANDIDATES

1. Write your candidate number here _____. Your name must not appear.
2. Do not break the seal of this book until the supervisor tells you to do so.
3. Tables and numerical values necessary for solving some of the questions on this examination will be distributed by the Supervisor.
4. This examination consists of 25 multiple-choice questions.
5. Each question has equal weight. Your score will be based on the number of questions which you answer correctly. No credit will be given for omitted answers and no credit will be lost for wrong answers; hence, you should answer all questions even those for which you have to guess.
6. A separate answer sheet is inside the front cover of this book. During the time allotted for this examination, record all your answers on the back of the answer sheet. **NO ADDITIONAL TIME WILL BE ALLOWED FOR THIS PURPOSE.** No credit will be given for anything indicated in the examination book but not transferred to the answer sheet. Failure to stop writing or coding your answer sheet after time is called will result in the disqualification of your answer sheet or further disciplinary action.
7. Five answer choices are given with each question, each answer choice being identified by a key letter (A to E). Answer choices for some questions have been rounded. For each question, blacken the circle on the answer sheet which corresponds to the key letter of the answer choice that you select.
8. Use a soft-lead pencil to mark the answer sheet. To facilitate correct mechanical scoring, be sure that, for each question, your pencil mark is dark and completely fills only the intended circle. Make no stray marks on the answer sheet. If you have to erase, do so completely.
9. Do not spend too much time on any one question. If a question seems too difficult, leave it and go on.
10. While every attempt is made to avoid defective questions, sometimes they do occur. If you believe a question is defective, the supervisor or proctor cannot give you any guidance beyond the instructions on the exam booklet.
11. Clearly indicated answer choices in the test book can be an aid in grading examinations in the unlikely event of a lost answer sheet.
12. Use the blank portions of each page for your scratch work. Extra blank pages are provided at the back of the examination book.
13. When the supervisor tells you to do so, break the seal on the book and remove the answer sheet.

On the front of the answer sheet, space is provided to write and code candidate information. Complete the information requested by printing in the squares and blackening the circles (one in each column) corresponding to the letters or numbers printed. For each empty box blacken the small circle immediately above the "A" circle. Fill out the boxes titled:
 - (a) Name
(include last name, first name and middle initial)
 - (b) Candidate Number
(Candidate/Eligibility Number, use leading zeros if needed to make it a five digit number)
 - (c) Test Site Code
(the supervisor will supply the number)
 - (d) Examination Part
(Code the examination that you are taking by blackening the circle to the left of "Exam MLC")
 - (e) Booklet Number
(booklet number can be found in the upper right-hand corner of this examination book. Use leading zeros if needed to make it a four digit number.)

In box titled "Complete this section only if instructed to do so", fill in the circle to indicate if you are using a calculator and write in the make and model number.

In the box titled "Signature and Date" sign your name and write today's date. **If the answer sheet is not signed, it will not be graded.**

Leave the boxes titled "Test Code" and "Form Code" blank.

On the back of the answer sheet fill in the Booklet Number in the space provided.
14. After the examination, the supervisor will collect this book and the answer sheet separately. **DO NOT ENCLOSE THE ANSWER SHEET IN THE BOOK.** All books and answer sheets must be returned. **THE QUESTIONS ARE CONFIDENTIAL AND MAY NOT BE TAKEN FROM THE EXAMINATION ROOM.**

****BEGINNING OF EXAMINATION****

1. You are given:

(i) $A_x = 0.30$

(ii) $A_{x+n} = 0.40$

(iii) $A_{\overline{x:n}|} = 0.35$

(iv) $i = 0.05$

Calculate $a_{\overline{x:n}|}$.

