Enrolled Actuaries Basic Examination

EA-1

Date: Wednesday, May 12, 2021

INSTRUCTIONS TO CANDIDATES

1. Special conditions generally applicable to all questions on this examination are found on the next page.

2. On this examination the symbol "a" will be used to represent an annuity. On this examination the symbol "ℓ_x" will be used to represent the number of lives at age x.

3. This examination consists of 30 multiple-choice questions worth a total of 100 points. The point value for each question is shown in parentheses at the beginning of the question.

4. Your score will be based on the point values of questions that 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.

5. Do not spend too much time on any one question. If a question seems too difficult, leave it and go on.

6. 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 computer screen.

7. Use the scratch paper booklets provided by Prometric for your scratch work. Extra scratch paper booklets are available if you run out of scratch paper in the booklet provided to you.

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Answer Key EA-1 Spring 2021
February 21, 2021

Question	Answer		Question	Answer
1	C		16	D
2	C		17	B
3	C		18	B
4	B		19	C
5	C		20	B
6	C		21	B
7	D		22	D
8	D		23	D
9	B		24	B
10	D		25	E
11	A		26	B
12	B		27	B
13	E		28	B
14	D		29	C
15	B		30	D

CONDITIONS GENERALLY APPLICABLE TO ALL EA-1 EXAMINATION QUESTIONS

If applicable, the following conditions should be considered a part of the data for each question, unless otherwise stated or implied.

(1)   The normal retirement age is 65.

(2)   Retirement pensions commence at normal retirement age and are paid monthly for life at the beginning of each month.

(3)   There are no pre-retirement death or disability benefits.

(4)   Actuarial equivalence is based on the mortality table and interest rate assumed for funding purposes.

(5)   Interest rates that are compounded more frequently than annually are expressed as nominal rates.

(6)   Where multiple lives are involved, future lifetimes are assumed to be independent of each other.

(7)   The term "gross single premium" is equivalent to "contract single premium;" the term "net single premium" is equivalent to "single benefit premium;" the term "gross annual premium" is equivalent to "annual contract premium;" the term "net annual premium" is equivalent to "annual benefit premium."

(8)   There are no policy loans in effect.

(9)   For a bond, the face amount and the redemption value are the same.

(10)   Interest rate equals yield rate.

(11)   The term "duration" means "Macaulay duration".

If applicable, the preceding conditions should be considered a part of the data for each question, unless otherwise stated or implied.

Data for Question 1 (3 points)

Smith invests 5.0% of his salary into a fund on January 1 of each year, beginning on 1/1/2021.

Salary on 1/1/2021	$50,000
Future salary increases	3.0% per year, compounded annually
Effective date of salary increases	1/1 of each year
Expected investment earnings	4.0% per year, compounded annually

X = the expected value of this fund on 12/31/2055.

Question 1

In what range is X?

(A)   Less than $283,500

(B) $283,500 but less than $293,500

(C) $293,500 but less than $303,500

(D) $303,500 but less than $313,500

(E) $313,500 or more

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Data for Question 2 (4 points)

Terms of a loan:

Amount borrowed	$10,000
Payment terms	Two payments:
	End of year 1: X End of year 2: $1.1X$
Force of interest	$0.06 + 0.01t$, for $t \le 2$

Question 2

In what range is X?

(A) Less than $5,210

(B) $5,210 but less than $5,280

(C) $5,280 but less than $5,350

(D) $5,350 but less than $5,420

(E) $5,420 or more

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A series of 30 annual payments is to be made, with the first payment at the end of the first year.

The first payment is $50, and the payments increase by $2 each year after that.

Interest rate: 8.0% per year, compounded semi-annually

$X=$ the present value of the payments.

Question 3

In what range is X?

(A)   Less than $750

(B) $750 but less than $755

(C) $755 but less than $760

(D) $760 but less than $765

(E) $765 or more

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Data for Question 4 (3 points)

An endowment fund is established to provide scholarships.

