Time Series

"The Art of Forecasting"

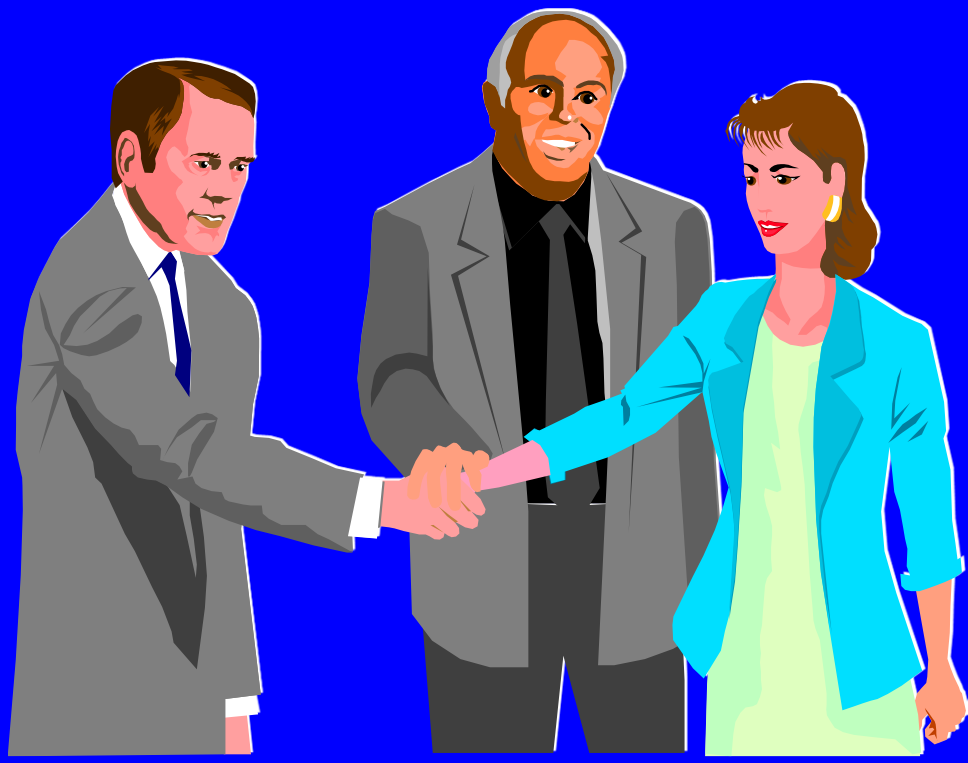
Learning Objectives

- Describe what forecasting is
- Explain time series & its components
- Forecast using trend models

  Simple Linear Regression

What Is Forecasting?

- Process of predicting a future event
- Underlying basis of all business decisions
  - Production
  - Inventory
  - Personnel
  - Facilities



Quantitative Forecasting

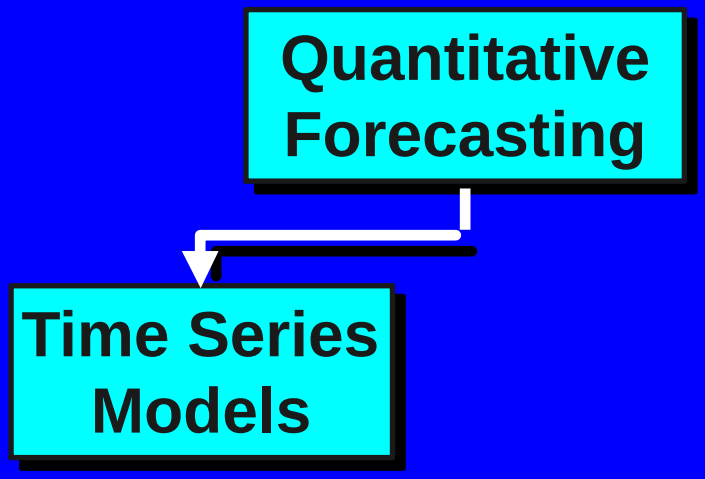
- Select several forecasting methods
- ‘Forecast’ the past
- Evaluate forecasts
- Select best method
- Forecast the future
- Monitor continuously forecast accuracy

