

ACT 247: Introductory Life Contingencies (Winter 2024)

Instructor & TA Information:

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Class times:

- **Lectures:** Thursdays 11:10AM to 01:00PM, KP 108.
- **Tutorials:** Tuesdays 10:00AM to 11:00AM, online.

High level description

Probability theory applied to survival and to costs and risks of life assurances, life annuities, and pensions; analysis of survival distributions; international actuarial notation.

Course outcomes:

By the end of the course, you will be able to:

- Understand the key elements behind the mathematics of pricing key life insurance products: sequences and series, probability theory, and time value at money.
- Recognize life contingency notation and comfortably apply it.
- Understand the concept behind and apply life contingency tables.
- Understand and apply parametric survival models for long-term insurance coverages.
- Understand the key features of life insurance and apply mathematical relationships to price them.
- Understand the key features of life annuities and apply mathematical relationships to price them.

Textbook: S. Broverman, Actuarial Science Coursebook for [ACT247H + ACT348H 2022-23] Edition.

Course tentative outline:

- (1) **Weeks 1 & 2: Part 1 – Foundations** (2024-01-07sun → 2024-01-20sat):
- a. Introduction.
 - b. Life insurance products (high level).
 - c. ABCs (Section 1):
 - i. Key geometric series.
 - ii. Key integrals.
 - iii. Probability theory.

1. Intro.
 2. Single variable functions.
 3. Multiple variable functions.
 4. Conditional probability.
 5. Independence.
 6. Mixture distributions.
 7. Conditional distributions.
 8. Distribution functions.
- iv. Time value of money.
- d. Modelling survival & mortality (Sections 2 & 3):
 - i. Survival probability in the context of life and death
 - ii. Time until death.
 - iii. Force of mortality.
 1. Of a newborn.
 2. Of a person aged x .

(2) Weeks 3, 4, & 5: Part 2 - Life tables & parametric survival models (2024-01-21sun → 2024-02-10sat):

- a. Life tables (Section 4)
- b. Mean and variance survival metrics (Section 5):
 - i. Complete lifetime expectation, T_x .
 - ii. n -year term expectation of life for x , $T_{x:n}$.
 - iii. Median and mode lifetime of T_x .
 - iv. Curtate expectation of life for x , K_x .
 - v. n -year curtate expectation of life for x , $K_{x:n}$.
 - vi. Variance of lifetime.
 - vii. Variance of curtate lifetime.
- c. Parametric survival models (Section 6).
- d. Fractional age assumptions (Section 7).
- e. Select and ultimate mortality (Section 8).

(3) Week 6: Midterm 1 (2024-02-11sun → 2024-02-17sat).

(4) Week 7: Reading week (2024-02-18sun → 2024-02-24sat).

(5) Weeks 8, 9, & 10: Part 3 - Life insurance products (2024-02-25sun → 2024-03-16sat):

- a. Introduction (Sections 9, 10, 11, 12, & 13):
 - i. Premise.
 - ii. Metrics (single policy).
 - iii. Metrics (multiple policies).
 - iv. Useful recursive expressions (APVs).
 - v. Useful continuous/yearly interchanging formula under UDD assumption.

- b. Constant paying benefits (Sections 9, 10, 11, & 12):
 - i. n -year term insurance.
 - ii. Whole life insurance.
 - iii. n -year pure endowment.
 - iv. n -year endowment insurance.
 - v. Special n -year endowment insurance.
 - vi. n -year deferred insurance.
 - vii. n -year deferred j year term insurance.
- c. Varying paying benefits (Sections 11, & 12):
 - i. Geometrically increasing benefit.
 - ii. Whole life increasing insurance.
 - iii. n -year term increasing insurance.
 - iv. n -year term decreasing insurance.
 - v. Other continuous varying benefit products.
- d. Simplifications when assuming distributions (Section 13):
 - i. Uniform.
 - ii. Exponential.
 - iii. Normal approximation.
- e. Mathematical relationships between insurance products (Section 13):
 - i. Simple, direct relationships.
 - ii. Recursive relationships.
 - iii. Discrete and continuous insurance relationships assuming UDD.
 - iv. Discrete and fractional (whole life insurance only).
 - v. Covariances.

(6) Week 11: Midterm 2 (2024-03-17sun → 2024-03-23sat).

(7) Weeks 12 & 13: Part 4 - Annuity insurance products (2024-03-24sun → 2024-04-06sat):

- a. Introduction (Sections 14, 15, 16, & 17).
- b. Discrete life annuities (Section 14 & 15):
 - i. Whole life annuity due.
 - ii. n -year temporary life annuity-due.
 - iii. n -year deferred life annuity-due.
 - iv. Simplifications under known probability distributions.
- c. Continuous life annuities (Section 16):
 - i. Continuous whole life annuities.
 - ii. Continuous n -year temporary life annuity.
 - iii. Continuous n -year deferred whole life annuity.
- d. Mathematical relationships between life annuities (Section 17):
 - i. Recursive relationships.
 - ii. Life annuities with m -thly payments.
 - iii. Varying life annuities.

- iv. Modified mortality risk & structured settlements.

Course Grading:

- 1) Assignments (40%):
 - a. Assignment 1 (Part 1): 10% (due 2024-01-26fri 11:59PM).
 - b. Assignment 2 (Part 2): 10% (due 2024-02-16fri 11:59PM).
 - c. Assignment 3 (Part 3): 10% (due 2024-03-22fri 11:59PM).
 - d. Assignment 4 (Part 4): 10% (due 2024-04-12fri 11:59PM).

- 2) Open book, online, timed MCQ tests (60%):
Standard weights:
 - a. Midterm 1 (Parts 1 & 2): 20% (on 2024-02-15thu 11:00AM to 01:00PM).
 - b. Midterm 2 (Parts 1, 2 & 3): 20% (on 2024-03-21thu 11:00AM to 01:00PM).
 - c. Final (Parts 1, 2, 3, & 4): 20% (TBD)The 60% weight follows the following formula:
$$\max(\text{Midterm1} + \text{Midterm2} + \text{Final}, \text{Midterm1} + \text{Final}, \text{Midterm2} + \text{Final}, \text{Final})$$

All final grades are rounded up to the nearest percentage. For grades that are within 2% short of 50%, 63%, 70%, and 80% will be rounded up to the closest grade. No other exceptions will be granted, and the student will need to apply to the department for a deferral.

Academic integrity: Three key principles are held in this course: fairness and transparency from the instructor, and a solid work ethic from the student. Anyone caught cheating or complicit of cheating (e.g., copying assignments, solving individual-based assessment problems in groups) will have their test grade zeroed and will be reported to the department.

Canadian Institute of Actuaries' University Accreditation Program (UAP):

UAP has moved away from the course-by-course accreditation and is now based on a program accreditation method. Under the new credentialing pathway, to obtain ACIA (Associate of CIA) professional credential, students need to:

1. Complete a degree from an actuarial program (ACT Specialist or Major) at University of Toronto and pass a list of mandatory courses. No minimum course grade or GPA is required. The full list of UofT's 16 mandatory courses are: ACT240, ACT245, ACT247, ACT348, ACT349, ACT370, ACT451, ACT452, ACT466, STA237/STA257, STA238/STA261, STA302, STA314, ECO101, ECO102, MGT201/RSM219;
2. Complete the ACIA Modules;
3. Complete an open-book ACIA Capstone Exam

For further information on ACIA modules and Capstone Exam, please email education@cia-ica.ca.

Textbook purchase information:

You may purchase the coursebook on the UofT Bookstore (physical copy only available).