This is the start of a project that will culminate in Ma 464. Complete relevant portions of the project prior to the in-class test on the corresponding material for most efficient learning.

Completion of each of the major portions of the assignment (Life Tables and Premium/Valuation) as described can earn at most a B+ for the project. The enhancements will give you the opportunity to raise your grade for each project respectively. However, it is better to do the main project very well and skip the enhancement than to submit an underdeveloped project.

There are several goals for this assignment.

- To help you develop your understanding of life tables and the computations involved in premium determination and policy valuation.
- To help you develop your ability to handle larger, less well-defined problems than homework and exam problems provide.
- To integrate skills learned in other courses and help you develop your R and communication skills.

1 Research Journal

Best practices in research include a systematic method of *journaling* – keeping a record of research-related activity including observations, results (both positive and negative), insights/patterns, and ideas/plans for future work. It should impose structure on your work. Your journal should be able to be submitted as a Word/Excel document or a PDF, and should demonstrate the following characteristics.

1. **Reflection:** The student will succinctly reflect on research activities including work attempted, insights and results gained, and further paths of inquiry to be pursued.
2. **Organization:** The student will create a single document (useful to self and others) that will serve as a quick reference of their work.
3. **Documentation:** The student will document when (dates), for how long (approximate elapsed time) course-engagement occurred, and keep a running total of the time spent on the project.

Guidelines for Journaling

1. **Style:** As long as all other elements are addressed, the student may use personal style in developing their research journal, although your professor reserves the right to direct changes to improve effectiveness. Journal entries are not meant to be formal pieces of research. Entries are to be useful rather than polished. Informal writing, abbreviation, and bulleted phrases are all acceptable as long as they can be easily deciphered by another researcher. Daily entries should take less than five minutes.

2. **Frequency:** The student should journal on each day that they engage in research activities.

3. **Date/Time:** Each entry should start with the date, an approximation of total elapsed time for that day, and a running total of time spent on research.

4. **Entry:** The entry for a day should be a brief synopsis of and reflection on the research activity. Some prompts that could be addressed are ...

   (a) What was the question you focused on?
   (b) What attempts were made? with what outcomes?
   (c) What impact might these outcomes have on other avenues of inquiry?
   (d) What questions arose? Do they need immediate or future attention, or setting aside?
   (e) What challenges appear to be hampering progress? How could these be resolved?
   (f) What should you work on next time? (This should be addressed in every entry.)

5. **Submission:** The Research Journal is to be submitted to Canvas (or elsewhere if directed) with each project meeting and each submission. Submissions should include your name in the file name as well as on the first page of the file. Failure to submit the journal will result in a 0 on that portion of the submission (your professor will not go searching for it).

2 Life Tables Assignment

1. Given ages at death data, construct a table with all the components of the SOA LTAM SULT as well as expected lifetimes. Assume an annual interest rate of 5%(1), a starting age of 20 and a final age of 115.

   - You must create your tables in R manually (not using the MortalityTables or other similar packages). You may not use the life table workbook provided with the LTAM tables. These resources defeat a major purpose of the exercise.
   - Documentation of how columns are computed should be included in the Rmd file.
   - Present your life table neatly and attractively formatted, easy to read, one page wide.

2. Estimate values for the Makeham's law from your table using a least squares technique/optimization technique. (You will need to do a little research into this topic.) Present your model and show that it fits the data well. Narrative is required in your presentation.

3. Estimate the probability of death at each age given they are alive at age 20, and address the error bounds for these estimates. Determine the sample size necessary for the estimates to be accurate to six decimals. (See sections 11.2 and/or 11.4 *Mathematical Statistics* by Miller and Miller to find a way to attack this problem.) Summarize your finding with appropriate narrative.

4. Life Table Enhancement: For each age $20, 20.25, 20.5, 20.75, \ldots, 114.75, 115$, compute $l_x, d_x, {}_{0.25}p_x$, and ${}_{0.25}q_x$. Using p_x and q_x for integer values of x from your table and the UDD and constant force of mortality assumptions estimate ${}_{0.25}p_x$ and ${}_{0.25}q_x$. Compare and discuss the accuracy of these estimators for mortality as described by your data set.

First Step: Make a list of every piece of information that you are going to need to generate even if it isn't explicitly listed on the table. Add the section number from the text that covers the material (include later sections in the text which may contain alternate formulas for the computation in question). Using the estimated test dates for the course and the content order of the textbook, add an estimated date that the material will be covered, and based on these dates estimate due dates to complete each task (order your list in chronological order).