The fund provides for 1 scholarship at the end of year one, 2 scholarships at the end of year two, and so forth, up to 10 scholarships at the end of year ten and at the end of each year after that.

The amount of each scholarship is $25,000.

Interest rate: 5.0% per year, compounded annually

X = the value of the endowment fund on the date of inception.

Question 4

In what range is X?

(A)   Less than $4,000,000

(B) $4,000,000 but less than $4,100,000

(C) $4,100,000 but less than $4,200,000

(D) $4,200,000 but less than $4,300,000

(E) $4,300,000 or more

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Terms of a loan issued on 1/1:

Amount	$10,000
Payment	Annual, on 12/31
Interest rate	7.0% per year, compounded annually

Payment schedule:

Years	Payment amount
1-5	$ 1,000
6-7	0
8	3,000
9-14	1,000
15	Balance of loan

X = the amount of interest included in the payment to be made in the 10th year.

Question 5

In what range is X?

(A)   Less than $425

(B) $425 but less than $450

(C) $450 but less than $475

(D) $475 but less than $500

(E) $500 or more

Data for Question 6 (4 points)
Terms of a loan:

Amount of loan	$100,000
Term	30 years
Payments	Level monthly, payable at the end of each month
Interest rate	8.0% per year, compounded monthly

Immediately after the 144th monthly payment is made, the loan is refinanced at 7.25% per year, compounded annually. The frequency of payments and the term of the loan are unchanged.

X = the amount of principal paid in the 19th year after the date of the loan.

Question 6

In what range is X?

(A)   Less than $3,550

(B) $3,550 but less than $3,650

(C) $3,650 but less than $3,750

(D) $3,750 but less than $3,850

(E) $3,850 or more

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Data for Question 7 (3 points)
Terms of a bond:

        Face amount $100,000
        Coupon rate   6.0% per year, payable semi-annually
        Term   10 years
        Redemption amount $100,000

Coupons are reinvested at 5.0% per year, compounded semi-annually.

Overall yield to purchaser: 5.5% per year, compounded semi-annually

X = the purchase price of the bond.

Question 7

In what range is X?

(A)   Less than $99,000

(B) $99,000 but less than $100,500

(C) $100,500 but less than $102,000

(D) $102,000 but less than $103,500

(E) $103,500 or more

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On 1/1/2021, Smith sets up an investment under an immunization strategy to meet the obligation shown:

Obligation	A single payment of $10,000 on 1/1/2026
Available investments	2-year and 10-year zero-coupon bonds
Yield to maturity	5.0%, compounded annually (for both investments)

The convexity of the assets is greater than the convexity of the obligation.

X = the amount invested in 2-year zero-coupon bonds.

Question 8

In what range is X?

(A)   Less than $2,800

(B) $2,800 but less than $3,800

(C) $3,800 but less than $4,800

(D) $4,800 but less than $5,800

(E) $5,800 or more

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Data for Question 9 (4 points)

A company is obligated to make a payment of $200,000 in 5 years.

The company has a zero-coupon bond that will mature for $91,923 in 14 years.

The company wishes to purchase a single zero-coupon bond maturing at the end of either year 1, 2, 3, 4, or 5 in order to immunize its position.

All calculations are based on an effective annual rate of interest of 7.0%.

Question 9

Which bond should the company purchase to immunize its position?

(A)   1 year

(B)   2 year

(C)   3 year

(D)   4 year

(E)   5 year

During the calendar year that just ended, a pension fund made benefit payments of $10,000 on the first day of each month.

Selected values from the fund's asset statements:

Market value of assets as of 1/1	$3,000,000
Contribution made on 7/1	300,000
Market value of assets as of 12/31	3,400,300

Assumed rate of simple interest: 6.0% per year

X = the excess of the actual investment earnings over the expected investment earnings (the "investment gain") for the calendar year that just ended.

Question 10

In what range is X?