Quantitative Forecasting Methods

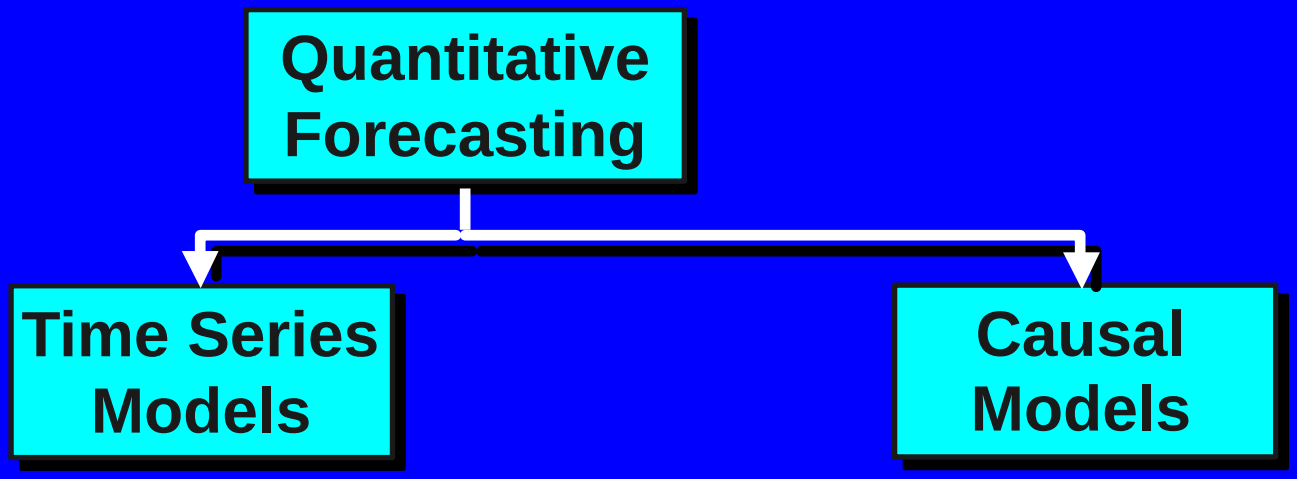
Quantitative Forecasting Methods

Quantitative Forecasting

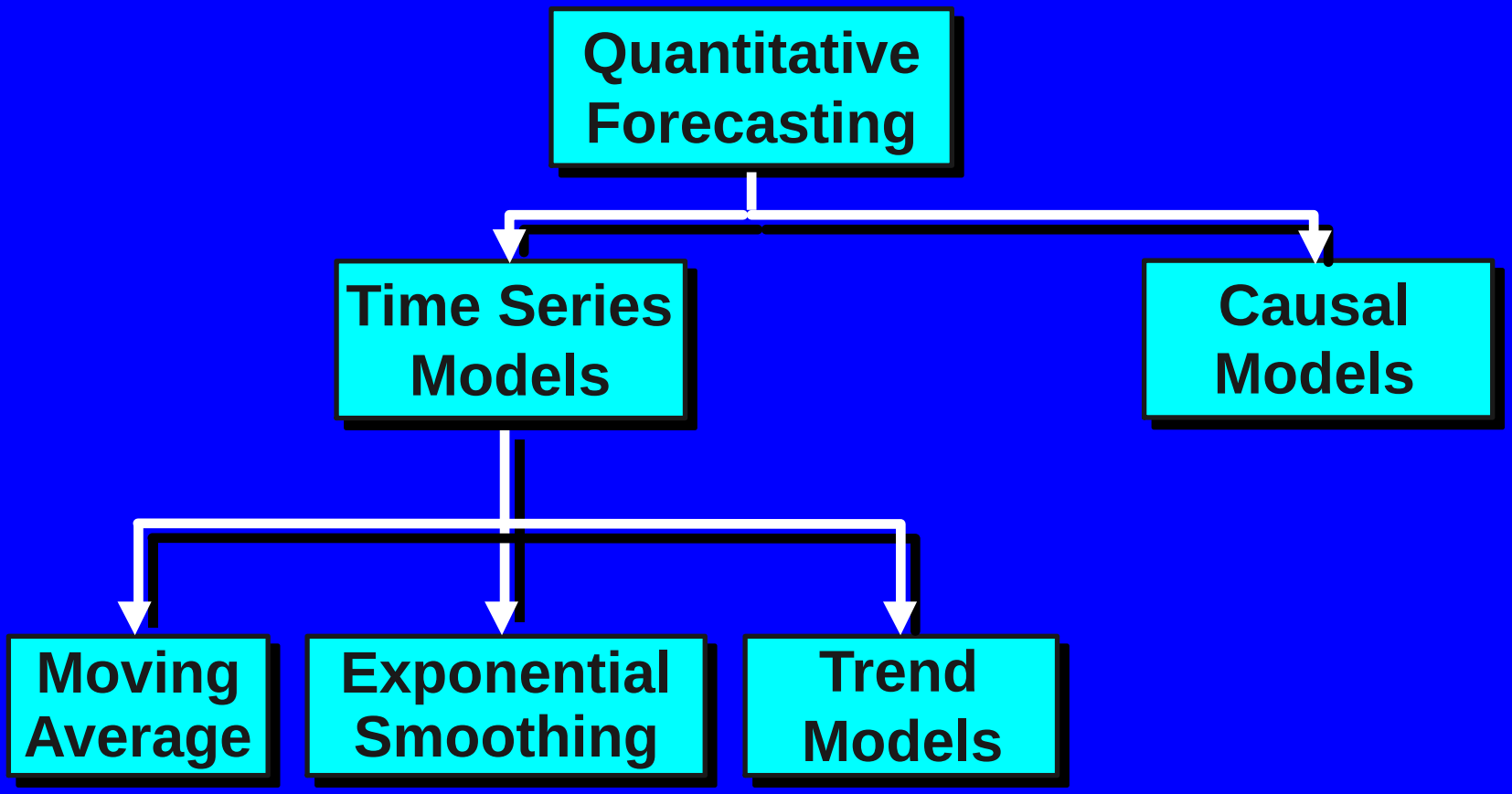
Quantitative Forecasting Methods



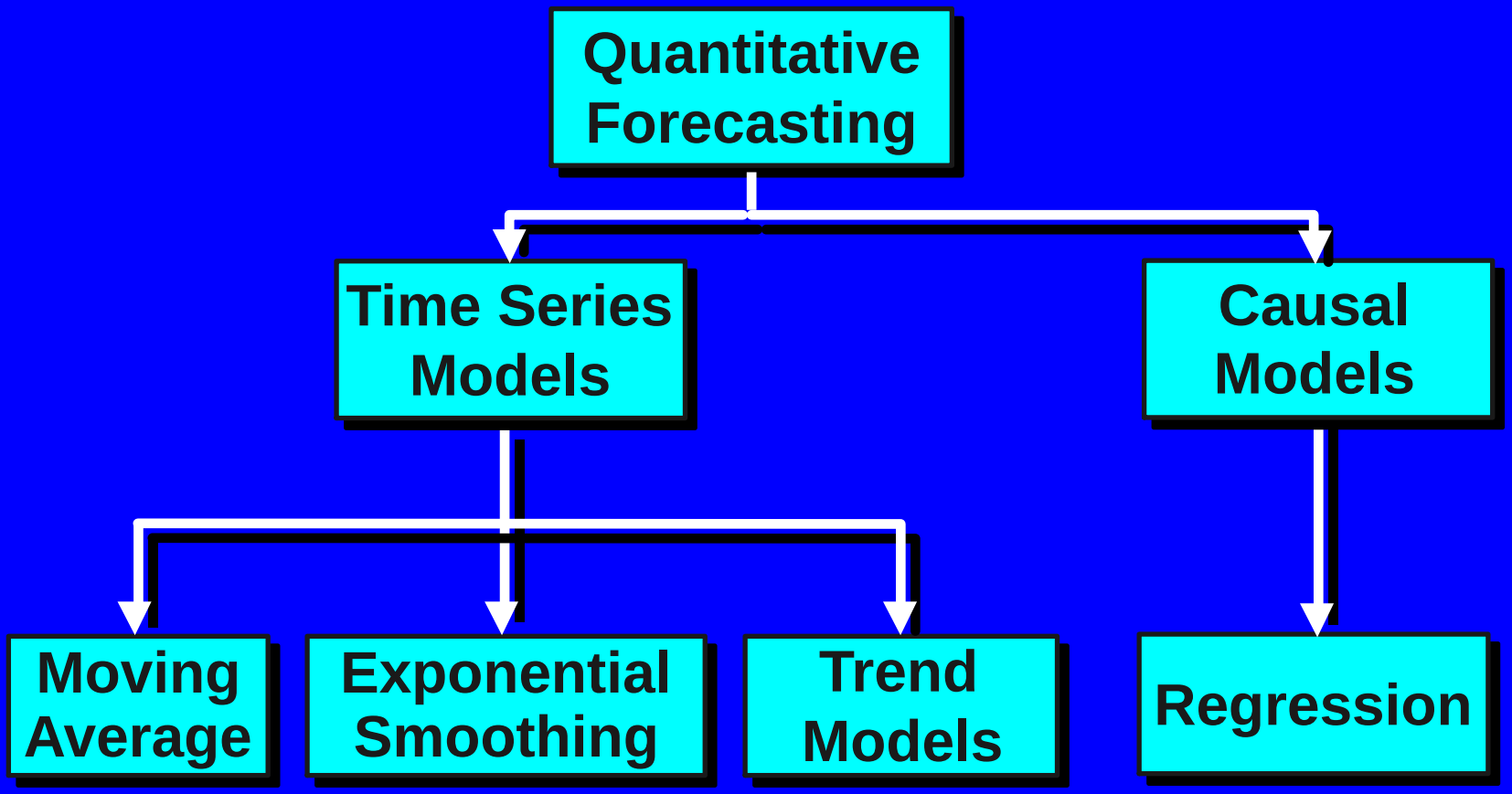
Quantitative Forecasting Methods



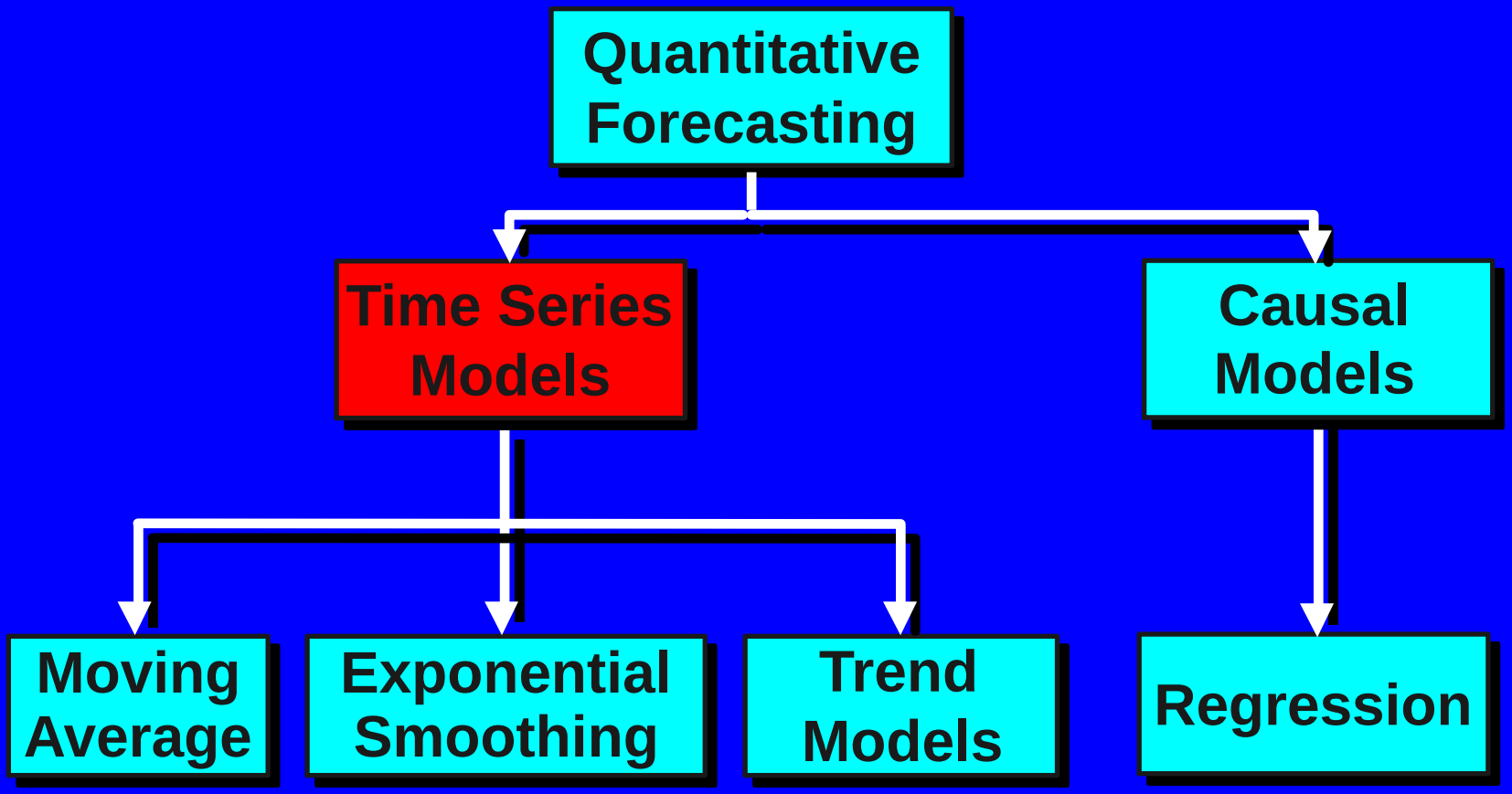
Quantitative Forecasting Methods



Quantitative Forecasting Methods



Quantitative Forecasting Methods



What is a Time Series?

- Set of evenly spaced numerical data
  - Obtained by observing response variable at regular time periods
- Forecast based only on past values
  - Assumes that factors influencing past, present, & future will continue
- Example
  - Year: 1995 1996 1997 1998 1999
  - Sales: 78.7 63.5 89.7 93.2 92.1

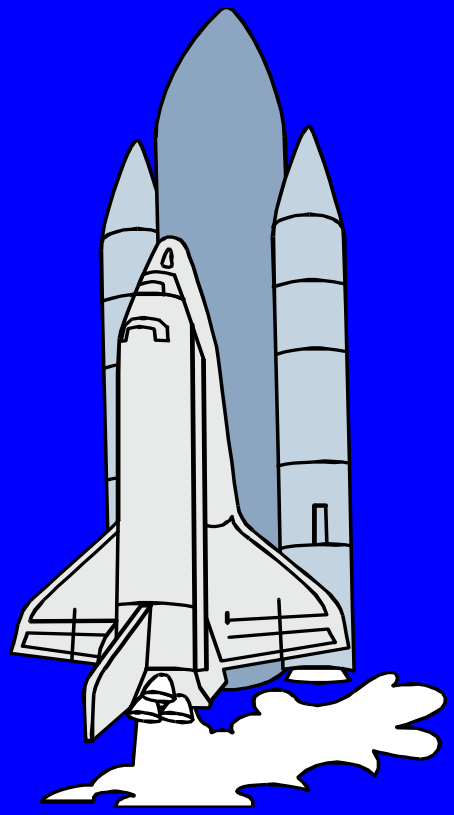
Time Series

Time series data is a sequence of observations

- **collected from a process**
- **with equally spaced periods of time.**

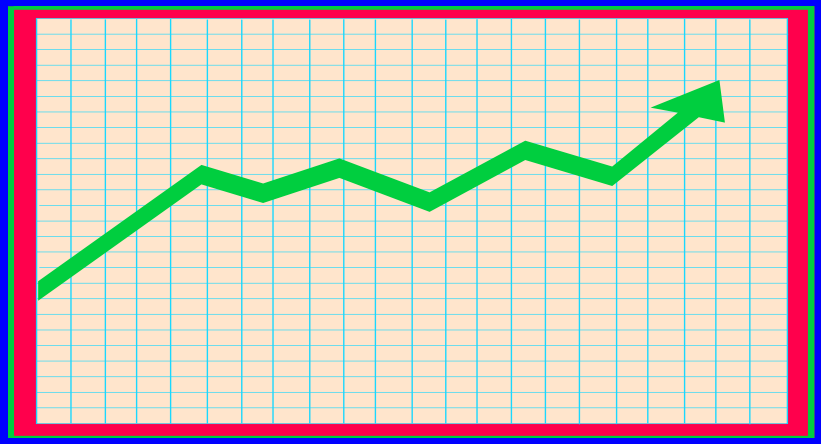
Time Series

Time series is **dynamic**, it does change over time.



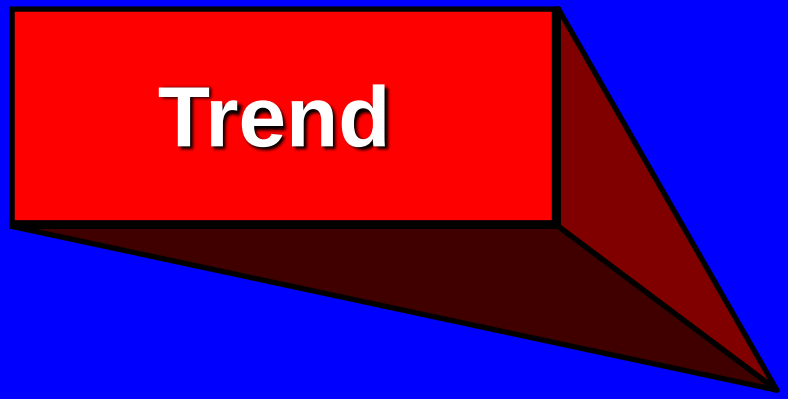
Time Series

When working with time series data, it is paramount that the data is plotted so the researcher can view the data.

