Society of Actuaries

Canadian Institute of Actuaries

Exam MLC
Actuarial Models
Life Contingencies

Tuesday,
November 6, 2012
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 side 2 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 oval 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 oval. 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 side 1 of the answer sheet, space is provided to write and to code candidate information. Complete Blocks A through G as follows:

(a) in Block A, print your name and the name of this test center;

(b) in Block B, print your last name, first name and middle initial and code your name by blackening the ovals (one in each column) corresponding to the letters of your name; for each empty box, blacken the small rectangle immediately above the "A" oval;

(c) write your candidate number in Block C (as it appears on your ticket of admission for this examination) and write the number of this test center in Block D (the supervisor will supply the number);

(d) code your candidate number and center number by blackening the five ovals (one in each column) corresponding to the five digits of your candidate number and the three ovals (one in each column) corresponding to the three digits of the test center number, respectively. Please be sure that your candidate number and the test center number are coded correctly;

(e) in Block E, code the examination that you are taking by blackening the oval to the left of "Exam MLC";

(f) in Block F, blacken the appropriate oval to indicate whether you are using a calculator and write in the make and model number; and

(g) in Block G, sign your name and write today's date. If the answer sheet is not signed, it will not be graded.

On side 2 of your answer sheet, space is provided at the top for the number of this examination book. Enter the examination book number, from the upper right-hand corner of this examination book, in the four boxes at the top of side 2 marked "BOOKLET NUMBER".

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.

1. For two lives, (80) and (90), with independent future lifetimes, you are given:

k	p_{80+k}	p_{90+k}
0	0.9	0.6
1	0.8	0.5
2	0.7	0.4

Calculate the probability that the last survivor will die in the third year.

(A)   0.20

(B)   0.21

(C)   0.22

(D)   0.23

(E)   0.24

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

2. You are given:

(i) An excerpt from a select and ultimate life table with a select period of 3 years:

x	$l_{[x]}$	$l_{[x]+1}$	$l_{[x]+2}$	l_{x+3}	$x+3$
60	80,000	79,000	77,000	74,000	63
61	78,000	76,000	73,000	70,000	64
62	75,000	72,000	69,000	67,000	65
63	71,000	68,000	66,000	65,000	66

(ii) Deaths follow a constant force of mortality over each year of age.

Calculate $1000 \, _{2|3} q_{[60]+0.75}$.

(A) 104

(B) 117

(C) 122

(D) 135

(E) 142

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

3. You are given:

(i) $S_0(t) = \left(1 - \dfrac{t}{\omega}\right)^{\frac{1}{4}}$, for $0 \le t \le \omega$

(ii) $\mu_{65} = \dfrac{1}{180}$

Calculate e_{106}, the curtate expectation of life at age 106.

(A) 2.2

(B) 2.5

(C) 2.7

(D) 3.0

(E) 3.2

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

4. For a special fully discrete whole life insurance on (40), you are given:

(i)   The death benefit is 50,000 in the first 20 years and 100,000 thereafter.

(ii)   Level benefit premiums of 1116 are payable for 20 years.

(iii)   Mortality follows the Illustrative Life Table.

(iv) $i = 0.06$

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

(A)   13,340

(B)   13,370

(C)   13,400

(D)   13,430

(E)   13,460

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

5. A special fully discrete 2-year endowment insurance with a maturity value of 2000 is issued to (x). The death benefit is 2000 plus the benefit reserve at the end of the year of death. For year 2, the benefit reserve is the benefit reserve just before the maturity benefit is paid.

You are given:

(i) $i = 0.10$

(ii) $q_x = 0.150$ and $q_{x+1} = 0.165$

Calculate the level annual benefit premium.

(A) 1070

(B) 1110

(C) 1150

(D) 1190

(E) 1230

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

6. For a special fully continuous 10-year increasing term insurance, you are given:

(i) The death benefit is payable at the moment of death and increases linearly from 10,000 to 110,000.

(ii) $\mu = 0.01$

(iii) $\delta = 0.05$

(iv) The annual premium rate is 450.

(v) Premium-related expenses equal 2% of premium, incurred continuously.

(vi) Claims-related expenses equal 200 at the moment of death.

(vii) $_tV$ denotes the gross premium reserve at time t for this insurance.

(viii) You estimate $_{9.6}V$ using Euler's method with step size 0.2 and the derivative of $_tV$ at time 9.6.

(ix) Your estimate of $_{9.8}V$ is 126.68.

Calculate the estimate of $_{9.6}V$.

(A) 230

(B) 250

(C) 270

(D) 280

(E) 290

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

7. You are calculating asset shares for a universal life insurance policy with a death benefit of 1000 on (x) with death benefits payable at the end of the year of death.

You are given:

    (i)   The account value at the end of year 4 is 30.

