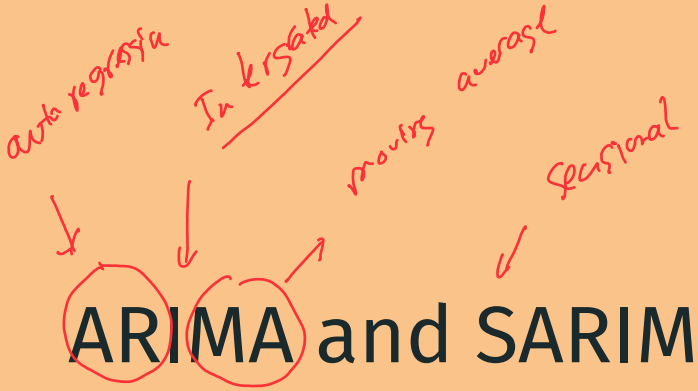


ARIMA and SARIMA Models

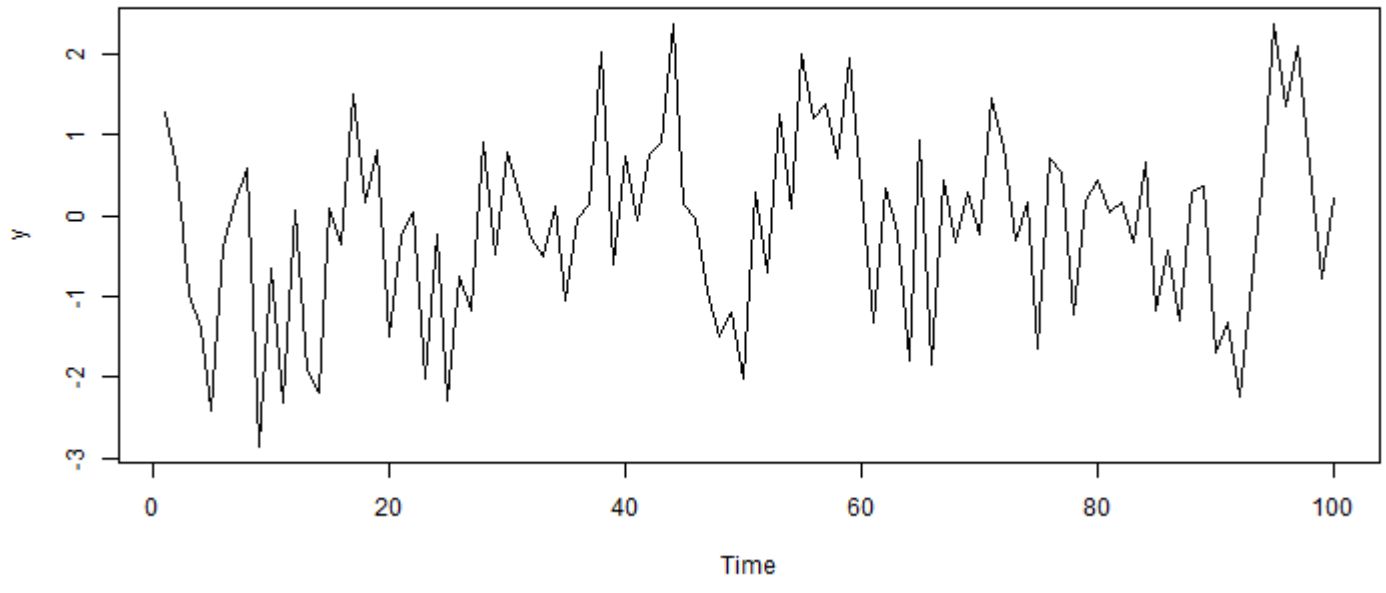
Son Nguyen

ARMA Models

- ARMA(p,q) is a combination of AR(p) and MA(q)
- ARMA(p, q) is a stationary process and can be used to model a stationary series

ARMA Models

```
set.seed(2024)
y = arima.sim(list(order=c(1,0,2), ar=c(.1), ma = c(.1, .4)), n=100)
plot(y)
```



ARIMA Models

- ARMA can not model a non-stationary data. Thus, it can not model a trend series, for example.
- If a dataset y_t is has a trend, we can use the differencing techniques (may need to difference the series multiple time) to transform the data to stationary, then model the differenced data, d_t, using the ARMA model.
- To make a forecast, we use the model to make a forecast on d_t, then calculate a forecast for y_t
- This could be `time-consuming`.