(A) 9.3

(B) 9.6

(C) 9.8

(D) 10.0

(E) 10.3

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2. For (x) and (y) with independent future lifetimes, you are given:

(i) $\bar{a}_x = 10.06$

(ii) $\bar{a}_y = 11.95$

(iii) $\bar{a}_{xy} = 12.59$

(iv) $\bar{A}_{xy}^1 = 0.09$

(v) $\delta = 0.07$

Calculate \bar{A}_{xy}^1 .

(A) 0.15

(B) 0.20

(C) 0.25

(D) 0.30

(E) 0.35

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3. You are given:

- (i) An excerpt from a select and ultimate life table with a select period of 2 years:

x	$l_{[x]}$	$l_{[x]+1}$	l_{x+2}	$x+2$
50	99,000	96,000	93,000	52
51	97,000	93,000	89,000	53
52	93,000	88,000	83,000	54
53	90,000	84,000	78,000	55

- (ii) Deaths are uniformly distributed over each year of age.

Calculate $10,000 \cdot {}_{2.2}q_{[51]+0.5}$.

- (A) 705
(B) 709
(C) 713
(D) 1070
(E) 1074

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4. In a homogeneous Markov model with three states: Healthy (H), Sick (S), and Dead (D), you are given:

- (i) The monthly transition probabilities are:

$$\begin{array}{c} \text{H} \\ \text{S} \\ \text{D} \end{array} \begin{pmatrix} \text{H} & \text{S} & \text{D} \\ 0.75 & 0.20 & 0.05 \\ 0.30 & 0.50 & 0.20 \\ 0.00 & 0.00 & 1.00 \end{pmatrix}$$

- (ii) Initially there are 10 Healthy lives with independent future states.

Calculate the probability that exactly 4 lives will die during the first two months.

- (A) 0.0005
(B) 0.0245
(C) 0.1132
(D) 0.2136
(E) 0.4414

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5. Russell, age 40, wins the SOA lottery. He will receive both:

- A deferred life annuity of K per year, payable continuously, starting at age $40 + \overset{\circ}{e}_{40}$ and
- An annuity certain of K per year, payable continuously, for $\overset{\circ}{e}_{40}$ years

You are given:

- (i) $\mu = 0.02$
- (ii) $\delta = 0.01$
- (iii) The actuarial present value of the payments is 10,000.

Calculate K .

- (A) 214
- (B) 216
- (C) 218
- (D) 220
- (E) 222

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6. For a fully discrete whole life insurance of 1000 on a select life [55], you are given:

- (i) Ultimate mortality follows the Illustrative Life Table.
- (ii) During the three-year select period, $q_{[x]+k} = (0.7 + 0.1k)q_{x+k}$, $k = 0, 1, 2$.
- (iii) $i = 0.06$
- (iv) The benefit premium for this insurance is 24.453.

Calculate ${}_1V$, the benefit reserve at the end of year 1 for this insurance.

- (A) 17.1
- (B) 18.4
- (C) 19.8
- (D) 20.6
- (E) 21.6

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7. For a semi-continuous 20-year endowment insurance of 100,000 on (45), you are given:

- (i) Benefit premiums of 258 are payable monthly.
- (ii) Mortality follows the Illustrative Life Table.
- (iii) Deaths are uniformly distributed over each year of age.
- (iv) $i = 0.06$

Calculate ${}_{10}V$, the benefit reserve at the end of year 10 for this insurance.

- (A) 35,700
- (B) 35,900
- (C) 36,100
- (D) 36,300
- (E) 36,500

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- 8.** For a fully discrete whole life insurance of 100,000 on (45), you are given:
- (i) Mortality follows the Illustrative Life Table.
 - (ii) $i = 0.06$
 - (iii) Commission expenses are 60% of the first year's gross premium and 2% of renewal gross premiums.
 - (iv) Administrative expenses are 500 in the first year and 50 in each renewal year.
 - (v) All expenses are payable at the start of the year.
 - (vi) The gross premium, calculated using the equivalence principle, is 1605.72.

Calculate ${}_5V^e$, the expense reserve at the end of year 5 for this insurance.