    (ii)   The asset share at the end of year 4 is 20.

    (iii)   At the beginning of year 5:

        a. A premium of 20 is paid.

        b. Annual cost of insurance charges of 2 and annual expense charges of 7 are deducted from the account value.

    (iv)   At the beginning of year 5, the insurer incurs expenses of 2.

    (v)   All withdrawals occur at the end of the policy year; the withdrawal benefit is the account value less a surrender charge of 20.

    (vi) $q_{x+4}^{(d)} = 0.001$ and $q_{x+4}^{(w)} = 0.050$ are the probabilities of death and withdrawal, respectively.

    (vii) The annual interest rate for asset shares is 0.08; the annual interest rate credited to the universal life insurance policy is 0.06.

Calculate the asset share at the end of year 5.

(A)   39

(B)   40

(C)   41

(D)   42

(E)   43

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

8. For a universal life insurance policy with a death benefit of 50,000 plus the account value, you are given:

(i)

Policy Year	Monthly Premium	Percent of Premium Charge	Monthly Cost of Insurance Rate per 1000	Monthly Expense Charge	Surrender Charge
1	300	$W\%$	2	10	500
2	300	15%	3	10	125

(ii) The credited interest rate is $i^{(12)} = 0.054$.

(iii) The cash surrender value at the end of month 11 is 1200.00.

(iv) The cash surrender value at the end of month 13 is 1802.94.

Calculate $W\%$, the percent of premium charge in policy year 1.

(A) 25%

(B) 30%

(C) 35%

(D) 40%

(E) 45%

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

9. You are given the following about a universal life insurance policy on (60):

(i)   The death benefit equals the account value plus 200,000.

(ii)

Age x	Annual Premium	Annual Cost of Insurance Rate per 1000	Annual Expense Charges
60	5000	5.40	100
61	5000	6.00	100

(iii)   Interest is credited at 6%.

(iv)   Surrender value equals 93% of account value during the first two years. Surrenders occur at the ends of policy years.

(v)   Surrenders are 6% per year of those who survive.

(vi)   Mortality rates are $1000q_{60} = 3.40$ and $1000q_{61} = 3.80$.

(vii) $i = 7\%$

Calculate the present value at issue of the insurer's expected surrender benefits paid in the second year.

(A)   380

(B)   390

(C)   400

(D)   410

(E)   420

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

10. For a special 3-year term life insurance policy on (x) and (y) with dependent future lifetimes, you are given:

(i) A death benefit of 100,000 is paid at the end of the year of death if both (x) and (y) die within the same year. No death benefits are payable otherwise.

(ii) $p_{x+k} = 0.84366, \quad k = 0, 1, 2$

(iii) $p_{y+k} = 0.86936, \quad k = 0, 1, 2$

(iv) $p_{x+k:y+k} = 0.77105, \quad k = 0, 1, 2$

(v)

Maturity (in years)	Annual Effective Spot Rate
1	3%
2	8%
3	10%

Calculate the expected present value of the death benefit.

(A) 9,500

(B) 10,100

(C) 12,100

(D) 12,500

(E) 14,100

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

11. For a whole life insurance of 1000 on (70), you are given:

        (i)   Death benefits are payable at the end of the year of death.

        (ii)   Mortality follows the Illustrative Life Table.

        (iii)

Maturity (in years)	Annual Effective Spot Rate
1	1.6%
2	2.6%

        (iv)   For the year starting at time $k-1$ and ending at time k, $k = 3, 4, 5...,$ the one-year forward rate is 6%.

Calculate the expected present value of the death benefits.

(A)   520

(B)   530

(C)   550

(D)   570

(E)   600

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

12. A party of scientists arrives at a remote island. Unknown to them, a hungry tyrannosaur lives on the island. You model the future lifetimes of the scientists as a three-state model, where:

> State 0: no scientists have been eaten.
> State 1: exactly one scientist has been eaten.
> State 2: at least two scientists have been eaten.

You are given:

(i) Until a scientist is eaten, they suspect nothing, so
$$\mu_t^{01} = 0.01 + 0.02 \times 2^t, \quad t > 0$$

(ii) Until a scientist is eaten, they suspect nothing, so the tyrannosaur may come across two together and eat both, with
$$\mu_t^{02} = 0.5 \times \mu_t^{01}, \quad t > 0$$

(iii) After the first death, scientists become much more careful, so
$$\mu_t^{12} = 0.01, \quad t > 0$$

Calculate the probability that no scientists are eaten in the first year.

(A) 0.928

(B) 0.943

(C) 0.951

(D) 0.956

(E) 0.962

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

13. You are given:

(i) The following excerpt from a triple decrement table:

x	$l_x^{(\tau)}$	$d_x^{(1)}$	$d_x^{(2)}$	$d_x^{(3)}$
50	100,000	490	8,045	1,100
51	90,365	-	8,200	-
52	80,000	-	-	-

(ii) All decrements are uniformly distributed over each year of age in the triple decrement table.

