**🧩 FULL DISSERTATION STRUCTURE**

**1. Title Page**

* Your full name
* Dissertation title
* Module code (MTHM038)
* Supervisor's name
* Date of submission

**2. Abstract *(~150–300 words)***

* Briefly state the aim, methods, results, and significance of your project.

**3. Declaration & Acknowledgements *(if required)***

* A formal statement of originality
* Acknowledgements to your supervisor and any collaborators

**4. Table of Contents / List of Figures / List of Tables**

**📘 Main Body**

**5. Introduction *(2–4 pages)***

**Purpose**: Set the context, define the problem, and state the objective.

* What are variable annuities (VAs) and why are they important?
* What risk do VAs pose to insurers?
* Why are stochastic-volatility markets more realistic than Black-Scholes?
* What is dynamic hedging and how does it mitigate those risks?
* Why does this topic matter from an **enterprise risk management (ERM)** point of view?
* **Research questions / objectives**:
  1. How do stochastic-volatility models affect hedge performance for equity-linked guarantees?
  2. What is the capital implication (VaR / CTE) of hedging under realistic market conditions?
  3. Do volatility-linked fee structures materially reduce residual risk?

**6. Background & Literature Review *(6–10 pages)***

**Purpose**: Show what others have done and where your contribution fits.

**6.1 Variable Annuities and Embedded Guarantees**

* Types of guarantees: GMWB, GMDB, GLWB
* Risk exposures (market risk, longevity, lapse risk)
* Brief overview of products in real markets (e.g. U.S. and EU insurers)

**6.2 Stochastic Volatility Models**

* Heston model and extensions (e.g. rough volatility)
* Why SV models outperform Black-Scholes in long-dated options
* Realistic calibration challenges

**6.3 Dynamic Hedging Techniques**

* Delta, Delta-Gamma, Vega hedging
* Least Squares Monte Carlo (LSMC) for path-dependent contracts
* Automatic differentiation (optional advanced angle)

**6.4 Risk Measures in ERM**

* Value-at-Risk (VaR) and Conditional Tail Expectation (CTE)
* Regulatory background (Solvency II, IFRS 17, ORSA)
* Capital efficiency metrics and enterprise-level optimization

**6.5 Recent Advances and Gaps**

* Deep learning and reinforcement learning in hedging (e.g. deep targeted hedging)
* Shapley decomposition and risk attribution
* Literature gap your project fills

**7. Methodology *(5–7 pages)***

**Purpose**: Precisely explain how you will conduct your research.

**7.1 Modelling Framework**

* Description of stochastic volatility model used (e.g. Heston)
* Risk-neutral measure assumptions
* Equation of VA guarantee payoffs (e.g. GLWB with path dependence)

**7.2 Simulation and Calibration**

* Monte Carlo setup: number of paths, rebalancing frequency
* Market calibration to real SPX option data
* Greek computation (finite difference vs auto-diff)

**7.3 Hedging Strategy Design**

* Hedging approach (delta, delta-gamma, etc.)
* Portfolio update rules and transaction costs (if any)

**7.4 Fee Structure Design (if included)**

* Volatility-linked vs fixed fee
* Implementation logic

**7.5 Risk Measures and Performance Evaluation**

* How VaR and CTE are computed
* Other metrics: hedge error, P&L distribution, capital buffer levels

**8. Results & Analysis *(7–12 pages)***

**Purpose**: Present and interpret numerical results.

**8.1 Hedge Performance Across Models**

* Comparison: Black-Scholes vs Heston vs rough volatility
* Hedge error plots over time
* Distribution of hedge P&L

**8.2 Capital Requirement Outcomes**

* VaR and CTE comparison across models
* Impact of SV on required economic capital
* Tables and visualizations

**8.3 Fee Structure Sensitivity**

* Fixed fee vs volatility-linked fee
* Capital efficiency improvement (if any)

**8.4 Risk Attribution (optional advanced section)**

* Use Shapley decomposition to isolate risk sources
* Heatmaps or bar charts of risk contribution

**9. Discussion *(2–4 pages)***

**Purpose**: Put your results in context.

* What insights do the results provide for insurers?
* How reliable are the results given model assumptions?
* Are there trade-offs between hedge quality and capital efficiency?
* How do your findings fit into existing actuarial risk management literature?

**10. Conclusion & Future Work *(1–2 pages)***

* Summary of key findings
* Practical implications for actuaries and risk managers
* Limitations and possible extensions (e.g., adding mortality/lapse risk, using RL)

**📎 Appendices**

* Mathematical derivations (e.g. PDE for Greeks)
* Code snippets (Monte Carlo setup, Greek estimation)
* Supplementary figures
* Data sources and calibration outputs

**📚 References**

Use a consistent academic style (e.g., Harvard, IEEE, or Journal of Risk and Insurance style). Cite all papers, textbooks, and datasets.

**🛠 Tools You’ll Likely Use:**

* **Python** (NumPy, pandas, matplotlib, JAX or PyTorch, QuantLib)
* **LaTeX** (for document writing)
* **GitHub** (for version control)
* **Excel** (for plotting / capital results summary)

Would you like me to help you build a Notion dashboard or Excel sheet to track each of these parts step-by-step? Or we can begin drafting your **Section 6 Literature Review** from the papers you've uploaded.