- (A) -1400
- (B) -1350
- (C) -1300
- (D) -1250
- (E) -1200

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9. For a fully discrete 20-year term insurance of 100,000 on (50), you are given:

- (i) Gross premiums are payable for 10 years.
- (ii) Mortality follows the Illustrative Life Table.
- (iii) $i = 0.06$
- (iv) Expenses are incurred at the beginning of each year as follows:

	Year 1	Years 2-10	Years 11-20
Commission as % of premium	40%	10%	Not applicable
Premium taxes as % of premium	2%	2%	Not applicable
Maintenance expenses	75	25	25

- (v) Gross premiums are calculated using the equivalence principle.

Calculate the gross premium for this insurance.

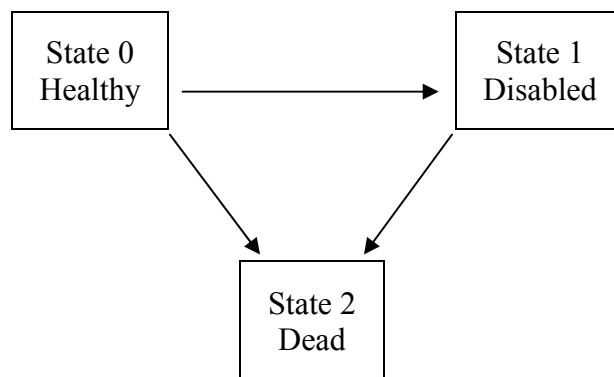
- (A) 1950
- (B) 2000
- (C) 2050
- (D) 2100
- (E) 2150

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10. For a multiple state model, you are given:

(i)



(ii) The following forces of transition:

(a) $\mu^{01} = 0.02$

(b) $\mu^{02} = 0.03$

(c) $\mu^{12} = 0.05$

Calculate the conditional probability that a Healthy life on January 1, 2004 is still Healthy on January 1, 2014, given that this person is not Dead on January 1, 2014.

(A) 0.61

(B) 0.68

(C) 0.74

(D) 0.79

(E) 0.83

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11. For a fully discrete 5-year term insurance of 100,000 on (80), you are given:

(i) $l_{80} = 1000$

(ii)

x	l_x	d_x
83	920	50
84	870	60

(iii)

Time to Maturity	Annual Spot Rate
1	0.04
2	0.04
3	0.04
4	0.05
5	0.06

(iv) The following values calculated at $i = 0.04$:

• $\ddot{a}_{80:\overline{5}|} = 4.3868$

• $A^1_{80:\overline{5}|} = 0.1655$

Calculate the annual benefit premium for this insurance.

(A) 3660

(B) 3680

(C) 3700

(D) 3720

(E) 3740

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- 12.** An insurance company sells 15-year pure endowments of 10,000 to 500 lives, each age x , with independent future lifetimes. The single premium for each pure endowment is determined by the equivalence principle.

You are given:

- (i) $i = 0.03$
- (ii) $\mu_x(t) = 0.02t, \quad t \geq 0$
- (iii) ${}_0L$ is the aggregate loss at issue random variable for these pure endowments.

Using the normal approximation without continuity correction, calculate $\Pr({}_0L > 50,000)$.

- (A) 0.08
- (B) 0.13
- (C) 0.18
- (D) 0.23
- (E) 0.28

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13. For a 3-year term insurance of 1000 on (70), you are given:

- (i) q_{70+k}^{LLT} is the mortality rate from the Illustrative Life Table, for $k = 0, 1, 2$.
- (ii) q_{70+k} is the mortality rate used to price this insurance, for $k = 0, 1, 2$.
- (iii) $q_{70+k} = (0.95)^k q_{70+k}^{LLT}$, for $k = 0, 1, 2$.
- (iv) $i = 0.06$

Calculate the single benefit premium.