(iii) $q_x'^{(3)}$ is the same for all ages.

Calculate $10,000 \, q_{51}'^{(1)}$.

(A) 130

(B) 133

(C) 136

(D) 138

(E) 141

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

14. For a special whole life insurance policy issued on (40), you are given:

(i) Death benefits are payable at the end of the year of death.

(ii) The amount of benefit is 2 if death occurs within the first 20 years and is 1 thereafter.

(iii) Z is the present value random variable for the payments under this insurance.

(iv) $i = 0.03$

(v)

x	A_x	$_{20}E_x$
40	0.36987	0.51276
60	0.62567	0.17878

(vi) $E\left[Z^2\right] = 0.24954$

Calculate the standard deviation of Z.

(A) 0.27

(B) 0.32

(C) 0.37

(D) 0.42

(E) 0.47

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

15. For a special 2-year term insurance policy on (x), you are given:

(i) Death benefits are payable at the end of the half-year of death.

(ii) The amount of the death benefit is 300,000 for the first half-year and increases by 30,000 per half-year thereafter.

(iii) $q_x = 0.16$ and $q_{x+1} = 0.23$

(iv) $i^{(2)} = 0.18$

(v) Deaths are assumed to follow a constant force of mortality between integral ages.

(vi) Z is the present value random variable for this insurance.
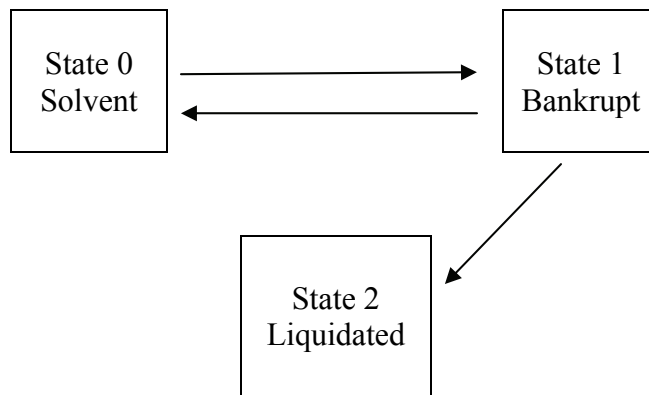
Calculate $\Pr(Z > 277,000)$.

(A)   0.08

(B)   0.11

(C)   0.14

(D)   0.18

(E)   0.21

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

16. You are evaluating the financial strength of companies based on the following multiple state model:

For each company, you assume the following constant transition intensities:

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

(ii) $\mu^{10} = 0.06$

(iii) $\mu^{12} = 0.10$

Using Kolmogorov's forward equations with step $h = 1/2$, calculate the probability that a company currently Bankrupt will be Solvent at the end of one year.

(A) 0.048

(B) 0.051

(C) 0.054

(D) 0.057

(E) 0.060

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

17. For a whole life insurance of 1000 with semi-annual premiums on (80), you are given:

    (i)   A gross premium of 60 is payable every 6 months starting at age 80.

    (ii)   Commissions of 10% are paid each time a premium is paid.

    (iii)   Death benefits are paid at the end of the quarter of death.

    (iv) $_tV$ denotes the gross premium reserve at time t.

    (v) $_{10.75}V = 753.72$

    (vi)

t	l_{90+t}
0	1000
0.25	898
0.50	800
0.75	706

    (vii) $i^{(4)} = 0.08$

Calculate $_{10.25}V$.

    (A)   680

    (B)   690

    (C)   700

    (D)   710

    (E)   730

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

18. For a special fully discrete whole life insurance on (40), you are given:

(i) The death benefit is 1000 during the first 11 years and 5000 thereafter.

(ii) Expenses, payable at the beginning of the year, are 100 in year 1 and 10 in years 2 and later.

(iii) π is the level annual premium, determined using the equivalence principle.

(iv) $G = 1.02 \times \pi$ is the level annual gross premium.

(v) Mortality follows the Illustrative Life Table.

(vi) $i = 0.06$

(vii) $_{11}E_{40} = 0.50330$

Calculate the gross premium reserve at the end of year 1 for this insurance.

(A) −70

(B) −60

(C) −50

(D) −40

(E) −30

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

19. For whole life annuities-due of 15 per month on each of 200 lives age 62 with independent future lifetimes, you are given:

(i) $i = 0.06$

(ii) $A_{62}^{(12)} = 0.4075$ and $^2A_{62}^{(12)} = 0.2105$

(iii) π is the single premium to be paid by each of the 200 lives.

(iv) S is the present value random variable at time 0 of total payments made to the 200 lives.

Using the normal approximation, calculate π such that $\Pr(200\,\pi > S) = 0.90$.

