### **Title Page**

* Title: Stock Price Prediction Using LSTM Neural Networks and Hyperparameter Tuning
* Author's Name
* Date
* Institution/Organization (if applicable)

### **Abstract (1 page)**

* A concise summary of the problem statement, objectives, methodology, key findings, and conclusions.

### **Table of Contents (1 page)**

* List all sections and subsections with page numbers.

### **1. Introduction (3-4 pages)**

* 1.1 Background
  + Overview of stock price prediction in financial markets.
  + Importance of accurate stock price prediction.
* 1.2 Problem Statement
  + Explanation of the problem: predicting stock prices using LSTM neural networks.
* 1.3 Objectives
  + Develop and optimise an LSTM model for predicting stock prices.
  + Determine the best hyperparameters for the LSTM model.
  + Identify the optimal window size for prediction using historical data.
* 1.4 Scope of the Study
  + Focus on four of the most volatile stocks in the S&P 500 index.
* 1.5 Structure of the Report
  + Overview of what each section will cover.

### **2. Literature Review (5-6 pages)**

* 2.1 Stock Price Prediction Using Neural Networks
  + History and evolution of neural networks in financial forecasting.
  + Focus on time-series prediction using LSTM models.
* 2.2 LSTM for Time-Series Data
  + Detailed explanation of LSTM architecture.
  + How LSTM captures long-term dependencies and patterns in stock price data.
* 2.3 Hyperparameter Tuning in Neural Networks
  + Importance of hyperparameter tuning in LSTM models.
  + Commonly tuned hyperparameters (e.g., learning rate, batch size, number of LSTM layers, number of units per layer).
* 2.4 Window Size in Time-Series Forecasting
  + Role of window size in time-series forecasting.
  + Previous research or insights on selecting window size in stock prediction.

### **3. Data Collection and Preprocessing (5-6 pages)**

* 3.1 Data Collection
  + Description of the data source (historical stock price data).
  + Criteria for selecting the four most volatile stocks from the S&P 500 (based on volatility index).
* 3.2 Data Exploration
  + Statistical summary of the selected stocks.
  + Volatility analysis: rationale for choosing these stocks.
  + Visualisations of stock price trends and volatility.
* 3.3 Data Preprocessing
  + Handling missing data (if any).
  + Normalisation or scaling of stock prices.
  + Creating the dataset with different window sizes (e.g., 90 days).
  + Splitting the dataset into training, validation, and test sets.

### **4. Model Development and Window Size Optimization (6-7 pages)**

* 4.1 LSTM Model Architecture
  + Detailed description of the LSTM model architecture used.
  + Explanation of key components: input layer, LSTM layers, dropout layers, dense layers, output layer.
* 4.2 Model Training and Evaluation
  + Training process: optimizer, loss function, and evaluation metrics (e.g., RMSE, MAE).
  + Initial model performance without hyperparameter tuning.
* 4.3 Window Size Optimization
  + Methodology for testing different window sizes.
  + Results and analysis: identifying the best window size for each stock.
  + Final selection of window size based on performance metrics.

### **5. Hyperparameter Tuning (7-8 pages)**

* 5.1 Overview of Hyperparameter Tuning Techniques
  + Explanation of the three tuning techniques used (e.g., Grid Search, Random Search, Bayesian Optimization).
* 5.2 Implementation of Hyperparameter Tuning
  + Detailed process of applying each tuning technique to the LSTM model.
  + List of hyperparameters tuned (e.g., learning rate, number of epochs, batch size, number of LSTM units).
* 5.3 Comparison and Results
  + Performance of the model under each tuning technique.
  + Comparison based on metrics like prediction accuracy, computational cost, and convergence speed.
  + Selection of the best hyperparameter configuration.

### **6. Results and Discussion (6-7 pages)**

* 6.1 Final Model Performance
  + Performance of the optimised LSTM model on the test set.
  + Comparison of model predictions with actual stock prices.
* 6.2 Analysis of Volatile Stocks
  + Specific insights gained from the model's performance on each of the four volatile stocks.
  + Discussion on how volatility affected prediction accuracy.
* 6.3 Discussion on Hyperparameter Tuning and Window Size
  + How the choice of window size and hyperparameters impacted the model’s performance.
  + Strengths and limitations of the tuning techniques used.

### **7. Conclusion and Future Work (3-4 pages)**

* 7.1 Summary of Key Findings
  + Recap of the study's main findings: optimal window size, best hyperparameters, and model performance.
* 7.2 Limitations
  + Discuss any limitations related to data, model, or methodology.
* 7.3 Practical Implications
  + How the findings can inform trading strategies and investment decisions.
* 7.4 Future Research Directions
  + Suggestions for extending the research, such as testing more stocks, exploring other neural network architectures, or advanced tuning methods.

### **8. References (2-3 pages)**

* List all sources cited in the report.

### **9. Appendices (Optional)**

* A.1 Detailed Hyperparameter Configurations
  + Specific hyperparameter settings for each tuning method.
* A.2 Additional Visualisations
  + Additional plots or charts that support the main text.
* A.3 Code Snippets
  + Key sections of code used for model development and tuning.

### **Additional Notes:**

* Visual Aids: Include relevant figures, tables, and charts to visually represent your findings, such as model performance with different window sizes, or comparison charts of hyperparameter tuning techniques.
* Flow and Clarity: Ensure a logical flow from one section to another. Each section should build upon the previous one, with clear explanations and technical details where necessary.
* Proofreading to be done.