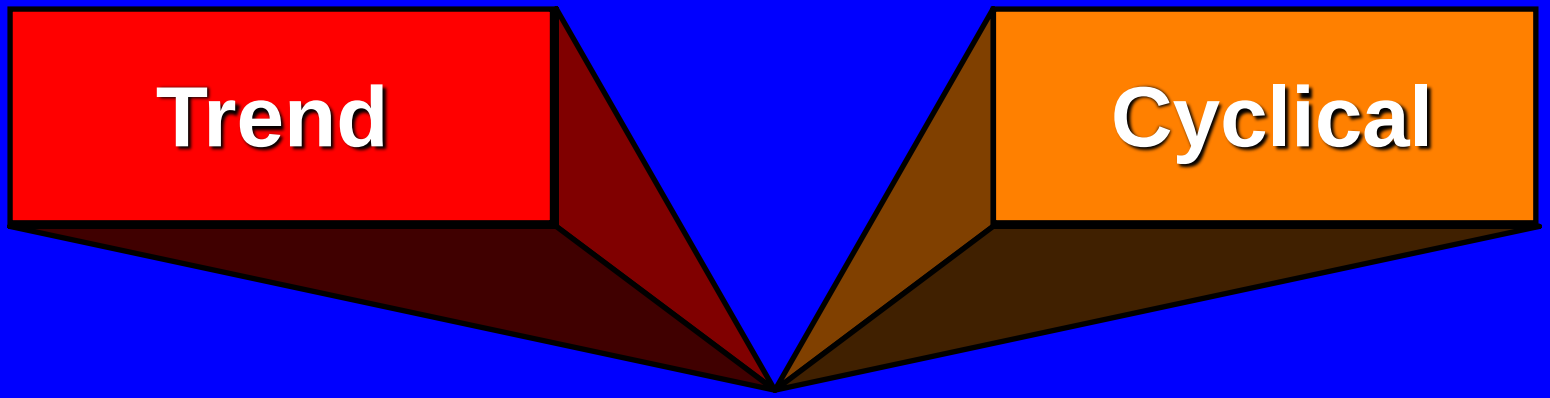


Time Series Components

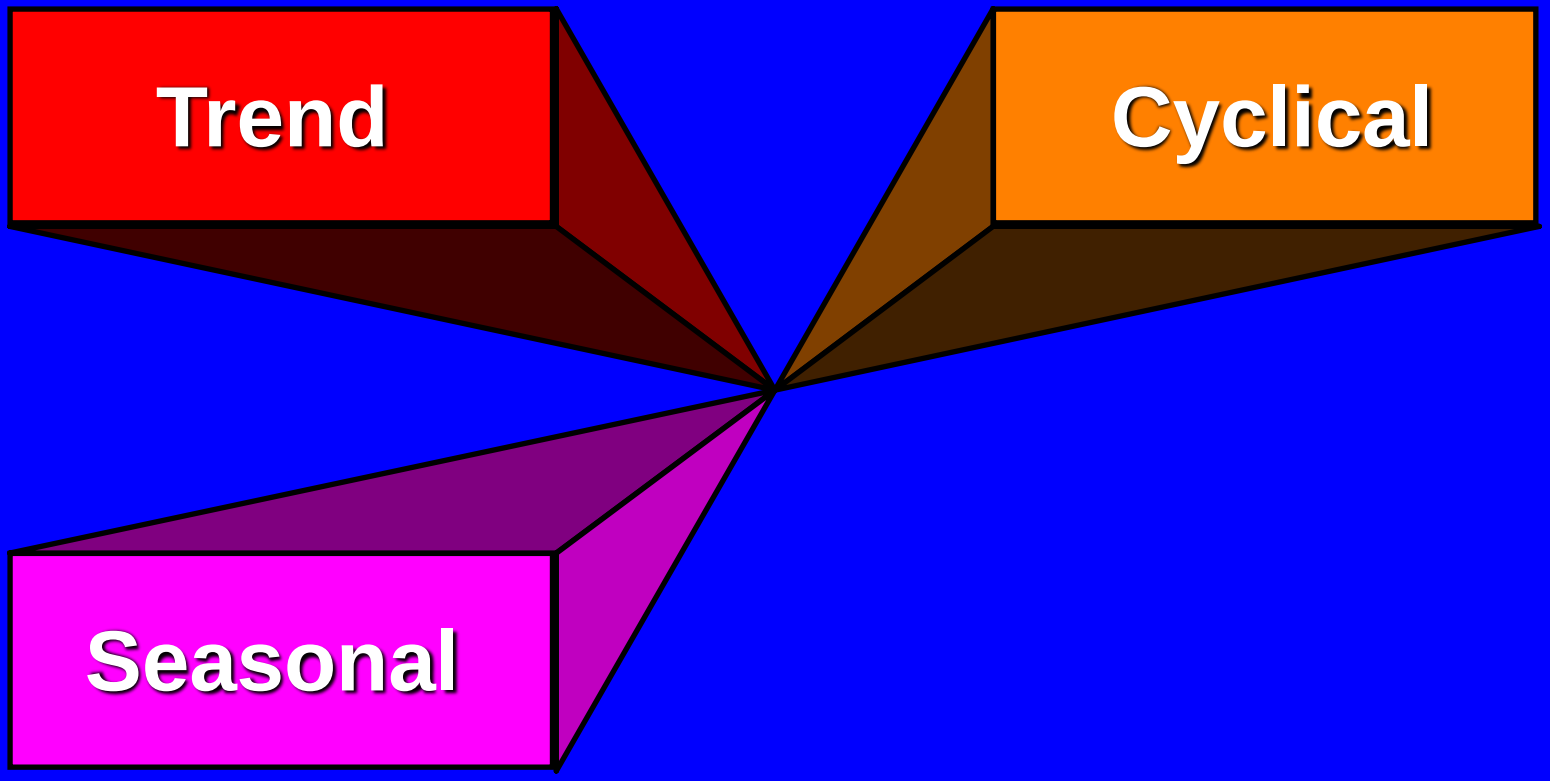
Time Series Components



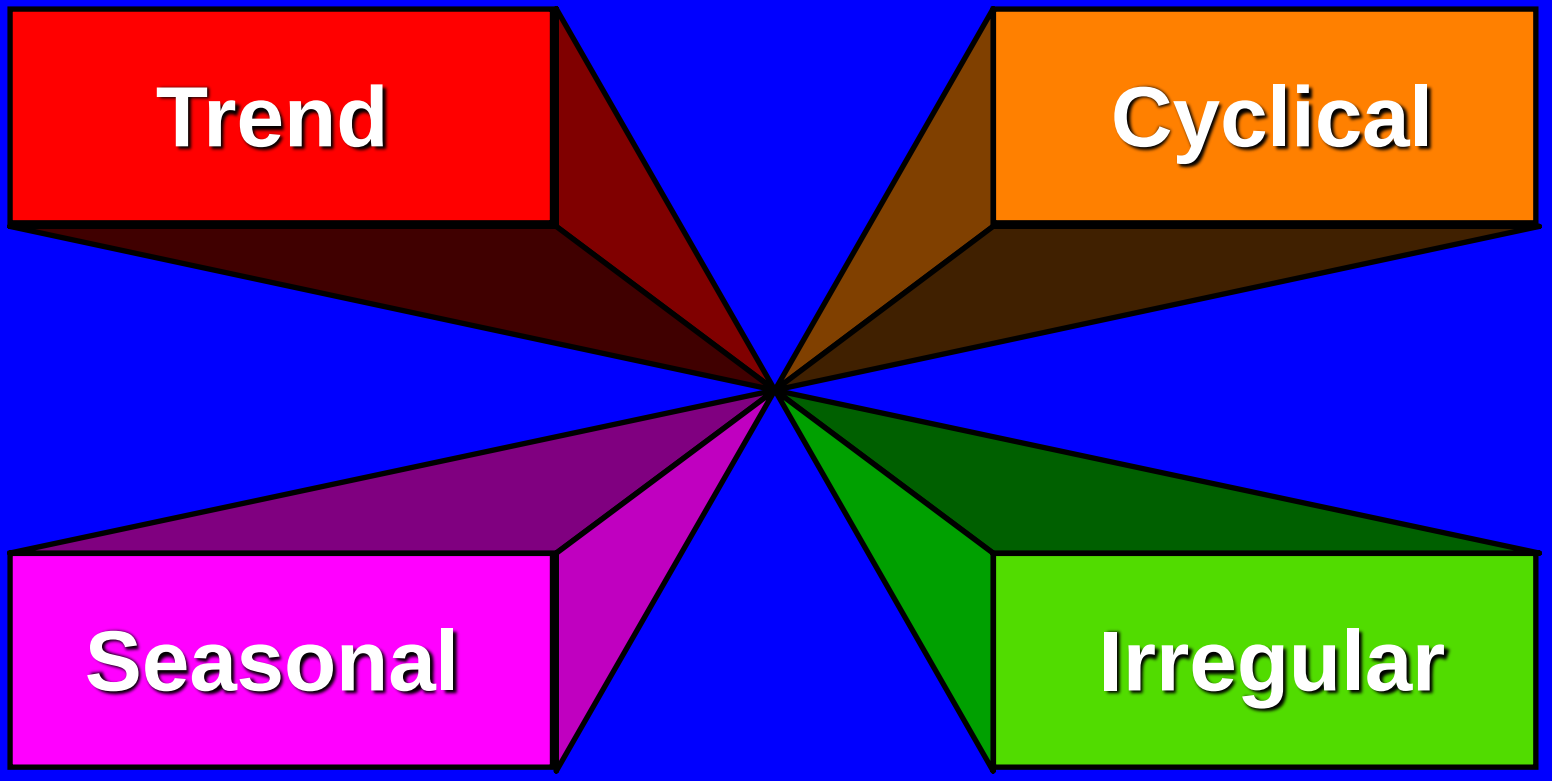
Time Series Components



Time Series Components

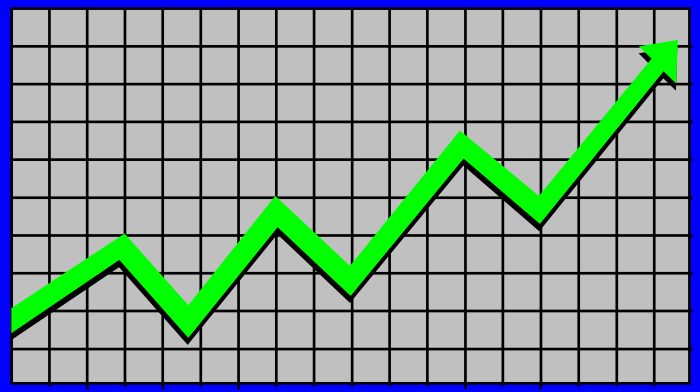


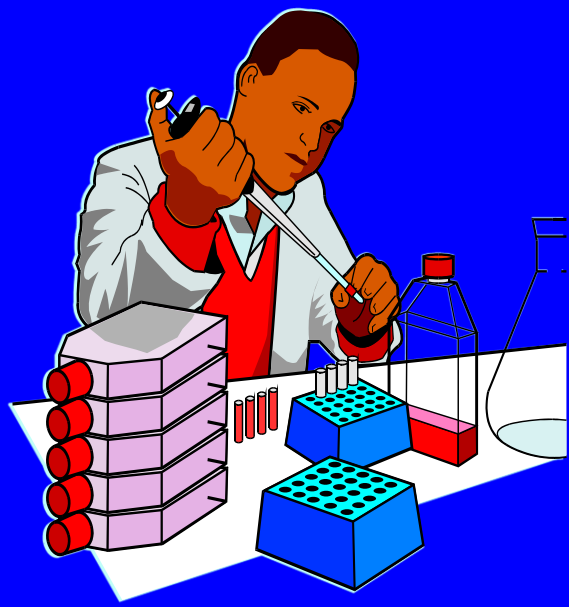
Time Series Components



Trend Component

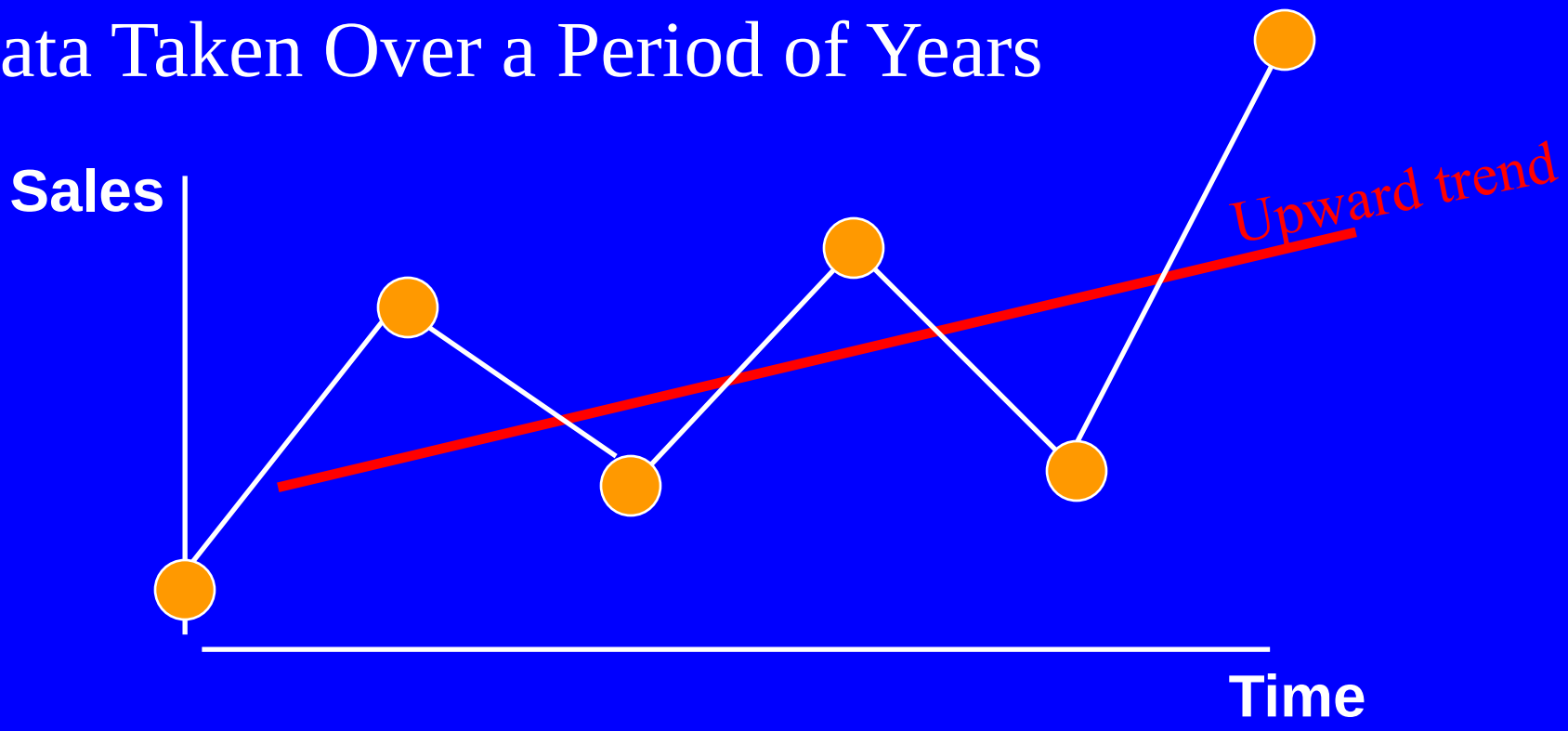
- Persistent, overall upward or downward pattern
- Due to population, technology etc.
- Several years duration