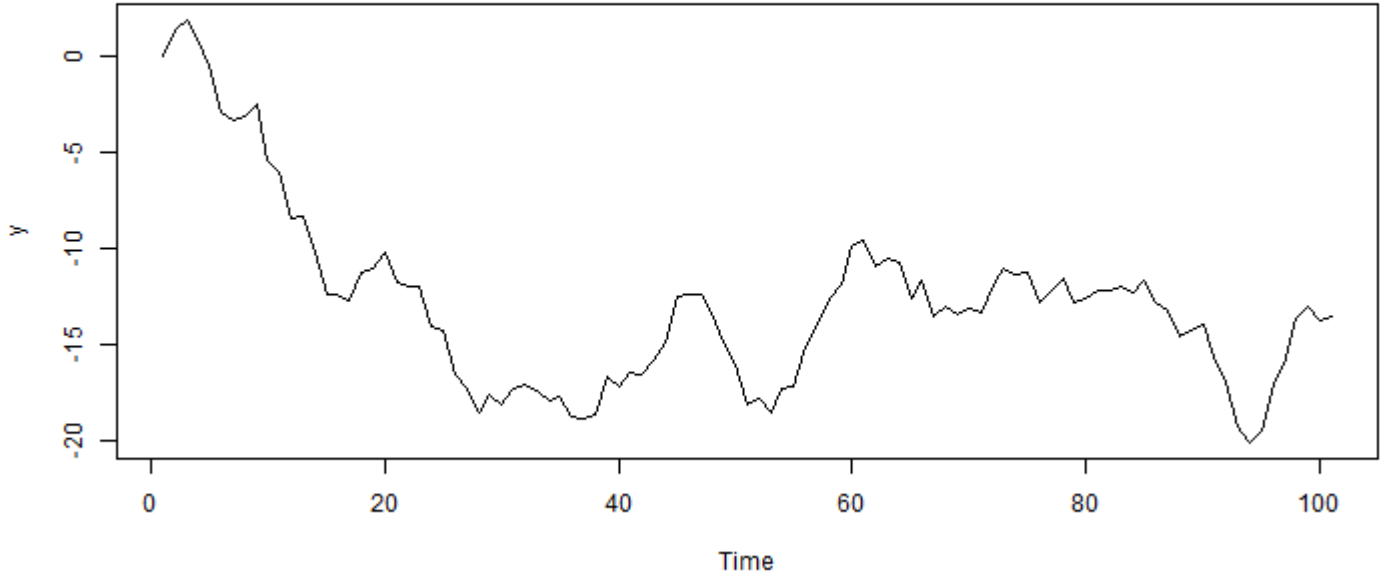
ARIMA Models

- ARIMA(p, d, q) integrate the differencing technique into the model. The parameter d is the number of time we need to difference the series to stationarize the series.
- Thus, ARIMA can model a trend series.

ARIMA Models

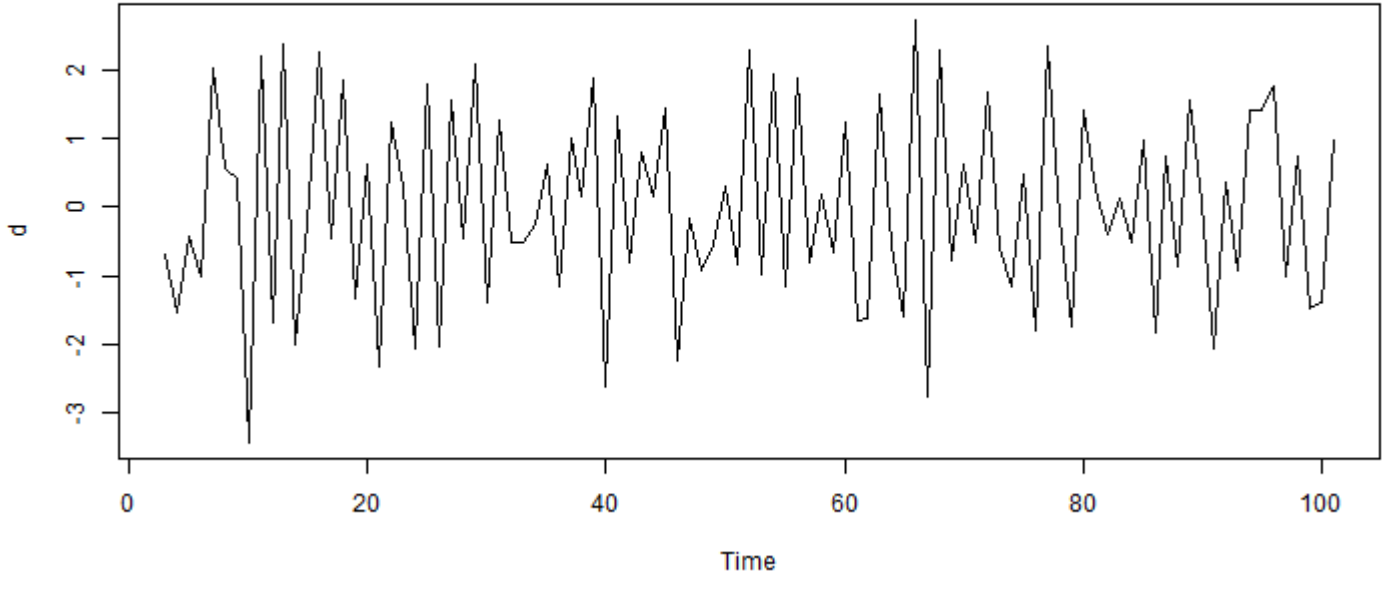
- Let simulate ARIMA with $d = 2$. This means that if we apply diffrencing two times, the series will be stationary

```
set.seed(2024)
y = arima.sim(list(order=c(1,1,2), ar=c(.1), ma = c(.1, .4)), n=100)
plot(y)
```