(A)   Less than $25,000

(B) $25,000 but less than $30,000

(C) $30,000 but less than $35,000

(D) $35,000 but less than $40,000

(E) $40,000 or more

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Data for Question 11 (4 points)

Terms of a mortgage:

Term	30 years
Payments	Level annual payments payable at the end of each year
Interest	6.0% per year, compounded annually
Probability of default	2.0% each year

The initial expected present value of the payments for this mortgage is $300,000.

X = the expected present value if the annual probability of default doubles, assuming the annual payment remains the same.

Question 11

In what range is X?

(A)   Less than $250,000

(B) $250,000 but less than $262,500

(C) $262,500 but less than $275,000

(D) $275,000 but less than $287,500

(E) $287,500 or more

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Smith's salary at the beginning of the year is $50,000.

Smith deposits 2.0% of his salary for the year into a fund at the end of each year.

Immediately after each deposit, Smith's salary increases by 4.0%.

The fund earns an effective annual rate of interest of 5.0%.

X = the accumulated value in the fund immediately after the 15th deposit is made.

Question 12

In what range is X?

(A)   Less than $27,000

(B) $27,000 but less than $28,000

(C) $28,000 but less than $29,000

(D) $29,000 but less than $30,000

(E) $30,000 or more

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Payments under an annuity are $2,500 at the end of each of the next 7 years.

Selected values from a yield curve:

Term (years)	Spot rate
1	2.00%
2	3.00%
3	3.80%
4	4.45%
5	5.00%
6	5.50%
7	5.75%

The spot rates at the end of 2 years are expected to be 150 basis points higher than the current spot rates for all periods.

$X=$ the present value of the remaining 5 payments immediately after the second payment has been made.

Question 13

In what range is X?

(A)   Less than $10,000

(B) $10,000 but less than $10,200

(C) $10,200 but less than $10,400

(D) $10,400 but less than $10,600

(E) $10,600 or more

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Data for Question 14 (4 points)

A pension plan shows the following statistics for its membership for a given year:

Number of active members on 1/1	3,000
Number of terminations (all occur on 9/1)	240
Number of retirements from active status (all occur on 10/1)	400
Number of new entrants (all on 11/1)	660
Number of deaths among active members	100

X = the mortality rate for active members for the year.

Question 14

In what range is X?

(A)   Less than 0.0330

(B)   0.0330 but less than 0.0335

(C)   0.0335 but less than 0.0340

(D)   0.0340 but less than 0.0345

(E)   0.0345 or more

Data for Question 15 (3 points)

In 2021, the following base rates of mortality are used to compute annuities:

x	q_x
50	0.0157
51	0.0167
52	0.0176
53	0.0187

Assumed annual decrease in rates of mortality, beginning in 2022: 3.0% per year, compounded annually

Interest: 5.0% per year, compounded annually

Smith (age 50) purchases a 3-year temporary life annuity-due with an annual payment of $10,000.

X = the purchase price of this annuity at 1/1/2021.

Question 15

In what range is X?

(A)   Less than $28,155

(B) $28,155 but less than $28,255

(C) $28,255 but less than $28,355

(D) $28,355 but less than $28,455

(E) $28,455 or more

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Data for Question 16 (4 points)

An actuary for a pension plan recently performed an experience study.

As a result of this experience study, the actuary revises the 2021 actuarial valuation's mortality table.

The new mortality assumption uses a generational mortality table.

Selected base mortality rates for 2021 are shown below:

x	q_x
60	0.00508
61	0.00566
62	0.00631
63	0.00704

Following is an excerpt of the mortality projection scale:

	Age			
Year	60	61	62	63
2022	(0.0007)	0.0006	0.0023	0.0043
2023	(0.0036)	(0.0029)	(0.0015)	0.0003
2024	(0.0058)	(0.0056)	(0.0046)	(0.0031)

Note that in this table, a positive value means a mortality improvement; a negative value means the opposite.

X= the value of q_{63} the actuary uses in 2024.

Question 16

In what range is X?