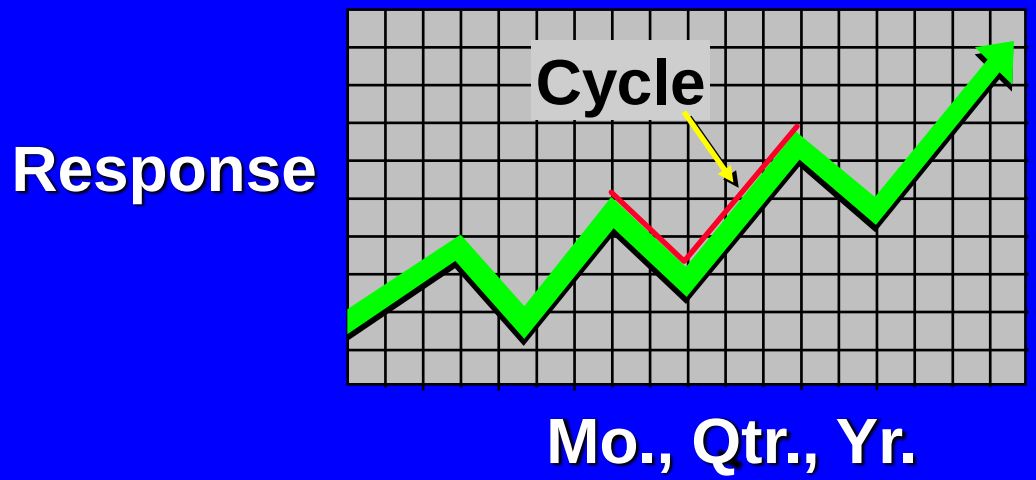
Trend Component

- Overall Upward or Downward Movement
- Data Taken Over a Period of Years



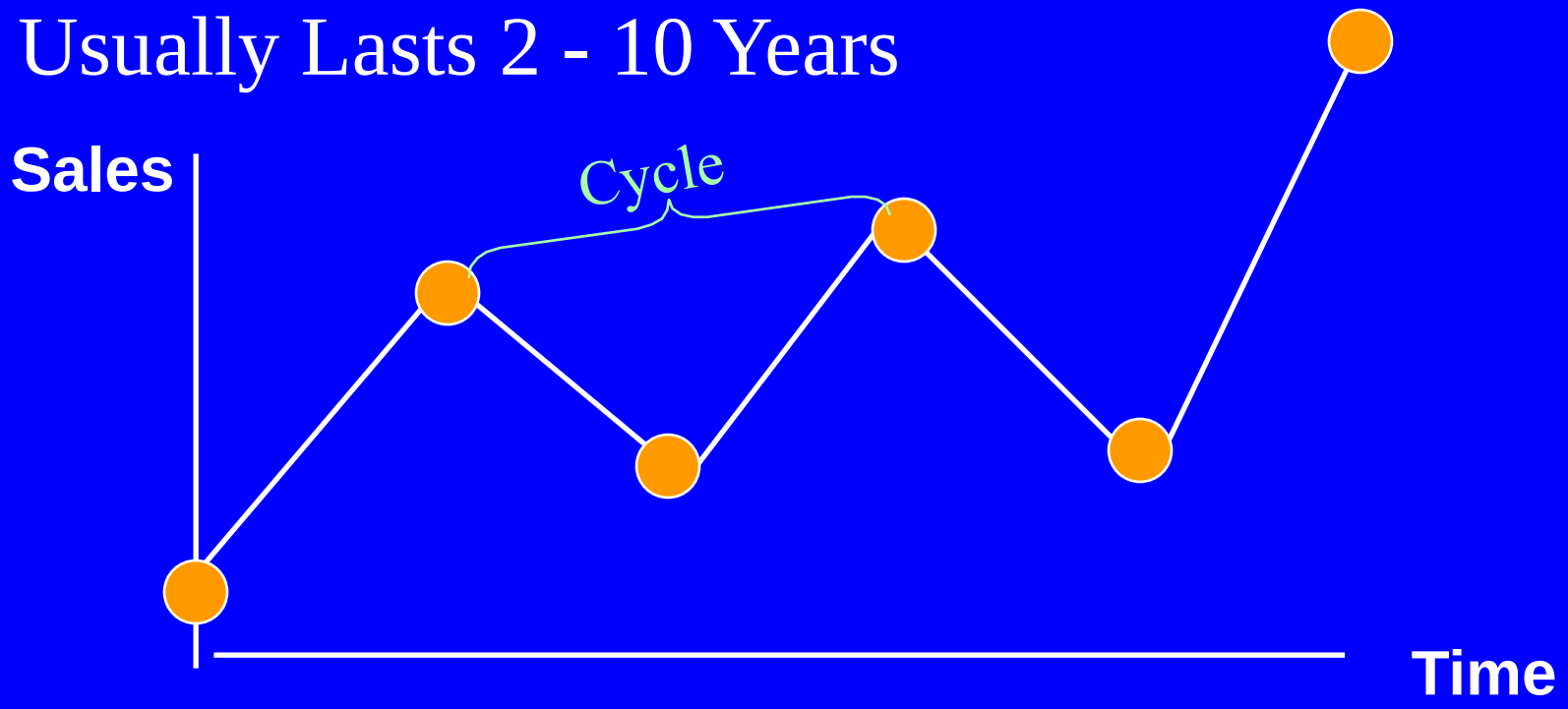
Cyclical Component

- Repeating up & down movements
- Due to interactions of factors influencing economy
- Usually 2-10 years duration



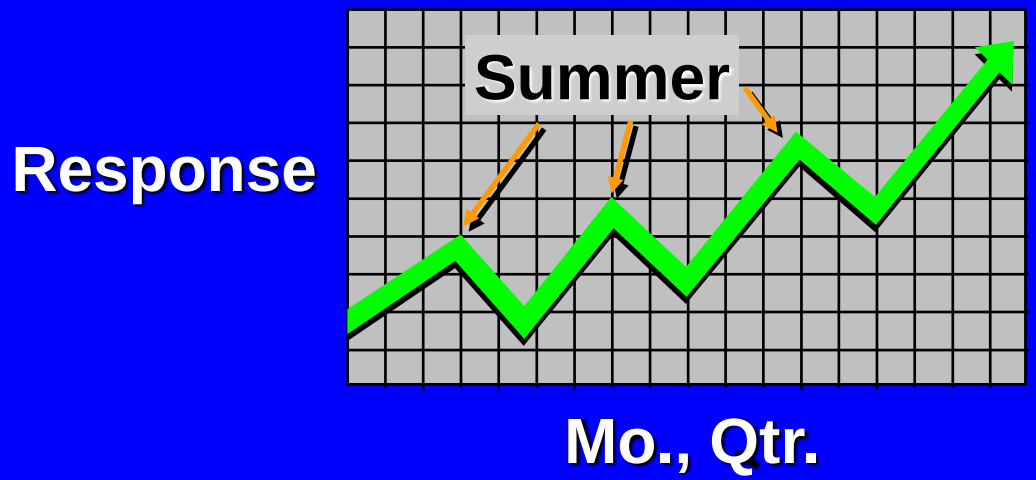
Cyclical Component

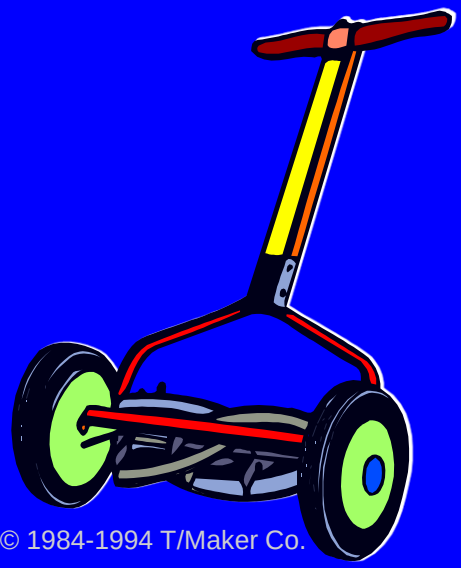
- Upward or Downward Swings
- May Vary in Length
- Usually Lasts 2 - 10 Years



Seasonal Component

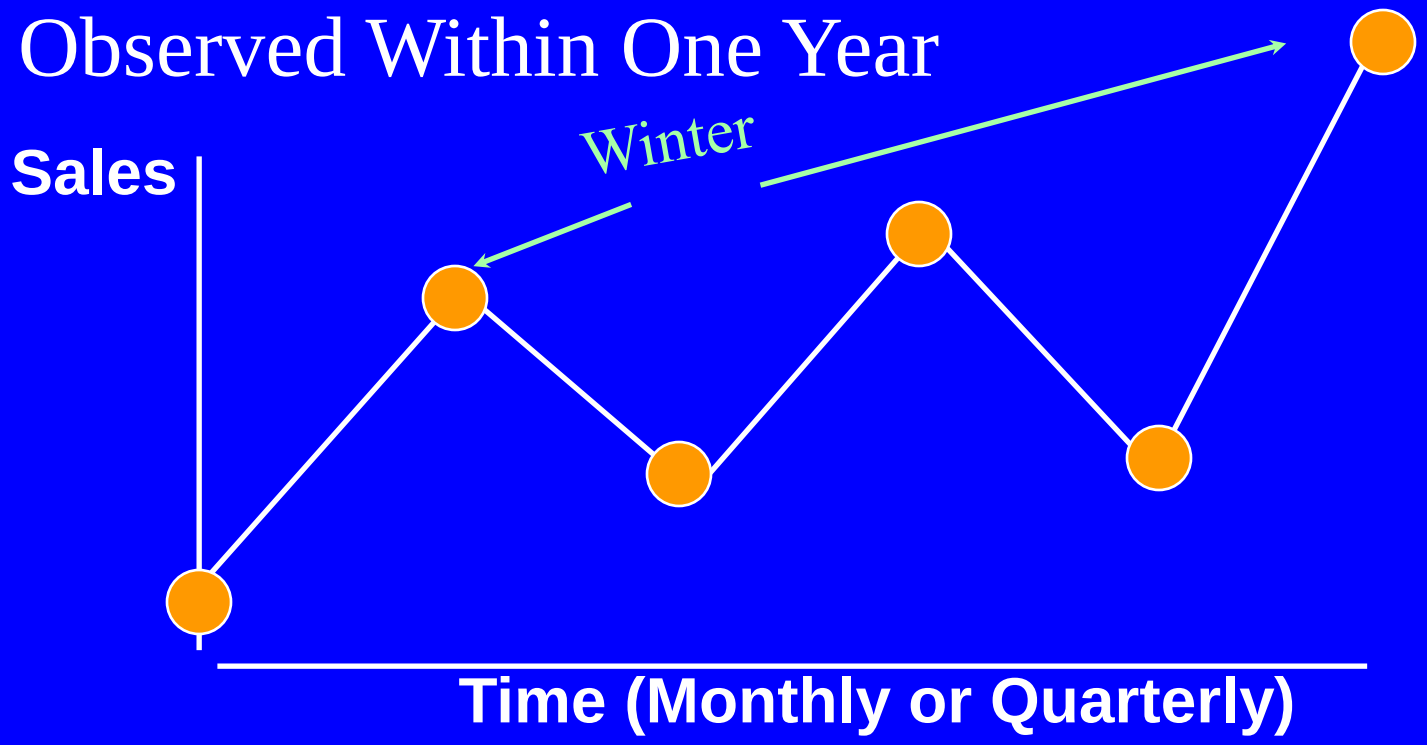
- Regular pattern of up & down fluctuations
- Due to weather, customs etc.
- Occurs within one year





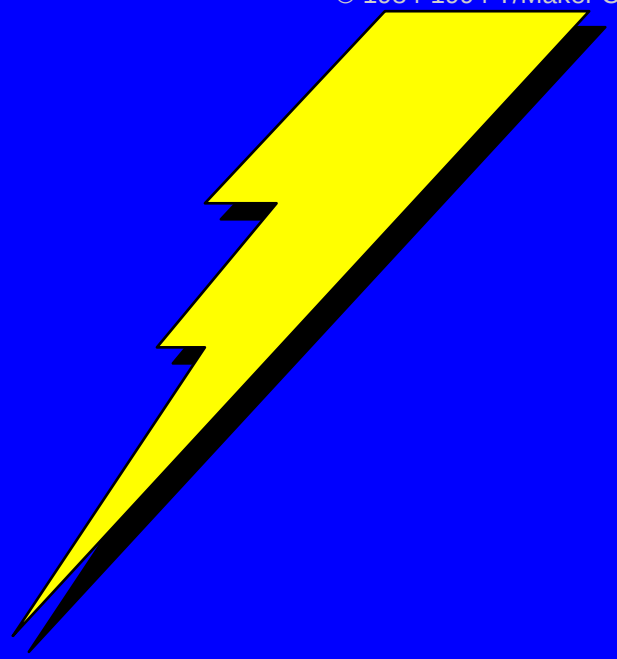
Seasonal Component

- Upward or Downward Swings
- Regular Patterns
- Observed Within One Year



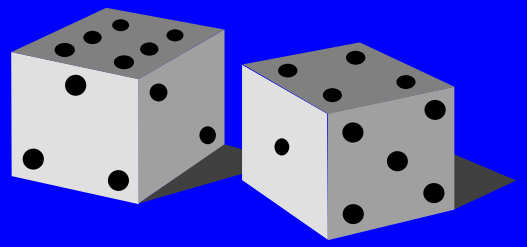
Irregular Component

- Erratic, unsystematic, ‘residual’ fluctuations
- Due to random variation or unforeseen events
  - Union strike
  - War
- Short duration & nonrepeating