ARIMA Models

```
# differencing the series 2 times
d = diff(diff(y))
plot(d)
```

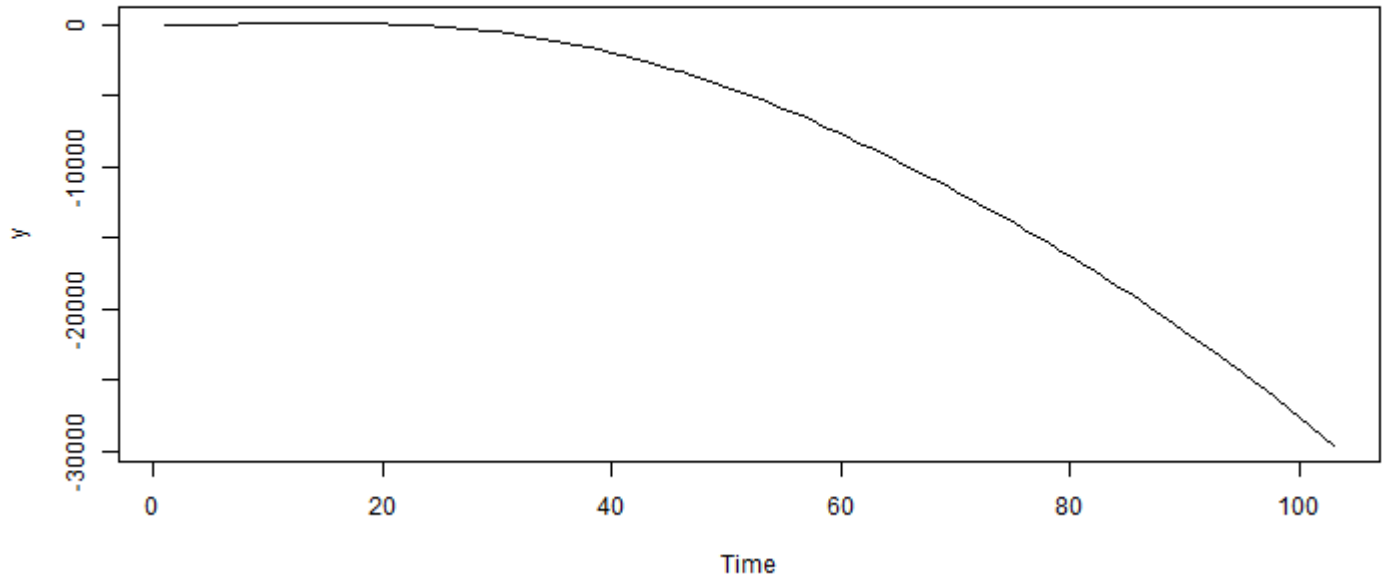


- We see that after differencing the series two time, we receive a stationary series.

