**Model Optimization and Tuning Phase Template**

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| Date | 24 June 2025 |
| Team | **AS PS VS VV** |
| Project Title | Unemployed Insurance Beneficiary Forecasting |
| Maximum Marks | 10 Marks |

**Model Optimization and Tuning Phase**

The Model Optimization and Tuning Phase involves refining machine learning models for peak performance. It includes optimized model code, fine-tuning hyperparameters, comparing performance metrics, and justifying the final model selection for enhanced predictive accuracy and efficiency.

### Hyperparameter Tuning Documentation (6 Marks):

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| **Model** | **Tuned Hyperparameters** | **Optimal Values** |
| ARIMA | p, d, q | (5, 0, 0) |
| SARIMA | p, d, q, seasonal\_order | (5, 0, 0), (0, 1, 2, 3) |
| AutoReg | lags | 10 |
| VAR | maxlags | 10 |
| Prophet | NA | Default (no tuning) |

### Performance Metrics Comparison Report (2 Marks):

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| --- | --- | --- |
| **Model** | **Baseline Metric (MSE/MAE/R2)** | **Optimized Metric** |
| ARIMA | MSE: (initial) NA | MSE: 102,763,733.35 MAE: 5,691.37 R2: -8.18e-05 |
| SARIMA | MSE: (initial) NA | MSE: 103,545,015.68 MAE: 5,862.50 R2: NA |
| AutoReg | MSE: (initial) NA | MSE: 102,771,796.73 MAE: 5,862.50 R2: NA |
| VAR | MSE: NA | NA |
| Prophet | MSE: (initial) NA | MSE: 57,301,995.56 MAE: 3,522.24 R2: -0.1636 |

*Note: Baseline metrics are marked NA as only optimized models were evaluated in this workflow. R2 is not always applicable for all models, especially for multivariate or differenced series.*

### Final Model Selection Justification (2 Marks):

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| --- | --- |
| **Final Model** | **Reasoning** |
| Prophet | Prophet achieved the lowest MSE and MAE among all tested models, indicating better predictive accuracy. It also handled trends and seasonality automatically, required minimal tuning, and provided interpretable forecasts. Despite a negative R2, its absolute error metrics were superior, making it the most suitable choice for this forecasting task. |