(A) 1850

(B) 1860

(C) 1870

(D) 1880

(E) 1890

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

20. Stuart, now age 65, purchased a 20-year deferred whole life annuity-due of 1 per year at age 45. You are given:

(i) Equal annual premiums, determined using the equivalence principle, were paid at the beginning of each year during the deferral period.

(ii) Mortality at ages 65 and older follows the Illustrative Life Table.

(iii) $i = 0.06$

(iv) Y is the present value random variable at age 65 for Stuart's annuity benefits.

Calculate the probability that Y is less than the actuarial accumulated value of Stuart's premiums.

(A) 0.40

(B) 0.42

(C) 0.44

(D) 0.46

(E) 0.48

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

21. For a fully continuous whole life insurance issued on (x) and (y), you are given:

(i)   The death benefit of 100 is payable at the second death.

(ii)   Premiums are payable until the first death.

(iii)   The future lifetimes of (x) and (y) are dependent.

(iv) $_t p_{xy} = \dfrac{1}{4}e^{-0.01t} + \dfrac{3}{4}e^{-0.03t}, \quad t \geq 0$

(v) $_t p_x = e^{-0.01t}, \ t \geq 0$

(vi) $_t p_y = e^{-0.02t}, \ t \geq 0$

(vii) $\delta = 0.05$

Calculate the annual benefit premium rate for this insurance.

(A)   0.96

(B)   1.43

(C)   1.91

(D)   2.39

(E)   2.86

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

22. You are given the following information about a special fully discrete 2-payment, 2-year term insurance on (80):

(i)   Mortality follows the Illustrative Life Table.

(ii) $i = 0.0175$

(iii)   The death benefit is 1000 plus a return of all premiums paid without interest.

(iv)   Level premiums are calculated using the equivalence principle.

Calculate the benefit premium for this special insurance.

(A)   82

(B)   86

(C)   90

(D)   94

(E)   98

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

23. A life insurance company issues fully discrete 20-year term insurance policies of 1000.

You are given:

        (i)   Expected mortality follows the Illustrative Life Table.

        (ii)   Death is the only decrement.

        (iii) $_3V,$ the reserve at the end of year 3, is 12.18.

On January 1, 2009, the company sold 10,000 of these policies to lives all aged 45. You are also given:

        (i)   During the first two years, there were 30 actual deaths from these policies.

        (ii)   During 2011, there were 18 actual deaths from these policies.

Calculate the company's gain due to mortality for the year 2011.

(A)   28,100

(B)   28,300

(C)   28,500

(D)   28,700

(E)   28,900

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

24. An insurance company is designing a special 2-year term insurance. Transitions are modeled as a four-state homogeneous Markov model with states:

- (H) Healthy
- (Z) infected with virus "Zebra"
- (L) infected with virus "Lion"
- (D) Death

The annual transition probability matrix is given by:

$$
\begin{array}{c}
\\
H \\
Z \\
L \\
D
\end{array}
\begin{array}{cccc}
H & Z & L & D \\
\end{array}
\left(
\begin{array}{cccc}
0.90 & 0.05 & 0.04 & 0.01 \\
0.10 & 0.20 & 0.00 & 0.70 \\
0.20 & 0.00 & 0.20 & 0.60 \\
0.00 & 0.00 & 0.00 & 1.00
\end{array}
\right)
$$

You are given:

    (i)   Transitions occur only once per year.

    (ii)   250 is payable at the end of the year in which you become infected with either virus.

    (iii)   For lives infected with either virus, 1000 is payable at the end of the year of death.

    (iv)   The policy is issued only on healthy lives.

    (v) $i = 0.05$

Calculate the actuarial present value of the benefits at policy issue.

    (A)   66

    (B)   75

    (C)   84

    (D)   93

    (E)   102

USE THIS PAGE FOR YOUR SCRATCH WORK

EXTRA BLANK PAPER IS PROVIDED AT THE END OF THE EXAM BOOK

25. For a fully discrete 10-year term life insurance policy on (x), you are given:

(i) Death benefits are 100,000 plus the return of all gross premiums paid without interest.

(ii) Expenses are 50% of the first year's gross premium, 5% of renewal gross premiums and 200 per policy expenses each year.

(iii) Expenses are payable at the beginning of the year.

(iv) $A^1_{x:\overline{10|}} = 0.17094$

(v) $(IA)^1_{x:\overline{10|}} = 0.96728$

(vi) $\ddot{a}_{x:\overline{10|}} = 6.8865$

Calculate the gross premium using the equivalence principle.

(A) 3200

(B) 3300

(C) 3400

(D) 3500

(E) 3600

END OF EXAMINATION

USE THIS PAGE FOR YOUR SCRATCH WORK

USE THIS PAGE FOR YOUR SCRATCH WORK