- (A) 85.5
- (B) 89.0
- (C) 91.5
- (D) 93.5
- (E) 95.0

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14. For a special 10-year deferred whole life annuity-due of 50,000 on (62), you are given:

- (i) Level annual benefit premiums are payable for 10 years.
- (ii) A death benefit, payable at the end of the year of death, is provided only over the deferral period and is the sum of the benefit premiums paid without interest.
- (iii) $\ddot{a}_{62} = 12.2758$
- (iv) $\ddot{a}_{62:\overline{10}|} = 7.4574$
- (v) $A^1_{62:\overline{10}|} = 0.0910$
- (vi) $\sum_{k=1}^{10} A^1_{62:k|} = 0.4891$

Calculate the benefit premium for this special annuity.

- (A) 34,400
- (B) 34,500
- (C) 34,600
- (D) 34,700
- (E) 34,800

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15. For a fully discrete 3-year term insurance of 1000 on (x) , you are given:

- (i) $p_x = 0.975$
- (ii) $i = 0.06$
- (iii) The actuarial present value of the death benefit is 152.85.
- (iv) The annual benefit premium is 56.05.

Calculate p_{x+2} .

- (A) 0.88
- (B) 0.89
- (C) 0.90
- (D) 0.91
- (E) 0.92

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16. For fully discrete whole life insurances of 1 issued on lives age 50, the annual benefit premium, P , was calculated using the following:

(i) $q_{50} = 0.0048$

(ii) $i = 0.04$

(iii) $A_{51} = 0.39788$

A particular life has a first year mortality rate 10 times the rate used to calculate P . The mortality rates for all other years are the same as the ones used to calculate P .

Calculate the expected present value of the loss at issue random variable for this life, based on the premium P .

(A) 0.025

(B) 0.033

(C) 0.041

(D) 0.049

(E) 0.057

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17. For a fully discrete whole life insurance of 10,000 on (45), you are given:

- (i) $i = 0.05$
- (ii) ${}_0L$ denotes the loss at issue random variable based on the benefit premium.
- (iii) If $K_{45} = 10$, then ${}_0L = 4450$.
- (iv) $\ddot{a}_{55} = 13.4205$

Calculate ${}_{10}V$, the benefit reserve at the end of year 10 for this insurance.

- (A) 1010
- (B) 1460
- (C) 1820
- (D) 2140
- (E) 2300

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18. For a fully discrete whole life insurance of 1000 on (x) , you are given:

(i) The following expenses are incurred at the beginning of each year:

	Year 1	Years 2+
Percent of premium	75%	10%
Maintenance expenses	10	2

(ii) An additional expense of 20 is paid when the death benefit is paid.

(iii) The gross premium is determined using the equivalence principle.

(iv) $i = 0.06$

(v) $\ddot{a}_x = 12.0$

(vi) ${}^2A_x = 0.14$

Calculate the variance of the loss at issue random variable.

(A) 14,600

(B) 33,100

(C) 51,700

(D) 70,300

(E) 88,900

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19. For a fully discrete whole life insurance of 10,000 on (45), you are given:

- (i) Commissions are 80% of the first year premium and 10% of subsequent premiums. There are no other expenses.
- (ii) Mortality follows the Illustrative Life Table.
- (iii) $i = 0.06$
- (iv) ${}_0L$ denotes the loss at issue random variable.
- (v) If $T_{45} = 10.5$, then ${}_0L = 3767$.

Calculate $E[{}_0L]$.

- (A) -900
- (B) -810
- (C) -720
- (D) -630
- (E) -540

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- 20.** A new employee is hired at exact age 45, with a starting salary of 50,000. Salary increases occur at the end of each year. Consider the following two pension plans:
1. A defined benefit plan that pays at retirement an annual annuity-due of 1.5% of the final 3-year average salary for each year of service;
 2. A defined contribution plan that contributes $X\%$ of the employee's salary at the start of each year before retirement and earns 5% per year.