Random or Irregular Component

- Erratic, Nonsystematic, Random, 'Residual' Fluctuations
- Due to Random Variations of
  - Nature
  - Accidents
- Short Duration and Non-repeating

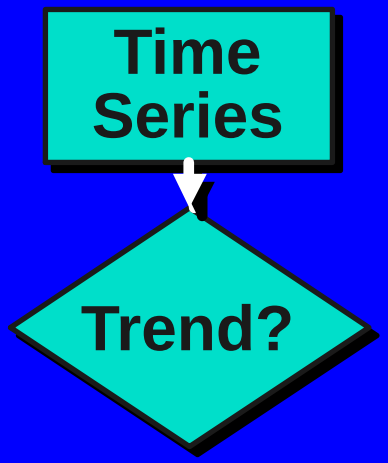


Time Series Forecasting

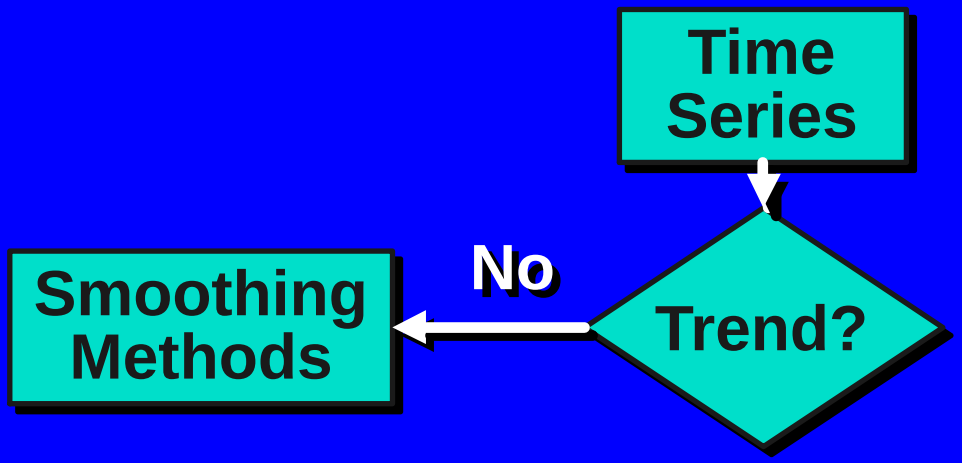
Time Series Forecasting

Time Series

Time Series Forecasting



Time Series Forecasting



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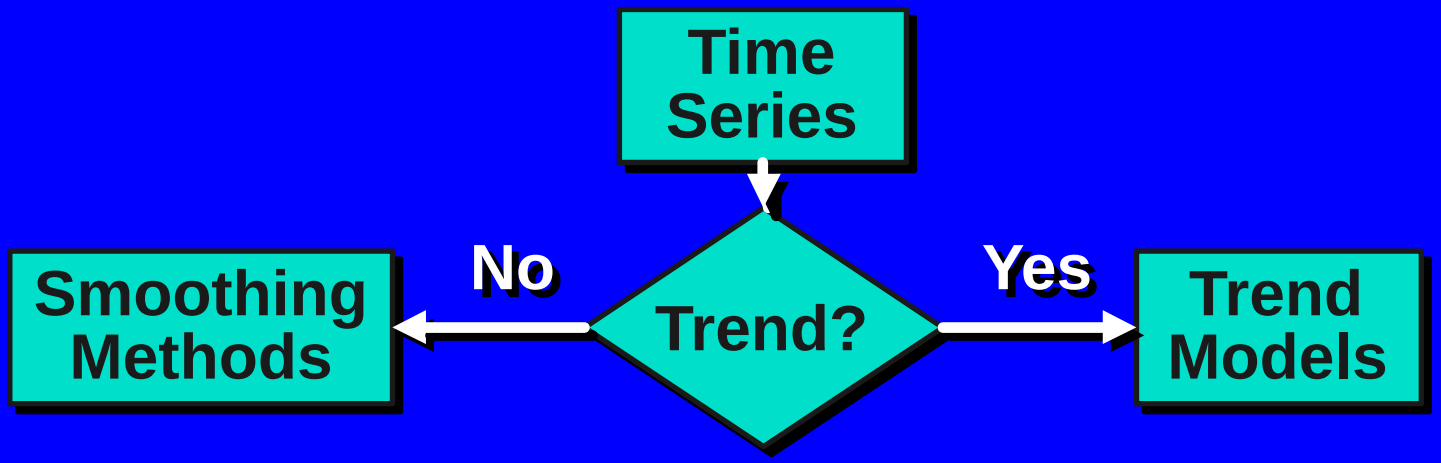
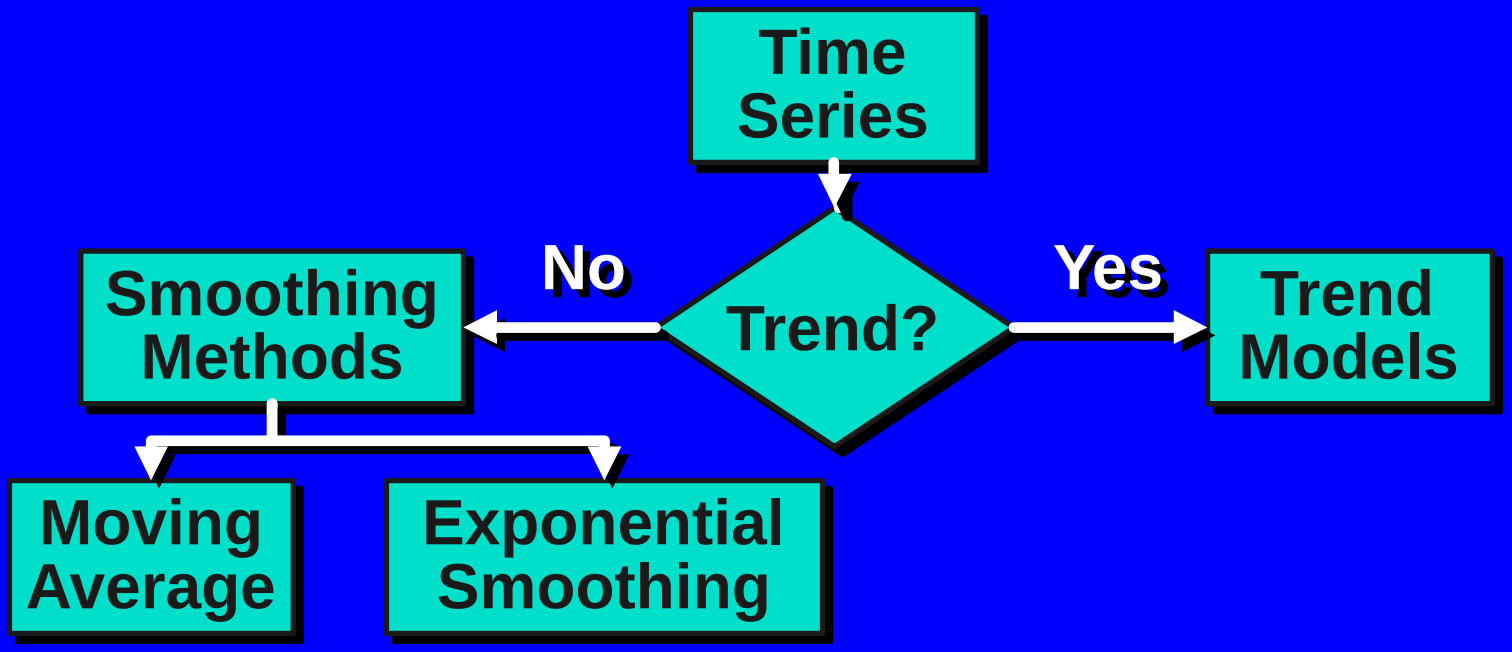
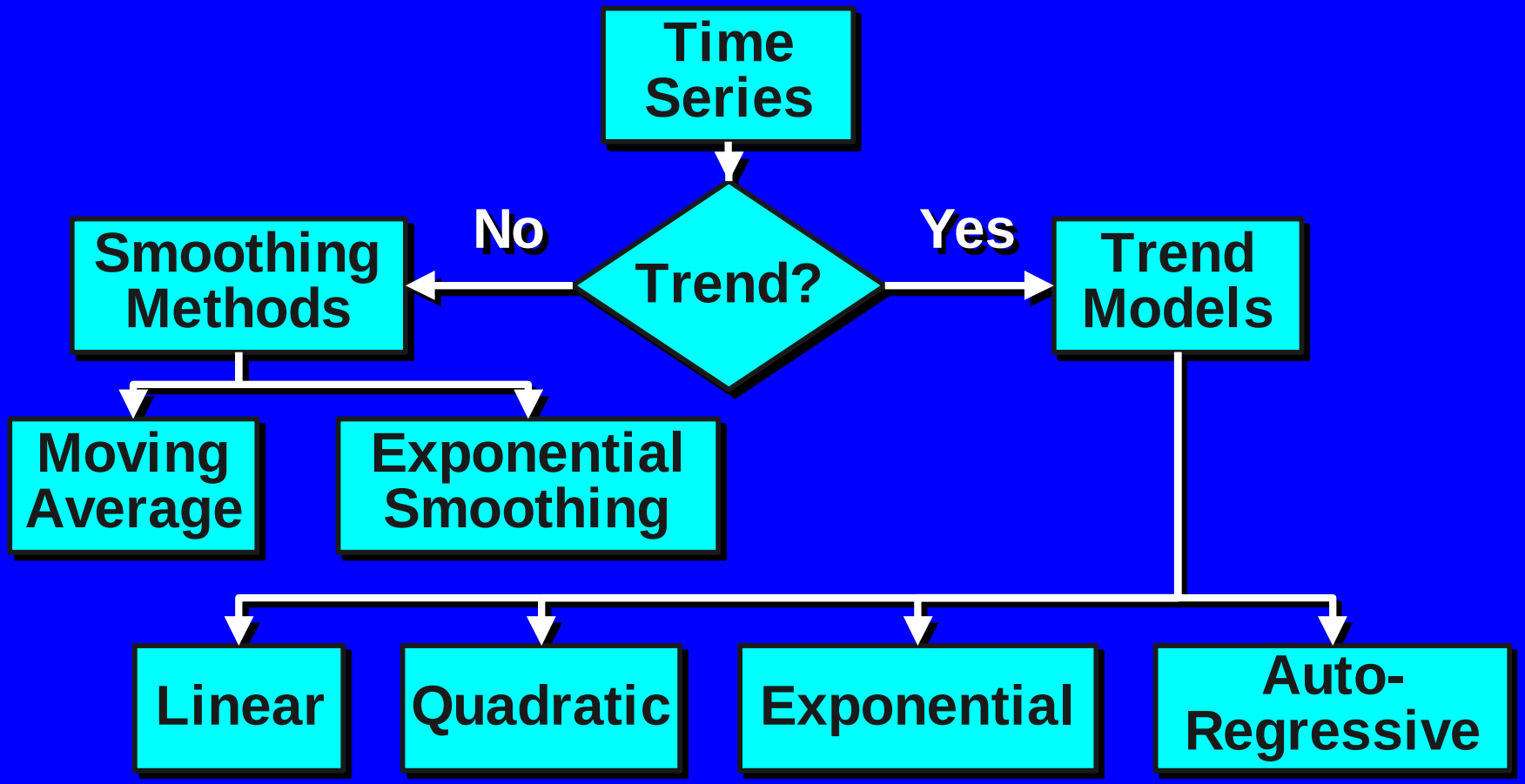