ARIMA Models

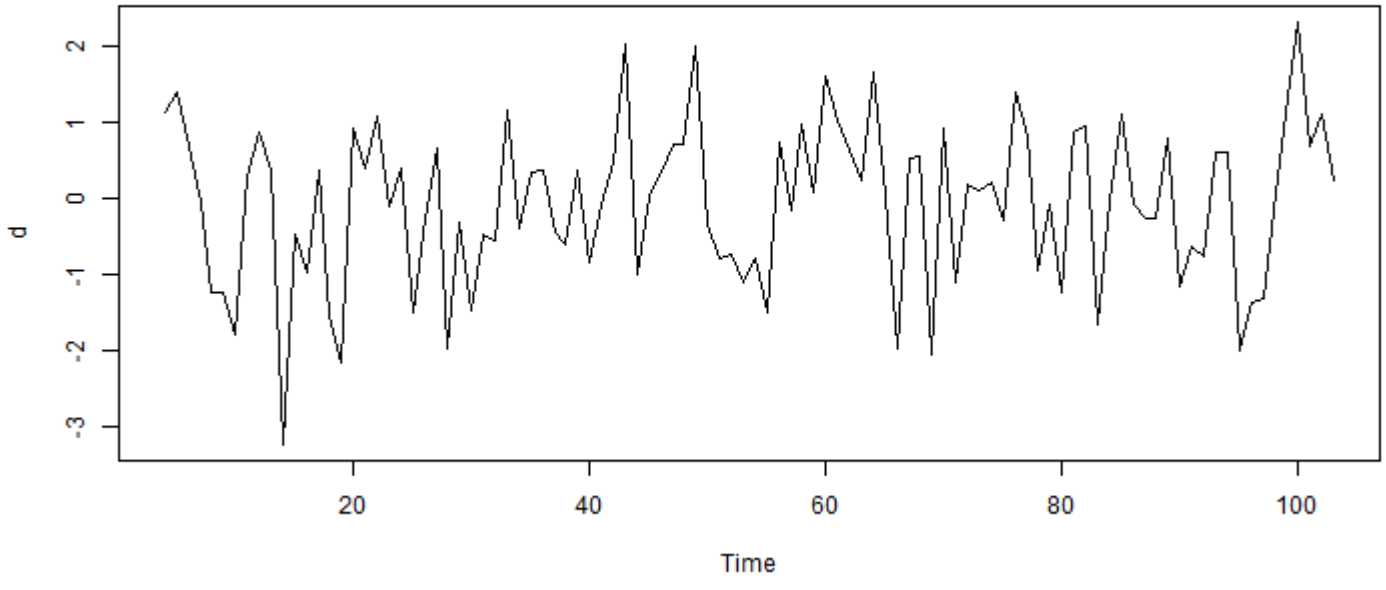
- Let simulate an ARIMA with $d = 3$.

```
set.seed(2024)
y = arima.sim(list(order=c(1,3,0), ar=c(.1)), n=100)
plot(y)
```