(A)   Less than 0.00390

(B)   0.00390 but less than 0.00495

(C)   0.00495 but less than 0.00600

(D)   0.00600 but less than 0.00705

(E)   0.00705 or more

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Data for Question 17 (3 points)

Smith purchases an annuity-immediate on his 65th birthday with the following provisions:

Payment	$10,000 per year, payable annually
Term	For Smith's lifetime, and continuing for two years following Smith's death

Select commutation functions at 6.0% interest, compounded annually:

x	N_x	M_x
65	12,111	800
66	10,625	700

X = the present value of this annuity at Smith's 65th birthday.

Question 17

In what range is X?

(A)   Less than $81,500

(B) $81,500 but less than $84,500

(C) $84,500 but less than $87,500

(D) $87,500 but less than $90,500

(E) $90,500 or more

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Data for Question 18 (4 points)

Mortality follows this formula:

$$\ell_x = 105 - x, \quad 0 \le x \le 105$$

Interest: 6.0% per year, compounded annually

Smith, 65 years old, purchases a 5-year temporary life annuity-due of $10,000 per year, with payments made semi-annually for the first two years and annually after that.

X = the present value of this annuity on Smith's 65th birthday.

Question 18

In what range is X?

(A)   Less than $42,100

(B) $42,100 but less than $42,300

(C) $42,300 but less than $42,500

(D) $42,500 but less than $42,700

(E) $42,700 or more

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Smith, age 50, purchases a life annuity.

Payment X per month, payable as a single life annuity; the first payment is made at the end of the first month.

Single premium $80,000

Selected commutation functions:

$D_{50} = 5,200$
$N_{50} = 83,500$

Question 19

In what range is X?

(A) Less than $424

(B) $424 but less than $429

(C) $429 but less than $434

(D) $434 but less than $439

(E) $439 or more

Data for Question 20 (3 points)

Mortality follows this formula:

$$\ell_x = 100 - x, \quad 0 \le x \le 100$$

Interest rate: 5.0% per year, compounded annually

Provisions of a 20-year temporary life annuity-due payable to Smith, age 70:

Frequency of payments Annual

Amount   Initial payment of $5,000
           Each subsequent payment is 5.0% greater than the previous
           payment

X = the present value of annuity on Smith's 70th birthday.

Question 20

In what range is X?

(A) Less than $65,000

(B) $65,000 but less than $70,000

(C) $70,000 but less than $75,000

(D) $75,000 but less than $80,000

(E) $80,000 or more

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Data for Question 21 (3 points)

Selected values:

x	e_x
63	9.5
64	9.0
65	8.5

$X = {}_2q_{63}$

Question 21

In what range is X?

(A)   Less than 0.099

(B)   0.099 but less than 0.104

(C)   0.104 but less than 0.109

(D)   0.109 but less than 0.114

(E)   0.114 or more

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Mortality follows this formula:

$$\ell_x = 100 - x, \quad 0 \le x \le 100$$

X = the probability that exactly one of two independent lives ages 25 and 35 survives to age 65.

Question 22

In what range is X?

(A)   Less than 0.25

(B)   0.25 but less than 0.35

(C)   0.35 but less than 0.45

(D)   0.45 but less than 0.55

(E)   0.55 or more

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Data for Question 23 (4 points)

You are reviewing probabilities for two sets of couples:

        Group A: Smith (age 35) and Jones (age 45)
        Group B: Brown (age 35) and Green (age 45)

Selected probabilities:

$$_{10}p_{35} = 0.92$$
$$_{10}p_{45} = 0.80$$
$$_{5}p_{50} = 0.84$$

$X=$ the probability that both members of Group A survive to age 50 <u>and</u> that both members of Group B die between age 50 and 55.

Question 23

In what range is X?

(A)   Less than 0.009

(B)   0.009 but less than 0.012

(C)   0.012 but less than 0.015

(D)   0.015 but less than 0.018

(E)   0.018 or more

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Selected actuarial values:

$$\ell_x = 1,000$$
$$q'^{(1)}_x = 0.050$$
$$q'^{(2)}_x = 0.030$$
$$q'^{(3)}_x = 0.300$$

Decrements (1) and (3) are uniformly distributed throughout the year.