R Initialization: Create an R project to contain all your work and save your environment/history and an R Markdown file to contain your code and the outputs. Import the provided data and create a dataframe with columns for everything you think you will need (give your columns readable/interpretable names). Fill the column containing the ages (the x column) for your table.

Using section labels (#, ##, etc.) in R Markdown (section titles should be concise and should not just be section numbers from the textbook), create an R code section and a short text description/formulas for each thing you think you will need to compute (preferably in the order that you will need to compute it). Impose structure/hierarchy to make it easier to follow and search through your code (use the Outline feature). Work on learning to format the text portions so that it knits attractively (Latex is helpful here). Include a due date and a completed date (when done) for each section.

Each computation should be clearly developed in your RMarkdown file (include a description and/or explanation of the computation prior to the computation). You may wish to learn about Latex for adding math equations to your RMarkdown.

** Files in R do not autosave, so save both your R Markdown and R Project files often.

Initial Research: Do enough research to be able to able to describe what a "least squares technique/optimization technique" is trying to accomplish. Cite at least one credible source and describe what you think the techniques are trying to do in your own words. Research packages in R that will accomplish these tasks. Give at least one package and command that you think will work. Describe the inputs necessary for the command.

Describe what a confidence interval is in your own words (see your stats textbook). Determine the appropriate confidence interval formula and address how you will be able to estimate a sample size from it.

Project Initialization/Plan Submission:
Your submission should include your journal, your RMarkdown file, and a knitted HTML file of your RMarkdown of your ordered outline with due dates.

Project Init/Plan (15 pts) Due online: 9/3/2025, 11:59pm

Initial Research Submission:
Your submission should include your journal, your RMarkdown file, and a knitted HTML file of your RMarkdown.

Initial Research (10 pts) Due online: 9/10/2025, 11:59pm

Meetings: Schedule a meeting with your professor during the weeks of September 8th, 22nd and October 6th to discuss your progress and your plan for next steps. See the rubric for the expectations.

Meeting Completed (10 pts) by: 9/12/25, 9/26/25, 10/10/25, 3:00pm

Life Tables Submission: Your submission should include your journal, a pdf of your life table (mirroring the LTAM SOA SULT Table), your RMarkdown file, and a knitted HTML file of your RMarkdown file.

Life Tables (175 pts) Due online: 10/23/2025, 11:59pm

Life Table Revision: Recompute any columns in your table that have incorrect values and resubmit the Life Table deliverables in its entirety. You may wish to confirm with your professor that your corrections are right before resubmitting them. You are welcome to get additional help from your professor. You may not continue with the project until you have a correct life table.

Revision Submission: Your submission should include your journal, a pdf of your corrected life table (mirroring the LTAM SOA SULT Table), your RMarkdown file, and a knitted HTML file of your RMarkdown file. If you received full credit for your table completeness and accuracy, you do not need to resubmit the life table.

Enhancement Submission: Your submission should include your journal, a pdf of your abridged life table containing the quarterly information requested, your RMarkdown file, and a knitted HTML file of your RMarkdown file.

Life Tables Revision (20 pts) and Enhancement (30 pts) Due online: 11/5/2025, 11:59pm

3 Premiums and Policy Valuation Assignment

First Step: Do some research using credible sources. Define anticipated characteristics about your life at age 25 and past, and determine the life insurance you expect to need (include everything necessary to define the policy). Explain the logic of your answer. Be sure to appropriately cite all sources for your research.

Life Insurance Policy (15 pts)

Due To Professor: November 12, 2025, close of building

Assignment: Use the following policy information: $500,000 40-year term insurance issued to (25), premiums payable annually for 30 years, initial expense $150 plus 40% of the premium, renewal expense of $15 plus 5% of the premium, expenses at death of $300 plus 2% of the issue amount. Using the life table, create an RMarkdown file that computes the premium for this policy as well as the valuation for each year the policy is active (assume that all premiums are paid).

Submission: Your submission should include your journal, your RMarkdown file, your knitted HTML file, and a stand-alone written report summarizing the policy information given and computed. The document should be professionally formatted and contain all information about the policy (a self-contained document).

Enhancement: Create a random interest rate for each year the policy is in effect. Using Monte Carlo simulation, recompute the valuations for each year using the randomly generated yearly rate. Present a report including the descriptives and a distribution for the interest rates and valuations for the year with largest valuation (justify from the data that you've selected the most likely year to have the largest valuation).