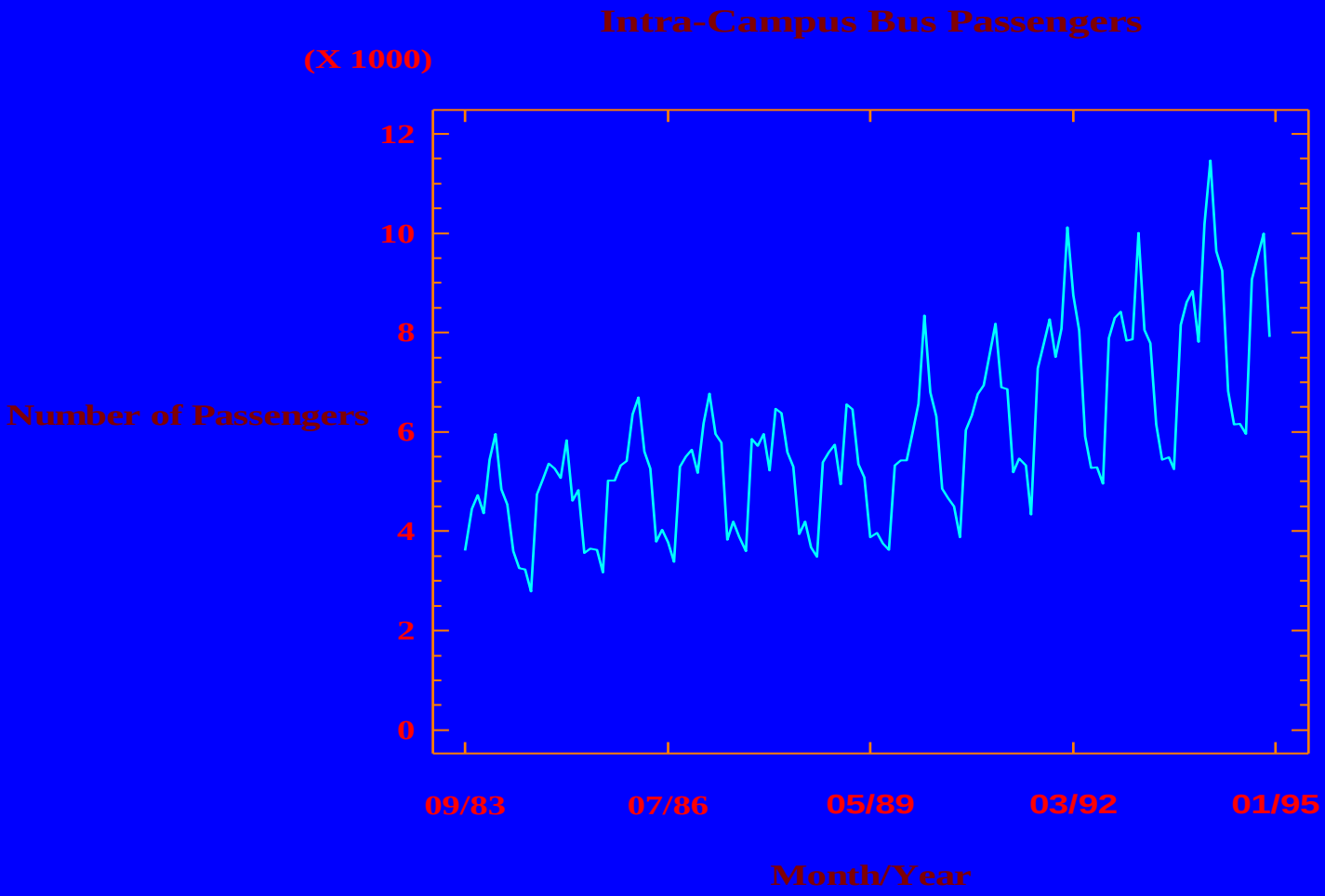
Time Series Forecasting



Time Series Forecasting



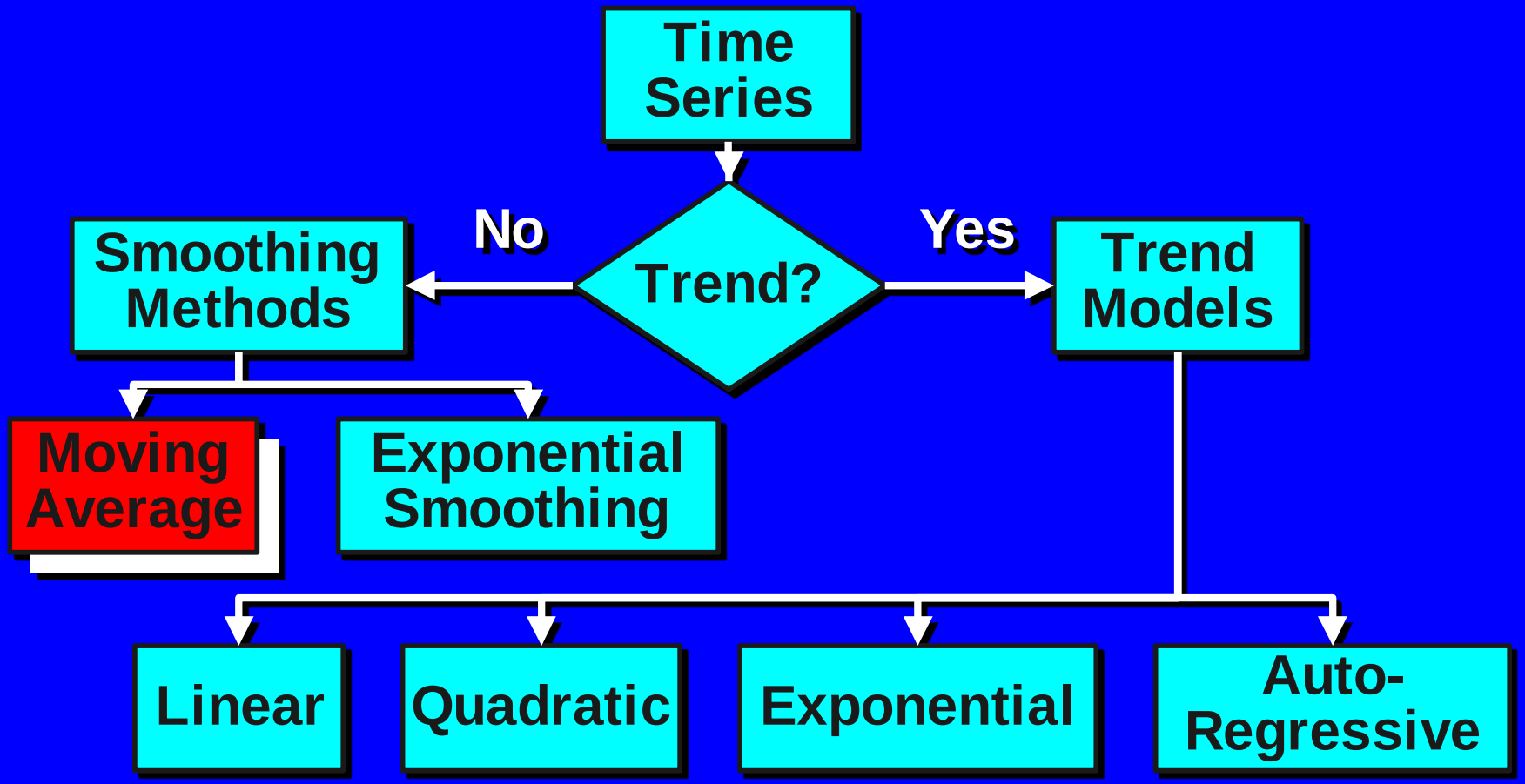
Plotting Time Series Data



Data collected by Coop Student (10/6/95)

Moving Average Method

Time Series Forecasting



Moving Average Method

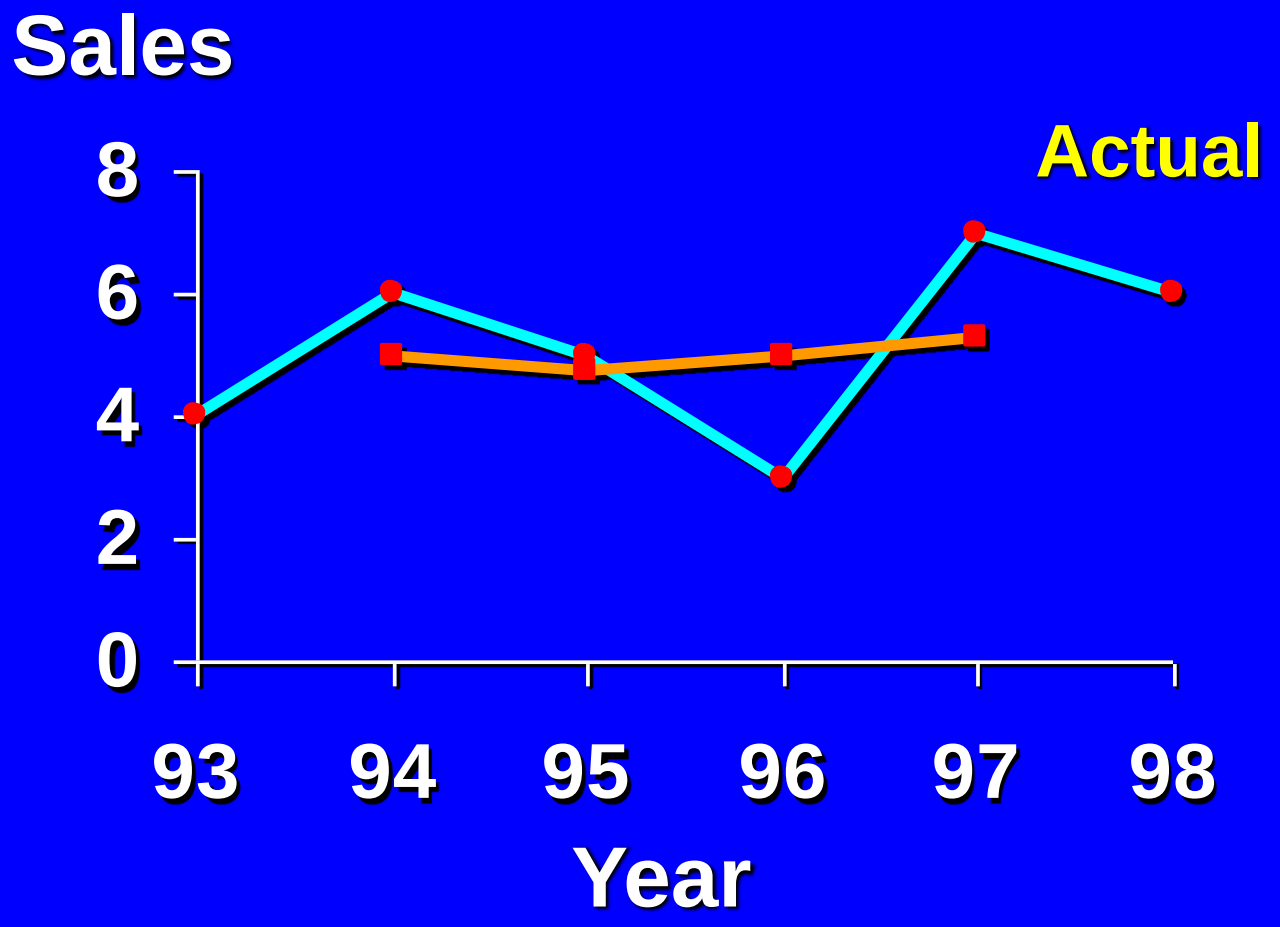
- Series of arithmetic means
- Used only for smoothing
  - Provides overall impression of data over time

Moving Average Method

- Series of arithmetic means
- Used only for smoothing
  - Provides overall impression of data over time

Used for elementary forecasting

Moving Average Graph



Moving Average
[An Example]

You work for Firestone Tire. You want to smooth random fluctuations using a 3-period moving average.