Decrement (2) occurs only at the end of the year.

X= the number of lives who decrement between age x and age $x+1$ due to cause (2).

Question 24

In what range is X?

(A)   Less than 19.50

(B)   19.50 but less than 20.00

(C)   20.00 but less than 20.50

(D)   20.50 but less than 21.00

(E)   21.00 or more

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Data for Question 25 (3 points)

For $40 \leq x \leq 60$, there are three sources of decrement:

$$q'^{(1)}_x = 0.01$$
$$q'^{(2)}_x = 0.05$$
$$q'^{(3)}_x = 0.02$$

$$X = {}_8 p^{(T)}_{47}$$

Question 25

In what range is X?

(A)   Less than 0.5025

(B)   0.5025 but less than 0.5075

(C)   0.5075 but less than 0.5125

(D)   0.5125 but less than 0.5175

(E)   0.5175 or more

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Data for Question 26 (4 points)

Terms of two actuarially equivalent annuities that provide monthly payments commencing at the end of the month in which the annuity is purchased:

	Annuity A	Annuity B
Issue age	40	40
Type of annuity	Perpetuity	Life
Amount of each payment	X	1,000

Selected values from a mortality table:

x	q_x	D_x	N_x
40	0.002125	651	8,700
41	0.002327	607	8,049

Question 26

In what range is X?

(A)   Less than $860

(B) $860 but less than $875

(C) $875 but less than $890

(D) $890 but less than $905

(E) $905 or more

Smith is retiring at age 65 and is deciding among the following actuarially-equivalent annuities, each of which is an annuity-due:

Option 1 $1,000 per year, payable for life

Option 2 $850 per year, payable for life, with $425 per year continuing to Smith's beneficiary for Smith's beneficiary's lifetime following Smith's death

Option 3   *X* per year, payable for life, with *X* per year continuing to Smith's beneficiary for Smith's beneficiary's lifetime following Smith's death

Question 27

In what range is *X*?

(A)   Less than $725

(B) $725 but less than $750

(C) $750 but less than $775

(D) $775 but less than $800

(E) $800 or more

Data for Question 28 (3 points)

Smith, age 65, purchases an annuity with the following provisions:

Frequency of annuity payments	Monthly, with the first payment made on the purchase date
Amount of each annuity payment	$50
Death benefit	$10,000, payable at the end of the year of death if death occurs during the first 10 years, $0 otherwise

Interest: 7.0% per year, compounded annually

Selected commutation functions:

x	D_x	N_x
65	965	8,872
75	346	2,379

X = the net single premium for this annuity.

Question 28

In what range is X?

(A)   Less than $6,500

(B) $6,500 but less than $7,500

(C) $7,500 but less than $8,500

(D) $8,500 but less than $9,500

(E) $9,500 or more

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Smith, age 50, and Jones, age 53, each purchase a $10,000 whole life insurance with the death benefit payable at the end of the year of death.

Interest: 8.0% per year, compounded annually

Selected values from the mortality table used to determine the premium for this insurance:

x	ℓ_x
50	100
51	95
52	90
53	85

The net single premium for this insurance for Smith is $5,000.

X = the net single premium for this insurance for Jones.

Question 29

In what range is X?

(A)   Less than $5,200

(B) $5,200 but less than $5,400

(C) $5,400 but less than $5,600

(D) $5,600 but less than $5,800

(E) $5,800 or more

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You are given the following:

$$q_x = 0.10$$
$$q_{x+1} = 0.15$$

$$X = 100 \,_{0.3|0.5}q_{x+0.4}$$

Question 30

In what range is X?

(A)   Less than 5.65

(B)   5.65 but less than 5.75

(C)   5.75 but less than 5.85

(D)   5.85 but less than 5.95

(E)   5.95 or more

END OF EXAMINATION

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