Meeting: Schedule a meeting with your professor during the week of December 1st to discuss your progress and your plan for next steps. See the rubric for the expectations.

Meeting Completed (10 pts) by: 12/5/2025, 3:00pm

Premium/Valuation (100 pts) and Enhancement (15 pts)

Due Online: 12/11/2025, 11:59pm

Project Initialization/Plan Submission ~ 15 points

_____/ 45% Content: complete list of items needing computing

_____/ 15% Order: items are reasonably listed in the order in which they will be computed

_____/ 30% R Technicalities: sections include descriptions, appropriate and strategic use of sections/hierarchy (making it easy to navigate in Rstudio), knits properly

_____/ 10% Reasonable Due Dates: Life Tables due 10/23/25, Final project (including Enhancement) due 11/5/25 - aligned with course lecture speed

_____ % = _____/ 15 pts

Initial Research Submission ~ 10 points

_____/ 30% Least squares/optimization technique description

_____/ 20% Least squares/optimization technique package/command with description

_____/ 20% Confidence interval description

_____/ 30% Confidence interval formula/connection to sample size

_____ % = _____/ 10 pts

Meetings ∼ 10 points, rubrics will be scored in Canvas

_____/ 35% Project Process: Journal maintained, appropriate time invested and progress made

Good progress: A/B Journal received by the meeting, time invested was adequate, progress made is sufficient to not be behind

Acceptable: C/D Journal received by the meeting, time invested was less than expected, progress was made but the work is behind schedule

_____/ 35% Journal Quality: Journal objectives, style , frequency (including date/times), entries quality

Good Document: A/B Journal objectives are met, style is effective, frequency is complete (including date/times), entries are substantive (addressing relevant prompts; all prompts should be addressed, but not every day)

Adequate: C/D Some journal objectives are met, style is adequate but can be improved, frequency is incomplete and/or does not include date/times, entries do not address all relevant prompts and/or some prompts are never addressed

_____/ 15% Meeting Preparedness: Prepared for the meeting with updates of progress and questions

Well Prepared: A/B Gave a clear update, had specific questions that were relevant and important to the work, had a plan for future work

Adequate: C/D Gave an update, had at least a question but was somewhat superficial/could have been answered by using the text, had some idea for what was next

_____/ 15% Meeting Management: Managed the meeting well

Well Handled: A/B Took initiative in the discussion, was comfortable discussing the work accomplished, asked questions clearly, did not need prompting, interaction was comfortable and conversational in nature while still being on task

Developing: C/D Participated in the discussion, was somewhat uncertain in places about the discussion, needed some prompting, interaction did not seem comfortable and conversational in nature or did not stay on task

_____ % = _____/ 10 pts

Life Table $\sim$ 175 points

_____/ 10% Clarity and organization of RMarkdown file, R code is easy to follow/good use of chunking, naming convention is readable, readability/presentation of tables, etc.

_____/ 50% Table completeness/accuracy

_____/ 20% Model for force of mortality, $\mu_x = a + be^{cx}$, presentation and fit (using visual and numeric methods to assess)

_____/ 20% Estimates and error bounds for ${}_{x-20}|q_{20}$, sample size

– _____/ 0% Penalty: failure to follow directions, lack of professionalism, etc.

_____ % = _____/ 175 pts

Life Table Revision $\sim$ 20 points

_____/ 20 pts Table completeness/accuracy

Enhancement $\sim$ 30 points

_____/ 70% Comp and approx complete/accuracy

_____/ 30% Accuracy comparison is clearly, professionally presented, includes all pertinent information

_____ % = _____/ 30 pts

Life Insurance ~ 15 points

_____/ 15 pts Appropriately researched, reasonable logic/amount, all information needed

Premiums and Policy Valuation ~ 100 points

_____/ 10% Clarity and organization of RMarkdown file, readability/presentation of tables, etc.

_____/ 70% Correct premium and valuation computation

_____/ 20% Summary is clearly, professionally presented, includes all pertinent information

– _____/ 0% Penalty: failure to follow directions, lack of professionalism, etc.

_____ % = _____/ 100 pts

Enhancement ~ 15 points

_____/ 65% Monte Carlo simulation for valuations

_____/ 25% Descriptives of simulation and distribution of valuation values, justification of largest

_____/ 10% Professionalism of presentation of results

_____ % = _____/ 15 pts