# Manual SARIMA Calculation for Forecasting

## globe-with-meridians SARIMA: Seasonal ARIMA

SARIMA combines ARIMA with seasonal components to handle:

- check-mark-button Trend
- check-mark-button Seasonality (repeating patterns like monthly/weekly effects)
- check-mark-button Noise

## open-book SARIMA General Formula

$$y'_t = c + \phi_1 y'_{t-1} + \theta_1 e_{t-1} + \Phi_1 y'_{t-s} + \Theta_1 e_{t-s} + \epsilon_t$$

Where:

| Term | Meaning |
|---|---|
| $c$ | Constant (intercept / drift) |
| $\phi_1 y'_{t-1}$ | AutoRegression (AR) – previous value |
| $\theta_1 e_{t-1}$ | Moving Average (MA) – previous error |
| $\Phi_1 y'_{t-s}$ | Seasonal AR – value from previous season |
| $\Theta_1 e_{t-s}$ | Seasonal MA – error from previous season |
| $\epsilon_t$ | Random noise |

Table 1: SARIMA Formula Terms

## memo What is $c$ in SARIMA?

Like ARIMA, $c$ is the constant term or intercept, representing the baseline mean level of the differenced data before seasonal adjustments. With seasonality, $c$ often acts as a seasonal drift if the series has upward or downward movement after differencing.

## fire Example (Monthly Forecast)

Forecasting air passengers:

| Month | Actual | Forecast | Error (Actual - Forecast) |
|---|---|---|---|
| Jan | 100 | – | – |
| Feb | 120 | 110 | +10 |
| Mar | 150 | 130 | +20 |
| Apr | ? | 189.5 | ? |
| Apr (prev year) | 80 | – | – |

Table 2: Passenger Data with Forecasts

**Formula for April Forecast**

$$y'_{Apr} = c + \underbrace{\phi_1 y'_{Mar}}_{AR} + \underbrace{\theta_1 e_{Mar}}_{MA} + \underbrace{\Phi_1 y'_{Apr-prev}}_{SeasonalAR} + \underbrace{\Theta_1 e_{Apr-prev}}_{SeasonalMA}$$

## memo Assumed Parameters

| Parameter | Value |
|---|---|
| $c$ | 5 |
| $\phi_1$ | 0.6 |
| $\theta_1$ | 0.4 |
| $\Phi_1$ | 0.3 |
| $\Theta_1$ | 0.2 |

Table 3: Assumed SARIMA Parameters

## fire Step 1: Previous Values

| Variable | Value |
|---|---|
| $y'_{Mar}$ | 30 |
| $e_{Mar}$ | +20 |
| $y'_{Apr-prev}$ | 25 |
| $e_{Apr-prev}$ | +5 |

Table 4: Previous Values for April Forecast

## ruler Step 2: Apply Formula

$$y'_{Apr} = 5 + (0.6)(30) + (0.4)(20) + (0.3)(25) + (0.2)(5)$$

$$y'_{Apr} = 5 + 18 + 8 + 7.5 + 1 = 39.5$$

This is the forecasted differenced value.

## ruler Step 3: Convert Back to Original Scale

$$y_{Apr} = y_{Mar} + y'_{Apr}$$
$$y_{Apr} = 150 + 39.5 = 189.5$$

## check-mark-button Final Forecast

The forecast for April is **189.5 passengers**.

| Month | Actual | Forecast | Error (Actual - Forecast) |
|---|---|---|---|
| Jan | 100 | – | – |
| Feb | 120 | 110 | +10 |
| Mar | 150 | 130 | +20 |
| Apr | ? | **189.5** | ? |

Table 5: Final Forecast Table

## bar-chart Visual Intuition

Contributions to the forecast:

| Component | Value Contribution |
|---|---|
| $c$ | +5 |
| AR(1) | +18 |
| MA(1) | +8 |
| Seasonal AR(1) | +7.5 |
| Seasonal MA(1) | +1 |
| **Total** | **+39.5** |

Table 6: Forecast Component Contributions

## light-bulb Key Difference from ARIMA

| ARIMA | SARIMA |
|---|---|
| Handles trend | Handles trend + seasonality |
| $c$ = intercept | $c$ = intercept + possible drift |
| Parameters: p,d,q | Parameters: p,d,q,P,D,Q,S |

Table 7: ARIMA vs. SARIMA