You are given:

- (i) $\ddot{a}_{65} = 10.0$
- (ii) Salary increases are 5% per year.
- (iii) The employee retires at exact age 65.
- (iv) The actuarial present value of the defined benefit annuity-due at age 65 is equal to the defined contribution account balance at age 65.

Calculate X .

- (A) 11.0
- (B) 11.7
- (C) 12.3
- (D) 13.0
- (E) 13.6

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- 21.** You are pricing an automobile insurance on (x) . The insurance pays 10,000 immediately if (x) gets into an accident within 5 years of issue. The policy pays only for the first accident and has no other benefits.

You are given:

- (i) You model (x) 's driving status as a multi-state model with the following 3 states:
0 - low risk, without an accident
1 - high risk, without an accident
2 - has had an accident
- (ii) (x) is initially in state 0.
- (iii) The following transition intensities for $0 \leq t \leq 5$:
$$\mu_{x+t}^{01} = 0.20 + 0.10t$$
$$\mu_{x+t}^{02} = 0.05 + 0.05t$$
$$\mu_{x+t}^{12} = 0.15 + 0.01t^2$$
No other transitions are possible.
- (iv) ${}_3p_x^{01} = 0.4174$
- (v) $\delta = 0.02$
- (vi) The continuous function $g(t)$ is such that the expected present value of the benefit up to time a equals $\int_0^a g(t)dt$, $0 \leq a \leq 5$, where t is the time of the first accident.

Calculate $g(3)$.

- (A) 1400
(B) 1500
(C) 1600
(D) 1700
(E) 1800

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22. For a universal life policy with a death benefit of 10,000 plus the account value on (60), you are given:

(i)

Month	Monthly Premium	Percent of Premium Charge	Monthly Cost of Insurance Rate per 1000	Monthly Expense Charges	Surrender Charge
12	100	15%	3.00	10	400

(ii) The credited interest rate is $i^{(12)} = 0.048$.

(iii) The account value at the end of month 11 is 1500.

The universal life policy is surrendered at the end of month 12. The cash surrender value is used as a single premium to purchase a whole life annuity-due whose first 10 annual payments are guaranteed. For this annuity, you are given:

(i) Mortality follows the Illustrative Life Table.

(ii) $i = 0.06$

(iii) The annuity is priced using the equivalence principle.

Calculate the amount of the annual annuity payment.

(A) 97

(B) 100

(C) 103

(D) 106

(E) 109

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23. For a universal life policy with a death benefit of 150,000 plus the account value on (25), you are given:

(i)

Year	Annual Premium	Percent of Premium Charge	Annual Cost of Insurance Rate per 1000	Annual Expense Charges	End of Year Account Value
1	3000	70%	1.22	75	-
2	3000	10%	1.27	R	-
3	3000	10%	1.33	R	6028.95

(ii) The credited interest rate is $i = 0.04$.

Calculate R .

- (A) 5.0
- (B) 7.5
- (C) 10.0
- (D) 12.5
- (E) 15.0

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- 24.** The ILT Club has 4000 members all age 25 with independent future lifetimes. The mortality for each member follows the Illustrative Life Table.

Calculate the largest N , using the normal approximation, such that the probability that there are at least N survivors at age 85 is at least 90%.

- (A) 930
- (B) 950
- (C) 970
- (D) 990
- (E) 1010

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25. You are given:

(i)

x	l_x
60	99,999
61	88,888
62	77,777
63	66,666
64	55,555
65	44,444
66	33,333
67	22,222

(ii) $a = {}_{3.4|2.5}q_{60}$ assuming a uniform distribution of deaths over each year of age.

(iii) $b = {}_{3.4|2.5}q_{60}$ assuming a constant force of mortality over each year of age.

Calculate $100,000(a - b)$.

- (A) -24
- (B) 9
- (C) 42
- (D) 73
- (E) 106

****END OF EXAMINATION****

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