ACT 247: Introductory Life Contingencies (Winter 2025)

Instructor & TA Information:

Name	Role	Contact
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Class times:

- **Lectures:** Tuesdays 10:10AM to 12:00PM, KP 108.
- **Tutorials:** Thursdays 11:00AM to 12:00PM, 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 2024-25] Edition.

Course tentative outline:

(1) Weeks 1 & 2: Part 1 – Foundations (2025-01-05**sun** → 2024-01-18**sat):**

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 (2024-01-29**sun** → 2024-02-08**sat):**

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 (2024-02-09**sun** → 2024-02-15**sat).**

(4) Week 7: Reading week (2024-02-16**sun** → 2024-02-22**sat).**

(5) Weeks 8, 9, & 10: Part 3 - Life insurance products (2024-02-23**sun** → 2024-03-15**sat):**

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 (2024-03-16**sun** → 2024-03-22**sat).**

(7) Weeks 12 & 13: Part 4 - Annuity insurance products (2024-03-23**sun** → 2024-04-05**sat):**

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) Closed book, with cheat sheets, in-person written tests (100%):
   Standard weights:
   a. Midterm 1 [M1] (Parts 1 & 2): 25% (on 2025-02-11tue 11:15AM to 12:45PM).
   b. Midterm 2 [M2] (Parts 1, 2, & 3): 25% (on 2025-03-18tue 11:15AM to 12:45PM).
   c. Final [F] (Parts 1, 2, & 3): 50% (date and time TBD).
      The final grade follows the following formula:
      $$\max(0.25 \times M1 + 0.25 \times M2 + 0.5 \times F, 0.25 \times M1 + 0.75 \times F, 0.25 \times M2 + 0.75 \times F, F)$$
      In the formula above, the standard weights get allocated to the final for midterms excluded.

Contesting exam question marks:

For the two midterm exams, students are allowed to contest their marks (solutions for each test will be provided) within 15 days of the day the solution sheets are distributed in class (typically one day after grades are posted on Quercus). The procedure to contest marks is to email the instructor with a snapshot of the question(s) in doubt.

For the final exam, students may contest grades as described here.

Make-up exams:

There are no make up exams for midterms or the final, regardless of the reason. The only alternative option is for the student who does not attend the final exam is to apply to the department for a deferral.

Rounding final grades:

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).