ARIMA Models

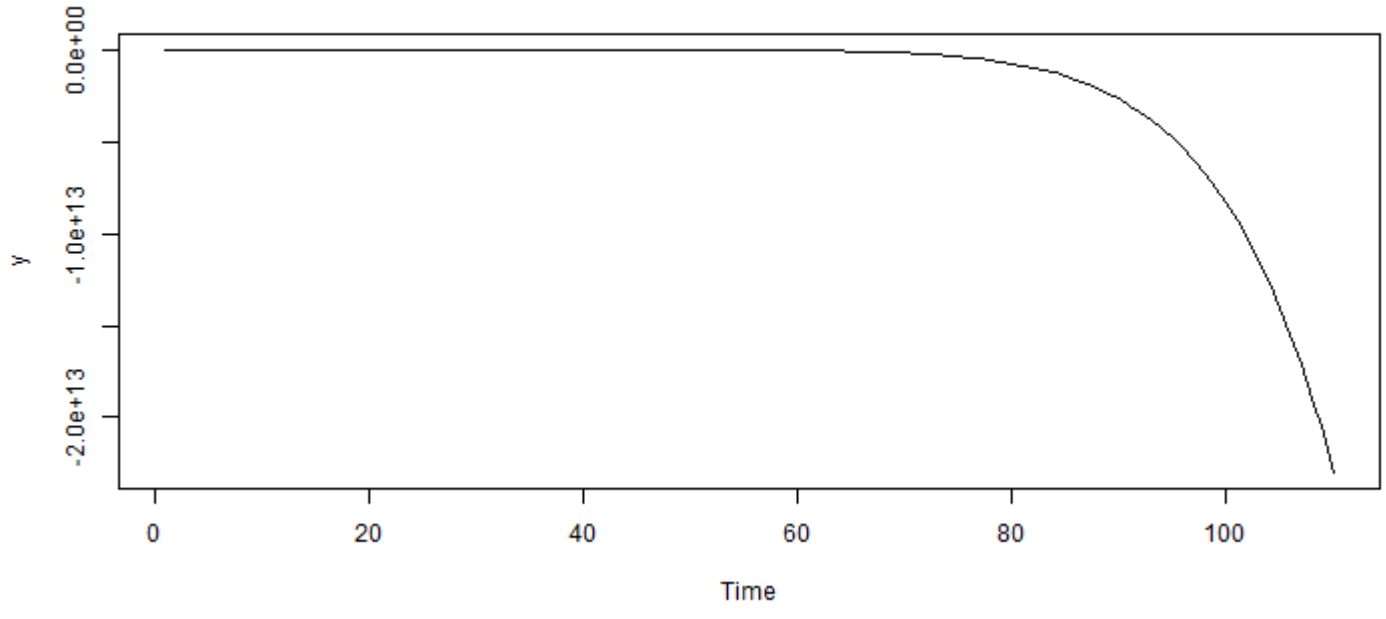
```
d = diff(diff(diff(y)))
plot(d)
```



- After diffeericing the series 3 times, we obtain a stationary series.

ARIMA Models

```
set.seed(2024)
y = arima.sim(list(order=c(1,10,2), ar=c(.1), ma = c(.1, .4)), n=100)
plot(y)
```

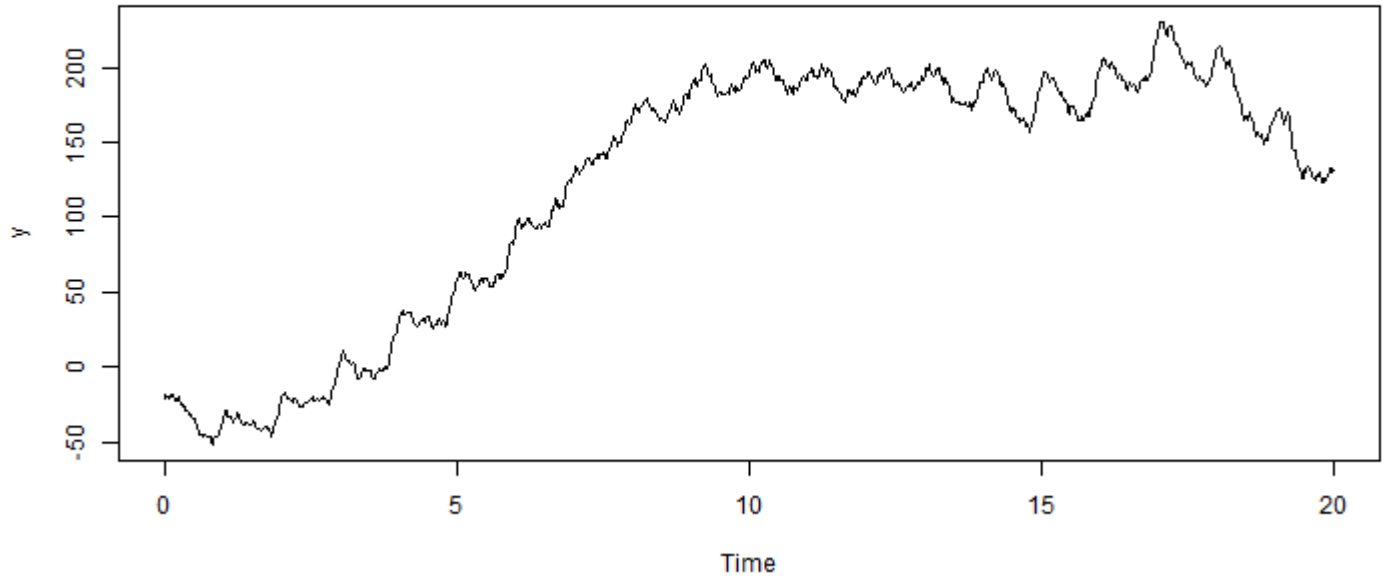


Seasonal ARIMA Models

- We see that from ARIMA can handle trend series, but what about seasonal series?
- ARIMA(p,d,q) can model a trend series but cannot model a seasonal series
- Seasonal ARIMA or SARIMA add the ability to model a seasonal component to the ARIMA models
- So from ARMA -> ARIMA -> SARIMA, the effort is to enable the ARMA to model trend and seasonal series.

SARIMA Examples

```
library(astsa)
set.seed(2024)
y = sarima.sim(ar = .5, d = 1, sar=.9, S=50, n=1000)
plot(y)
```



- This is a simulation of a SARIMA model. We observe that the series has a seasonal component. The series has trend as the result of $d = 1$.