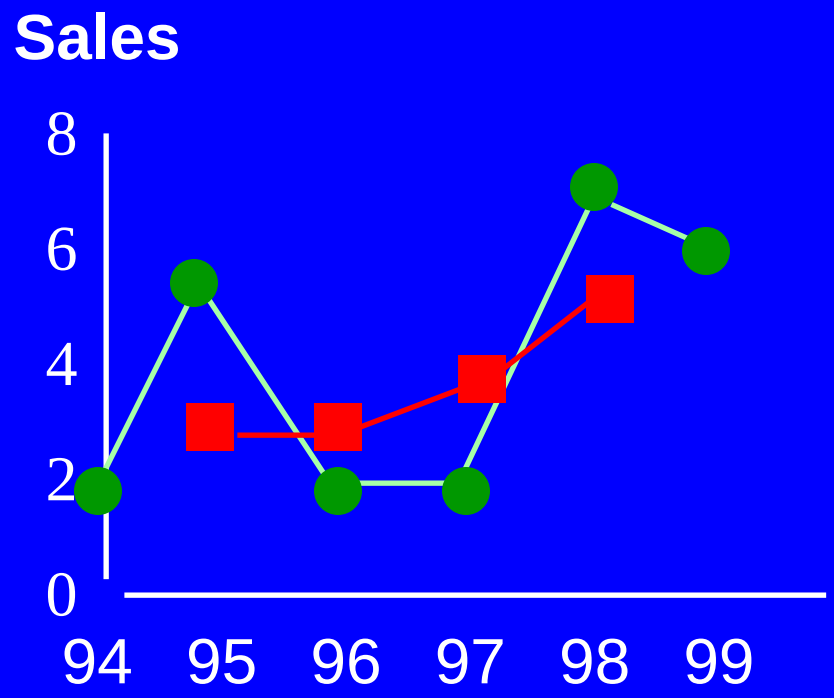
1995	20,000
1996	24,000
1997	22,000
1998	26,000
1999	25,000

Moving Average
[Solution]

Year	Sales	MA(3) in 1,000
1995	20,000	NA
1996	24,000	(20+24+22)/3 = 22
1997	22,000	(24+22+26)/3 = 24
1998	26,000	(22+26+25)/3 = 24
1999	25,000	NA

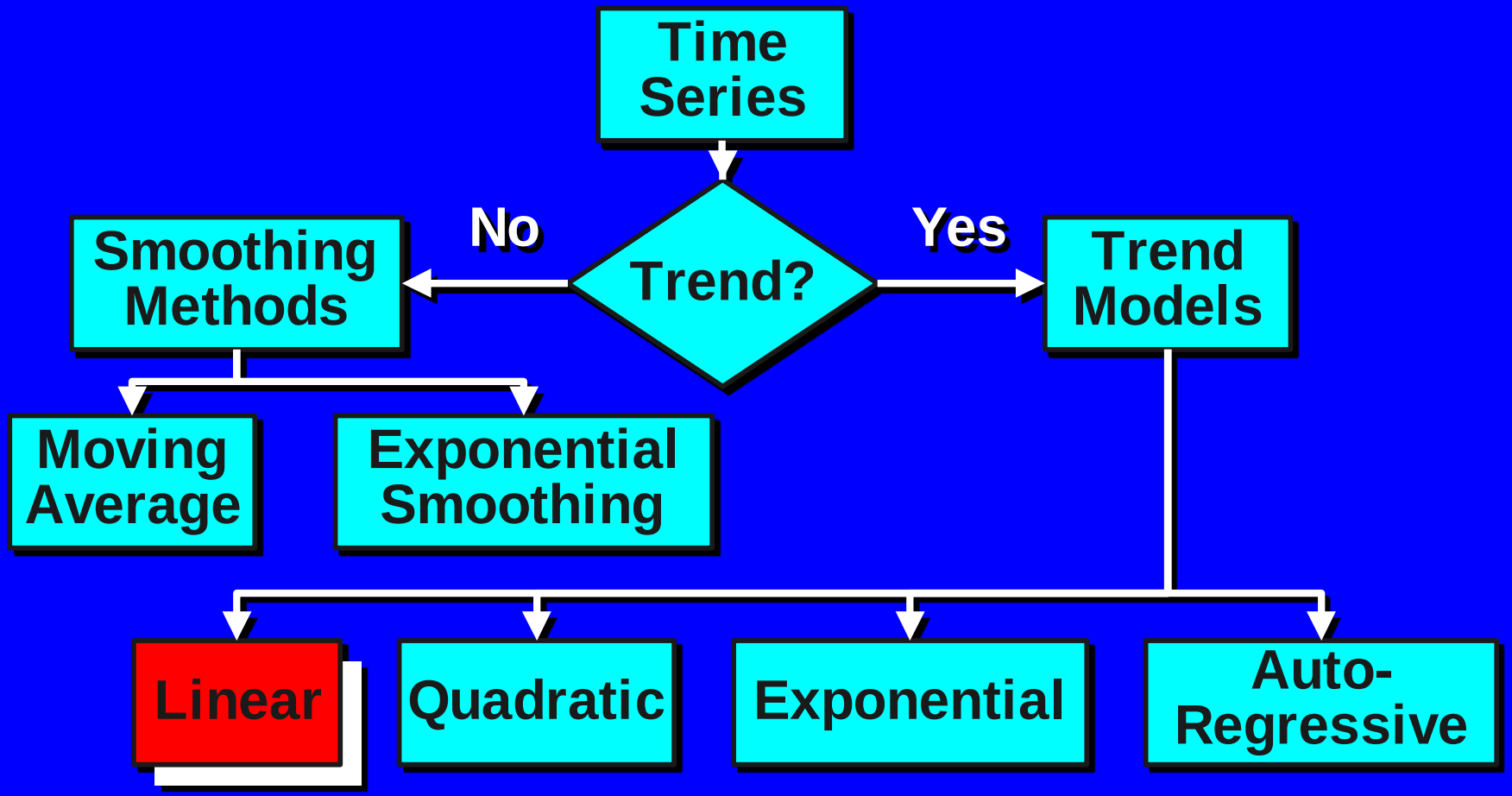
Moving Average

Year	Response ●	Moving Ave ■
1994	2	NA
1995	5	3
1996	2	3
1997	2	3.67
1998	7	5
1999	6	NA



Linear Time-Series Forecasting Model

Time Series Forecasting



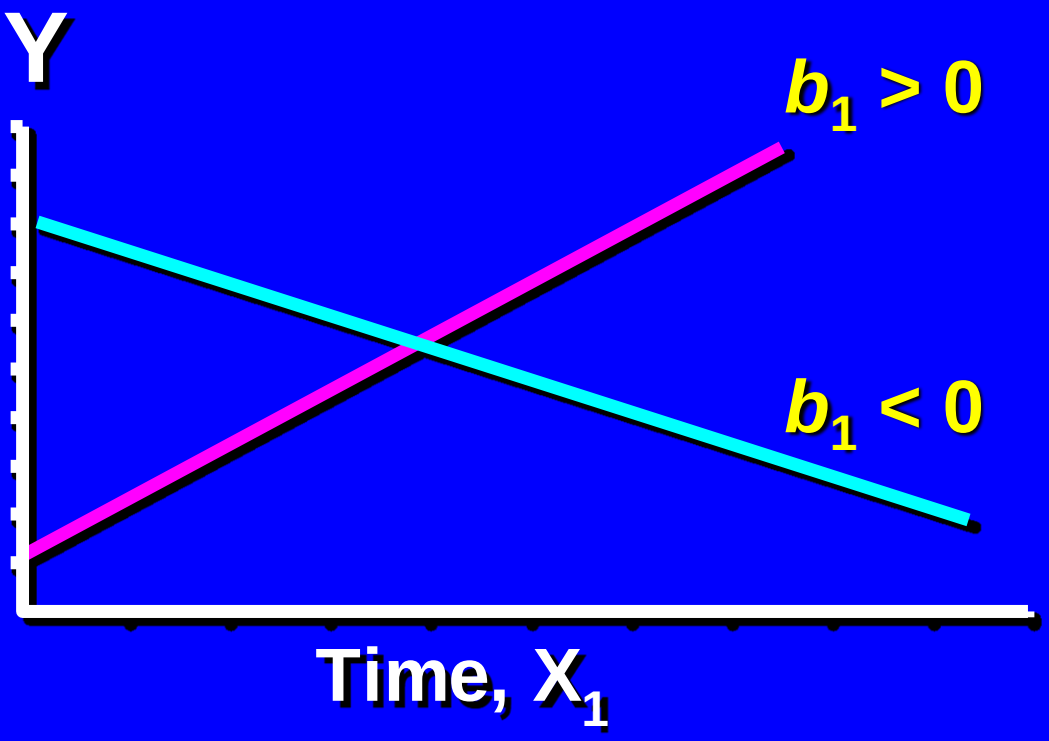
Linear Time-Series Forecasting Model

- Used for forecasting trend
- Relationship between response variable *Y* & time *X* is a linear function
- Coded *X* values used often

– Year *X*:	1995	1996	1997	1998	1999
– Coded year:	0	1	2	3	4
– Sales *Y*:	78.7	63.5	89.7	93.2	92.1

Linear Time-Series Model

$$\hat{Y}_i = b_0 + b_1 X_{1i}$$

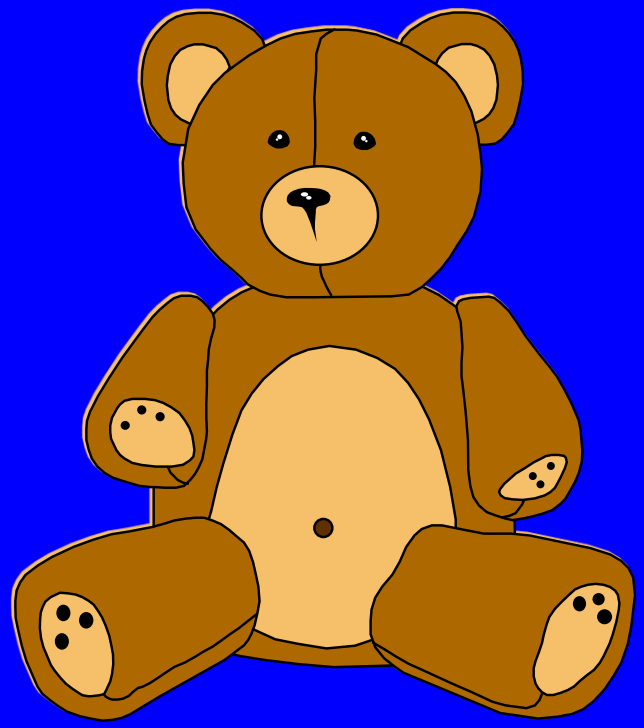


Linear Time-Series Model
[An Example]

You're a marketing analyst for Hasbro Toys. Using coded years, you find $\hat{Y}_i = .6 + .7X_i$.

1995	1
1996	1
1997	2
1998	2
1999	4

Forecast 2000 sales.



Linear Time-Series [Example]

Year	Coded Year	Sales (Units)
1995	0	1
1996	1	1
1997	2	2
1998	3	2
1999	4	4
2000	5	?

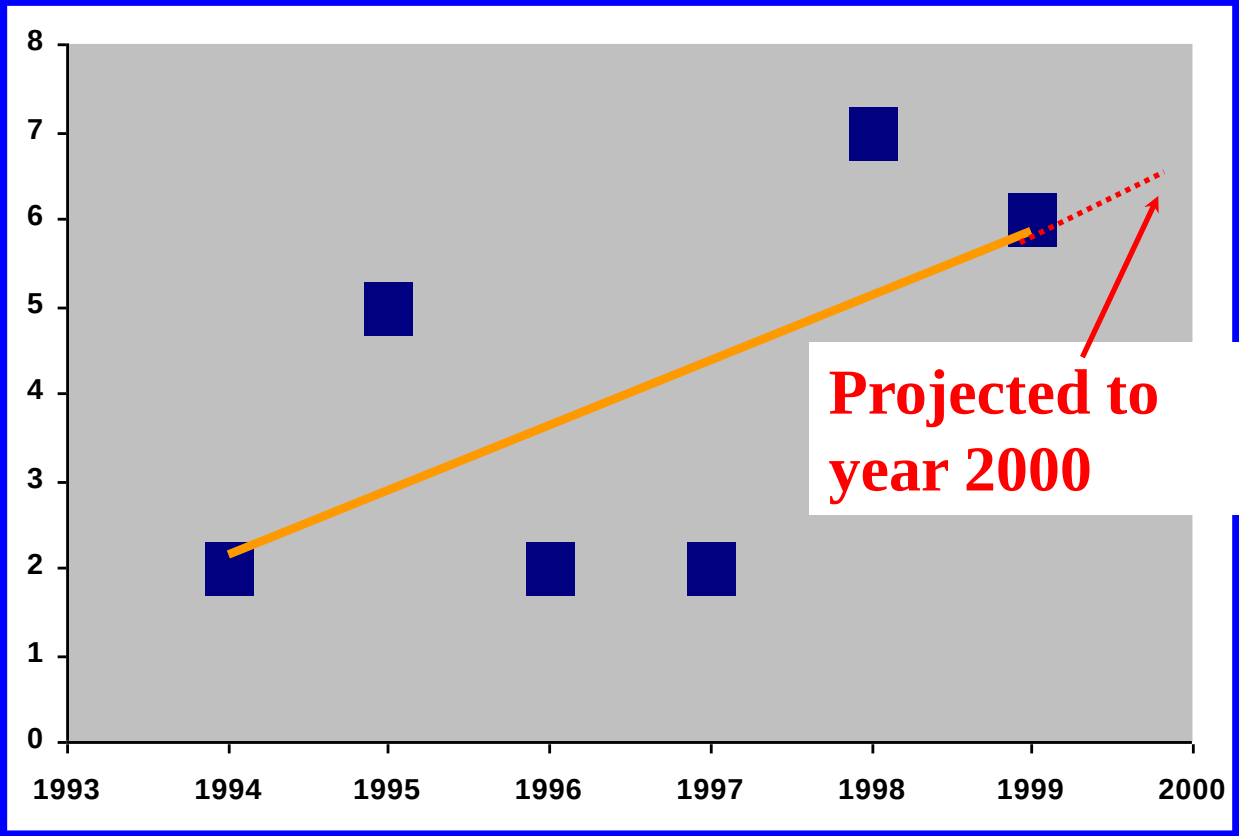
2000 forecast sales: $\hat{Y}_i = .6 + .7 \cdot (5) = 4.1$

The equation would be different if 'Year' used.

