ACT 247: Introductory Life Contingencies (Winter 2022)

Instructor & TA Information:

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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 + ACT238H 2020-21 Edition.

Course tentative outline:

(1) Weeks 1, 2: Foundations

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. 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: Life tables & parametric survival models

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

(4) Week 7: Reading week.

(5) Weeks 8, 9, & 10: Life insurance products

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.

(7) Weeks 12 & 13: Annuity insurance products

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 (30%):
   a. Assignment 1: 10% (due 2022-01-28Fri 11:59PM – covers W1-W2)
   b. Assignment 2: 10% (due 2022-02-11Fri 11:59PM – covers W1-W5)

c. Assignment 3: 10% (due 2022-04-01Fri 11:59PM – covers W1-W11)

2) Open book, in-class tests (75%):
   Standard weights:
   a. Midterm 1: 25% (on 2022-02-10Thu 11:00AM to 01:00PM – covers W1-W5)
   b. Midterm 2: 25% (on 2022-03-24Thu 11:00AM to 01:00PM – covers W1-W6)
   c. Final: 25% (TBD – covers W1-W13)
      The final 75% weight follows the following formula:
      $$\max(Midterm1 + Midterm2 + Final, Midterm1 + Final, Midterm2 + Final, Final)$$
      With the weight of the omitted midterm or midterms shifted to the final

You can earn up to 105 points. Grade is capped at 100 points.

Academic integrity: Two key principles are held in this course: fairness from the instructor and a solid work ethic from the student. Thus, anyone caught cheating (e.g., copying assignments, solving individual-based assessment problems in groups) will be met with the strictest penalties provided by UT's guidelines.

Canadian Institute of Actuaries (CIA)'s University Accreditation Program (UAP)
ACT247 is an accredited course under the UAP program. You may apply for a credit for Exam LTAM if you achieve the minimum grades for the following three courses: ACT247, ACT348, ACT455. The minimum grade required for ACT247 is 70. For detailed information on UAP, please visit the following webpage:
https://www.cia-ica.ca/membership/university-accreditation-program-home/accredited-universities/accredited-university-detail?pav_universityid=06f6b138-61e5-e511-80b9-00155d111030

Note: CIA will grant credits to students for SOA/CAS examinations based on the achievement of the minimum Grade towards Associateship (ACIA) and Fellowship (FCIA) in CIA. At the time of this agreement, CIA credits are recognized by the following actuarial organizations towards their respective designations:
Casualty Actuarial Society (CAS): ACAS, FCAS
UK Institute and Faculty of Actuaries (IFoA): FIA, AIA
Institute of Actuaries of Australia (IAA): AIAA, FIAA
Actuarial Society of South Africa (ASSA): AMASSA, FASSA
American Academy of Actuaries (AAA): MAAA
CIA does not guarantee that credits granted to students under the CIA UAP will be recognized by any other actuarial organizations towards their actuarial designations.

Textbook purchase information:

You may purchase the coursebook on the UofT Bookstore website.

Navigate to the **Digital Course Materials** section on the University of Toronto Bookstore Website at https://uoftbookstore.com/textbooks/access_codes.asp?

From here, scroll down the list and select your course, which appears as:

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