This is the expansion of the project that you started in Ma 463. This semester you will focus on developing more sophisticated policies, computing their premiums and policy values, and profit testing both your single life and multi-state policies. The project will be collected in two stages: multiple state model and profit testing. You should plan to complete relevant portions of the project as the topics are discussed in class for most efficient learning. Due to the time investment necessary for this project as well as the significant contribution it can make to your learning, it will be worth 480 points.

There are several goals for this assignment.

- To help you develop your understanding of advanced policies and the computations involved in premium determination, policy valuation, and profit testing.
- To help you develop your ability to handle larger, less well-defined problems than homework and exam problems provide. Feel free to ask questions if any portion of the assignment is not clear.
- 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 Reflection

Reflection is an important part of your learning and professional development. It gives you the opportunity to consider your personal growth and evaluate how a current project fits into your career path. This reflection will ask you to address the four questions listed below.

1. Course Connections: How has your experience in the Ma 463 and 464 projects connected to learning (ideas/theory, facts, skills, applications) you have done in courses (or work-experience) in your chosen field?

2. Career Competencies: How did your career competencies grow as a result of your project experience this year? (Specifically reference the NACE Career Competencies listed.)

   NACE Career Competencies:

   - Critical thinking/problem-solving
   - Oral/written communication
   - Teamwork/collaboration
   - Digital technology
   - Leadership/initiative
   - Professionalism/work ethic
   - Career management
   - Global intercultural fluency

3. Critical Thinking: What problems did you solve related to your project experience this year? How did you solve the problems?

4. Creation-Fall-Redemption (CFR) Worldview: How has your project experience helped you develop an understanding of actuarial science that is consistent with the biblical arc of creation-fall-redemption?

This paper is an essay style paper. Each question should comprise its own section (word count per section: 150 - 600 - more is not necessarily better) with each section clearly labeled. This reflection will be collected in five parts, an initial draft for each question based predominantly on your experience from last semester, and a final draft of all four questions incorporating the work from both the 463 and 464 projects. Your final draft should be revised appropriately based on the feedback provided on your initial drafts.

Course Connections Draft (5 pts)	Due Online: January 20, 2026, 11:59pm
Career Competencies Draft (5 pts)	Due Online: January 22, 2026, 11:59pm
Critical Thinking Draft (5 pts)	Due Online: February 5, 2026, 11:59pm
CFR Worldview Draft (5 pts)	Due Online: February 12, 2026, 11:59pm
Final Reflection (40 pts)	Due Online: April 21, 2026, 11:59pm

3 Multiple State Model

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. Expectations for organization, structure, documentation of your code are to do better than you did last fall. You will be expected to submit both your R code and an HTML knitted file. Easy navigation of the knitted file through a table of contents is expected.

Probabilities and EPVs:
Consider the standard sickness-death policy (see your textbook for the model). You may assume that no person will change state more than one time in any given month. You may also assume a constant interest rate of 5% unless otherwise stated.

1. Import the ${}_{\frac{1}{12}}p_x^{ij}$ (`hpxij.xlsx`) and ${}_xp_0^{ij}$ (`xp0ij.xlsx`) values provided for ages 0 through 110. Using Latex in the RMarkdown file, state the formulas that were used to compute these values. Using these formulas, compute ${}_{\frac{1}{12}}p_{\frac{1}{12}}^{ij}$ for all i, j and confirm the values provided.

   Use Kolmogorov's forward equations to estimate ${}_xp_0^{ij}$ using $h = \frac{1}{12}$. Compare these to the values provided.

2. Compute the actuarial present value of the annuity where a payment of \$1 is made at the end of each month in which the insured is ill, for an insured who is either in a healthy or sick state at age x, and add it to your table.

3. Create a function to compute the actuarial present value of the annuity where a payment of \$1 is made at the end of each month in which the insured is ill until a given age k, for an insured who is either in a healthy or sick state at age x.

4. Compute the present value of the annuity where a payment of \$1 made at the beginning of each month in which the insured is healthy, for an insured who is either in a healthy or sick state at age x. Present the formulas necessary, compute the actuarial present value of this annuity, and add it to your table.

5. Create a function to compute the actuarial present value of the annuity where a payment of \$1 is made at the beginning of each month in which the insured is healthy until a given age k, for an insured who is either in a healthy or sick state at age x.

6. Compute the present value of a payment of \$1 made at the end of the month in which the insured dies for an insured who is either in a healthy or sick state at age x. Present the formulas necessary, compute the actuarial present value of this insurance, and add it to your table.

7. Present your table neatly formatted, easy to read, preferably one page wide (you may wish to export the required values to Excel for easier formatting).

Premiums and Reserving:
Consider a policy that pays \$2500 at the end of the month in which a person was sick until age 72 and a \$100,000 death benefit. Assume that premiums are payable monthly until age 72 if the insured is healthy and are suspended if the insured is sick.

Given initial expenses are \$150 plus 40% of the premium, renewal expenses are \$15 plus 5% of the premium, sick benefit expenses are \$25, and death benefit expenses are \$300 plus 2% of the issue amount.

1. The previous information is insufficient for you to correctly compute premiums and valuations. You are to submit a policy summary and include specific requests for clarification to ensure that you compute values for the correct information.

   You will be assessed based on your ability to correctly infer policy information and ambiguities, propose "best" interpretations, the completeness of your request for additional information, as well as the professionalism of your submission.

2. Compute a net and gross premium for a policy issued to a person (25) as well as the valuation from time of issue forward for both premiums assuming the patient is in a healthy state at age 25 (assume that all premiums owed are paid).

3. Compute the monthly policy valuations in both the sick and healthy states from time of issue forward for both of the premiums that you computed.

4. Present your premiums and table of valuations neatly formatted and easy to read.

Meetings: Schedule a meeting with your professor during the week of January 26 to discuss your progress and your plan for next steps. See the rubric for the expectations.

Policy Summary (30 pts) — Due Online: January 27, 2026, 11:59pm
Meeting Completed (10 pts) — by: January 30, 2026, 3:00pm

Standard Sickness-Death Policy Submission: Your submission should include your journal, pdfs of your tables (one page wide if possible), your RMarkdown file, a knitted HTML file of your RMarkdown file, and a stand-alone written report unambiguously summarizing the policy information given and computed (premiums and valuations). Highlight the valuations at age 30 and age 80. The document should be professionally formatted and contain all information about the policy (a self-contained document).

Standard Sickness-Death (200 pts) — Due Online: February 17, 2026, 11:59pm

Standard Sickness-Death Revision: Recompute any columns in your tables that have incorrect values and resubmit the Standard Sickness-Death deliverables in their 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 correct values. If there were no errors in your computations, you do not need to resubmit anything.

Standard Sickness-Death Revision (20 pts) — Due Online: March 5, 2026, 11:59pm

4 Profit Testing

You will need the following additional information. For the single life policy: Withdrawals/defaults happen at a rate of $q^w_{25+t} = 0.05^{\frac{1}{3}t}$ where t is the number of years since issue as long as premiums are paid and 0 otherwise. Assume a corporate expectation of a 10% return rate with annual cash flows.

For the MSM policy: You will use the probabilities provided for the MSM project, the valuations and the gross monthly premium that you computed, as well as the additional file of probabilities, ${}_tp^{ij}_{25}$ (`xp25_ij.xlsx`), provided. Assume a corporate expectation of a 10% return rate with monthly cash flows.

1. Clearly restate the basis for the single life policy from the Ma 463 life policy and the Ma 464 Multiple States policy.
2. Construct a cash flow table for each policy.
3. Compute the profit signature for each policy.
4. Compute the various profit measures and draw conclusions about the profitability of your policies based on your work.

Meetings: Schedule a meeting with your professor during the week of March 30 to discuss your progress and your plan for next steps. See the rubric for the expectations.

Meeting Completed (10 pts) by: April 3, 2026, 3:00pm

Profit Testing Submission: Your submission should include your journal, a pdf of your table/signatures, your RMarkdown file, a knitted HTML file of your RMarkdown file, and a written (standalone) summary presenting your conclusions about the profitability of your policies (citing evidence for your claims). Your table/signatures should not include probabilities, values should be formatted properly, the single life should be one page wide, and there should be two files for the MSM - one per state.

Profit Testing (150 pts) Due Online: April 16, 2026, 11:59 pm

Reflection Drafts ∼ 20 points

	Exemplary (4.5-5)	Acceptable (3.5-4)	Developing (0-3)	Score
Course Connections: student will be able to connect the project to other learning	Word-count ≥ 150; Draws conclusions between the project and coursework by combining relevant specific examples, facts, or theories from both inside and outside your field of study or perspective.	Word-count ≥ 150; Draws conclusions between the project and other courses by combining relevant examples, facts, or theories from either your field of study or another discipline.	Word-count < 150; Draws general conclusions between the project and other courses in your discipline, or attempts to make connections that are not relevant.	
Career Competencies: student will be able to grow career competencies through the project.	Word-count ≥ 150; Assesses how the project furthered your career skill set by giving specific evidence for growth in four or more career competencies in light of the project.	Word-count ≥ 150; Assesses how the project furthered your career skill set by giving specific evidence for growth in only two or three career competencies in light of the project.	Word-count < 150; Assesses how the project furthered your career skill sets by giving specific evidence for growth in only one career competency in light of the project.	
Critical Thinking: student will be able to solve problems related to the project.	Word-count ≥ 150; Clearly defines a complex problem encountered in the project. Demonstrates how you applied skills, abilities, theories, or methodologies to solve the problem.	Word-count ≥ 150; Defines a problem encountered in the project. Applies general learning to solve the problem encountered.	Word-count < 150; Adapts and applies general learning to the work encountered in the project.	
CFR Worldview: student will be able to connect the project to biblical worldview.	Word-count ≥ 150; Uses specific examples to connect the project with each part of CFR model and relates them to major ideas in Scripture. Explains clear and detailed strategies to counter distortions or fallenness.	Word-count ≥ 150; In general terms, connects the project with each part of the CFR model and relates them to general ideas in Scripture. Mentions strategies to counter distortions or fallenness.	Word-count < 150; Deals with some parts of the CFR model. Does not adequately connect the project with the CFR model or to ideas in Scripture. Omits or only mentions strategies to counter distortions.	

Reflection ∼ 40 points

	Exemplary (9-10)	Acceptable (7-8)	Developing (0-6)	Score
Course Connections: student will be able to connect the project to other learning	Word-count ≥ 150; Draws conclusions between the project and coursework by combining relevant specific examples, facts, or theories from both inside and outside your field of study or perspective.	Word-count ≥ 150; Draws conclusions between the project and other courses by combining relevant examples, facts, or theories from either your field of study or another discipline.	Word-count < 150; Draws general conclusions between the project and other courses in your discipline, or attempts to make connections that are not relevant.	
Career Competencies: student will be able to grow career competencies through the project.	Word-count ≥ 150; Assesses how the project furthered your career skill set by giving specific evidence for growth in four or more career competencies in light of the project.	Word-count ≥ 150; Assesses how the project furthered your career skill set by giving specific evidence for growth in only two or three career competencies in light of the project.	Word-count < 150; Assesses how the project furthered your career skill sets by giving specific evidence for growth in only one career competency in light of the project.	
Critical Thinking: student will be able to solve problems related to the project.	Word-count ≥ 150; Clearly defines a complex problem encountered in the project. Demonstrates how you applied skills, abilities, theories, or methodologies to solve the problem.	Word-count ≥ 150; Defines a problem encountered in the project. Applies general learning to solve the problem encountered.	Word-count < 150; Adapts and applies general learning to the work encountered in the project.	
CFR Worldview: student will be able to connect the project to biblical worldview.	Word-count ≥ 150; Uses specific examples to connect the project with each part of CFR model and relates them to major ideas in Scripture. Explains clear and detailed strategies to counter distortions or fallenness.	Word-count ≥ 150; In general terms, connects the project with each part of the CFR model and relates them to general ideas in Scripture. Mentions strategies to counter distortions or fallenness.	Word-count < 150; Deals with some parts of the CFR model. Does not adequately connect the project with the CFR model or to ideas in Scripture. Omits or only mentions strategies to counter distortions.	

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

Policy Summary $\sim$ 30 points

_____/ 90% Identified ambiguities/requested all necessary clarifications/proposed reasonable interpretations

_____/ 10% Professional presentation

_____ % = _____/ 30 pts

Standard Sickness-Death Rubric $\sim$ 200 points

_____/ 12% Force of transitions μ_x^{01} μ_x^{02} μ_x^{10} μ_x^{12} , additional force assumptions stated, best assumptions used and supported

_____/ 48% Probabilities of transitions

$_{\frac{1}{12}}p_x^{00}$ $_{\frac{1}{12}}p_x^{01}$ $_{\frac{1}{12}}p_x^{02}$ $_{\frac{1}{12}}p_x^{10}$ $_{\frac{1}{12}}p_x^{11}$ $_{\frac{1}{12}}p_x^{12}$ $_xp_0^{00}$ $_xp_0^{01}$ $_xp_0^{02}$ $_xp_0^{10}$ $_xp_0^{11}$ $_xp_0^{12}$

_____/ 14% Sick annuity EPV and death benefit EPV computations $2500{*}12a^{(12)\,01}_{x:\overline{72-x}|}$ $100000A_x^{(12)\,02}$

_____/ 10% Net and gross premium computations P^n P^g

_____/ 16% Valuation computations $_xV_n^0$ $_xV_n^1$ $_xV_g^0$ $_xV_g^1$

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

_____ % = _____/ 200 pts

Standard Sickness-Death Revision $\sim$ 20 points

_____/ 20 pts Table completeness/accuracy

$2500 * 12\ddot{a}^{(12)\,01}_{x:\overline{72-x}|}$ $100000\bar{A}_x^{(12)\,02}$ P^n P^g $_xV_n^0$ $_xV_n^1$ $_xV_g^0$ $_xV_g^1$

Profit Testing $\sim$ 150 points

_____/ 40% Accurate cash flow table for each policy under a reasonable profit testing basis

_____/ 20% Accurate profit signature computed for each policy

_____/ 40% Profit measures computed computed for each policy; reasonable, clearly supported claims regarding profitability for each policy

$NPV_{r\%}$ Partial $NPV_{r\%}$ IRR DPP

Profit Margin Profitability Conclusions

_____/ 0% Penalty for poor presentation, failure to follow directions, lack of clarity, etc.

_____ % = _____/ 150 pts