The Linear Trend Model

Year	Coded	Sales
94	0	2
95	1	5
96	2	2
97	3	2
98	4	7
99	5	6

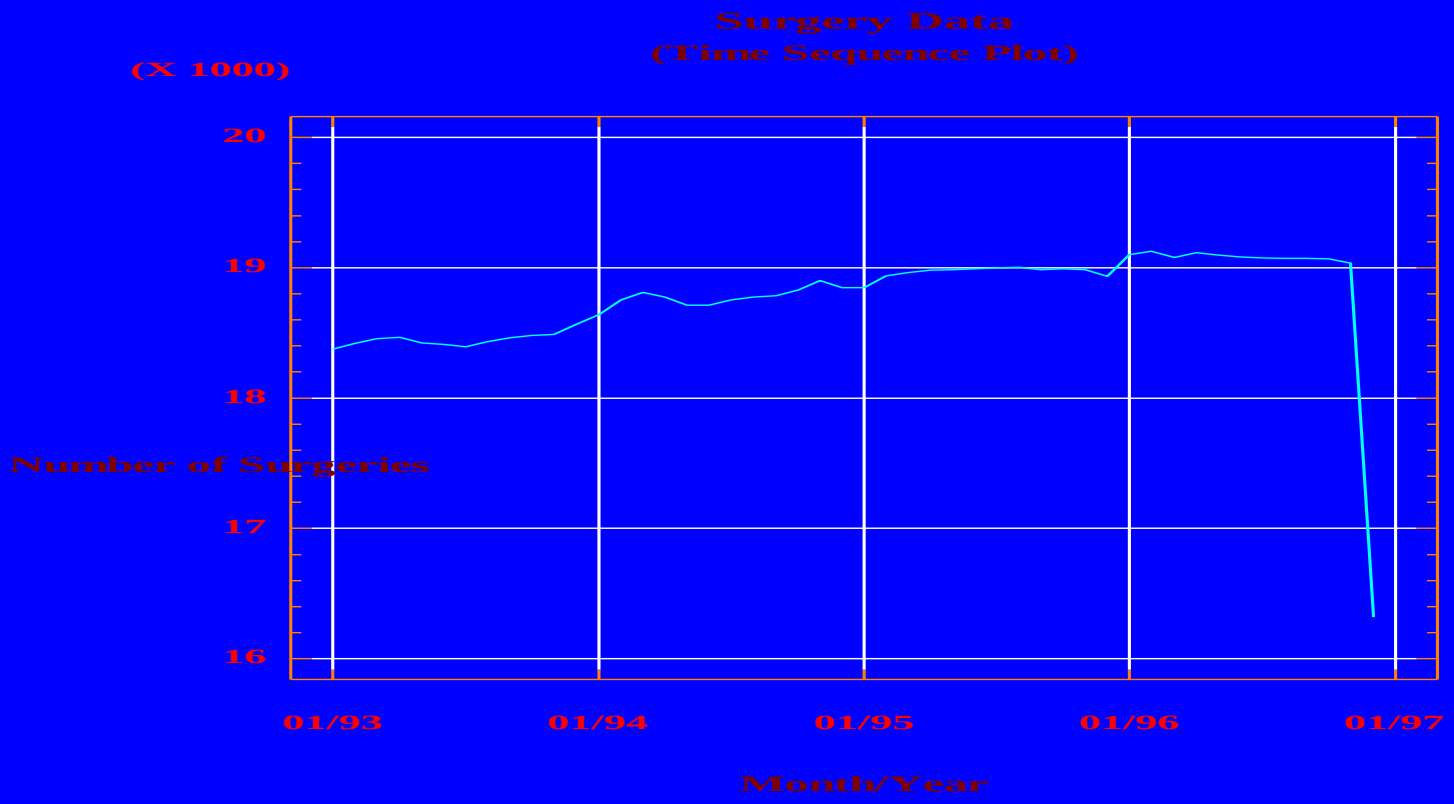
$$\hat{Y}_i = b_0 + b_1 X_i = 2.143 + .743 X_i$$



Excel Output

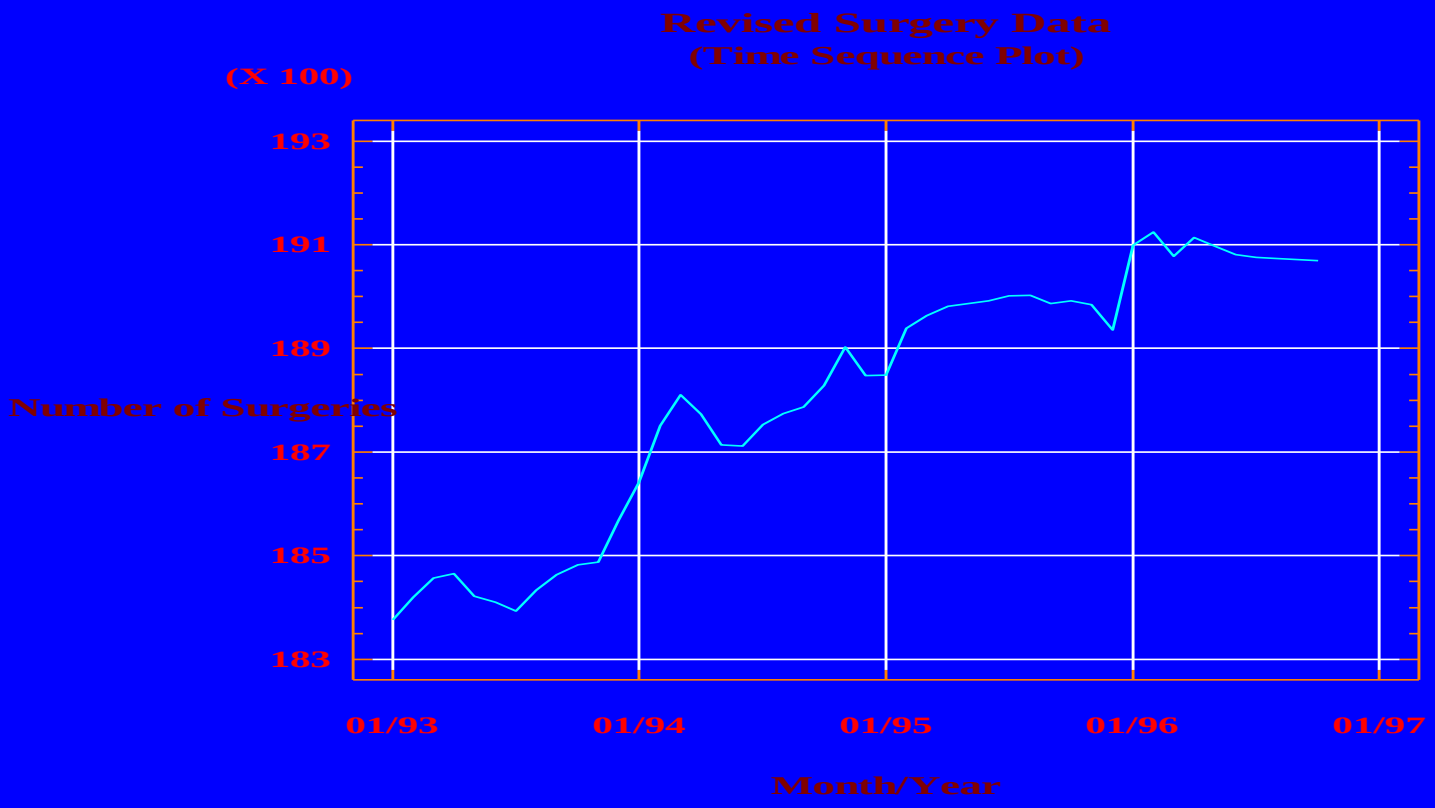
	Coefficients
Intercept	2.14285714
X Variable 1	0.74285714

Time Series Plot



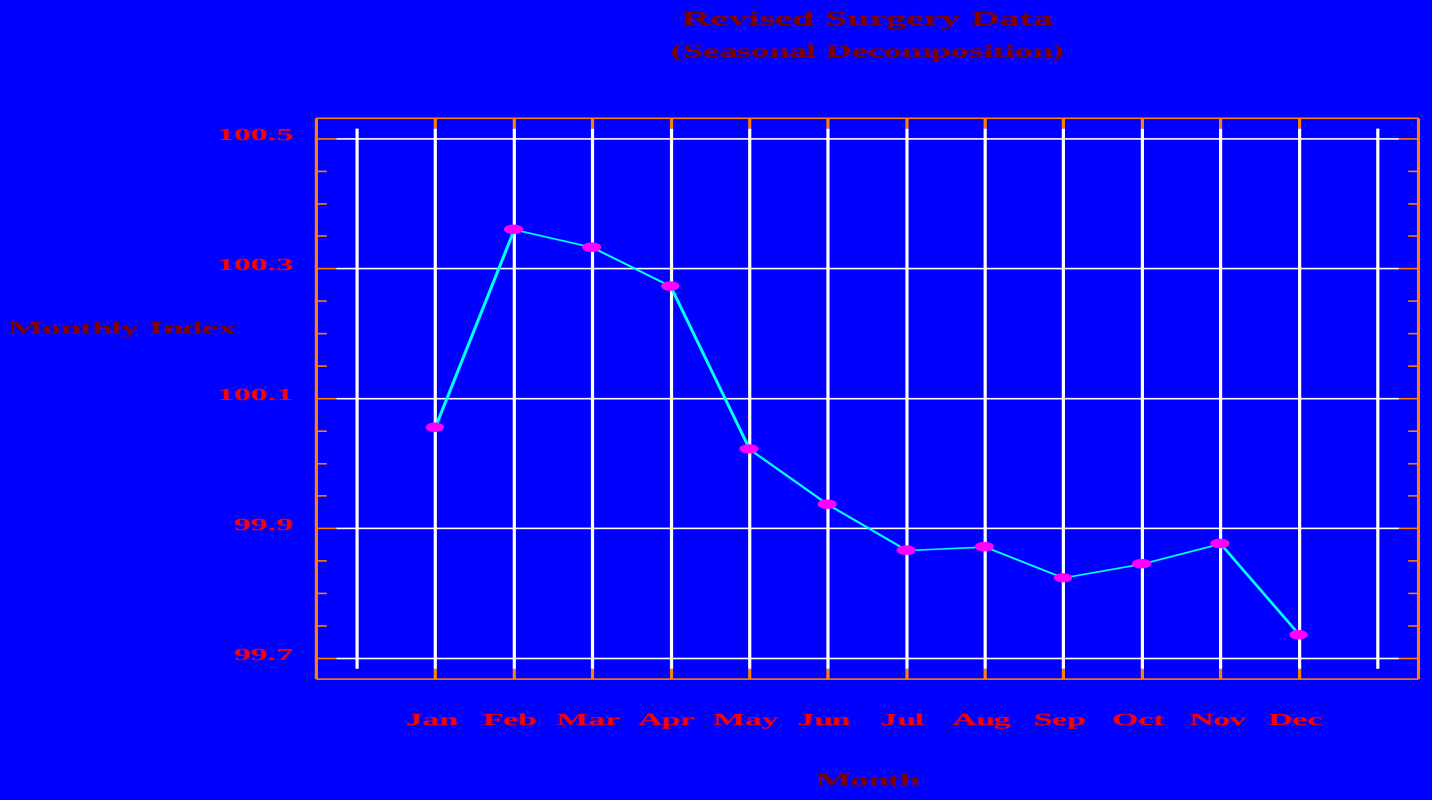
Source: General Hospital, Metropolis

Time Series Plot [Revised]



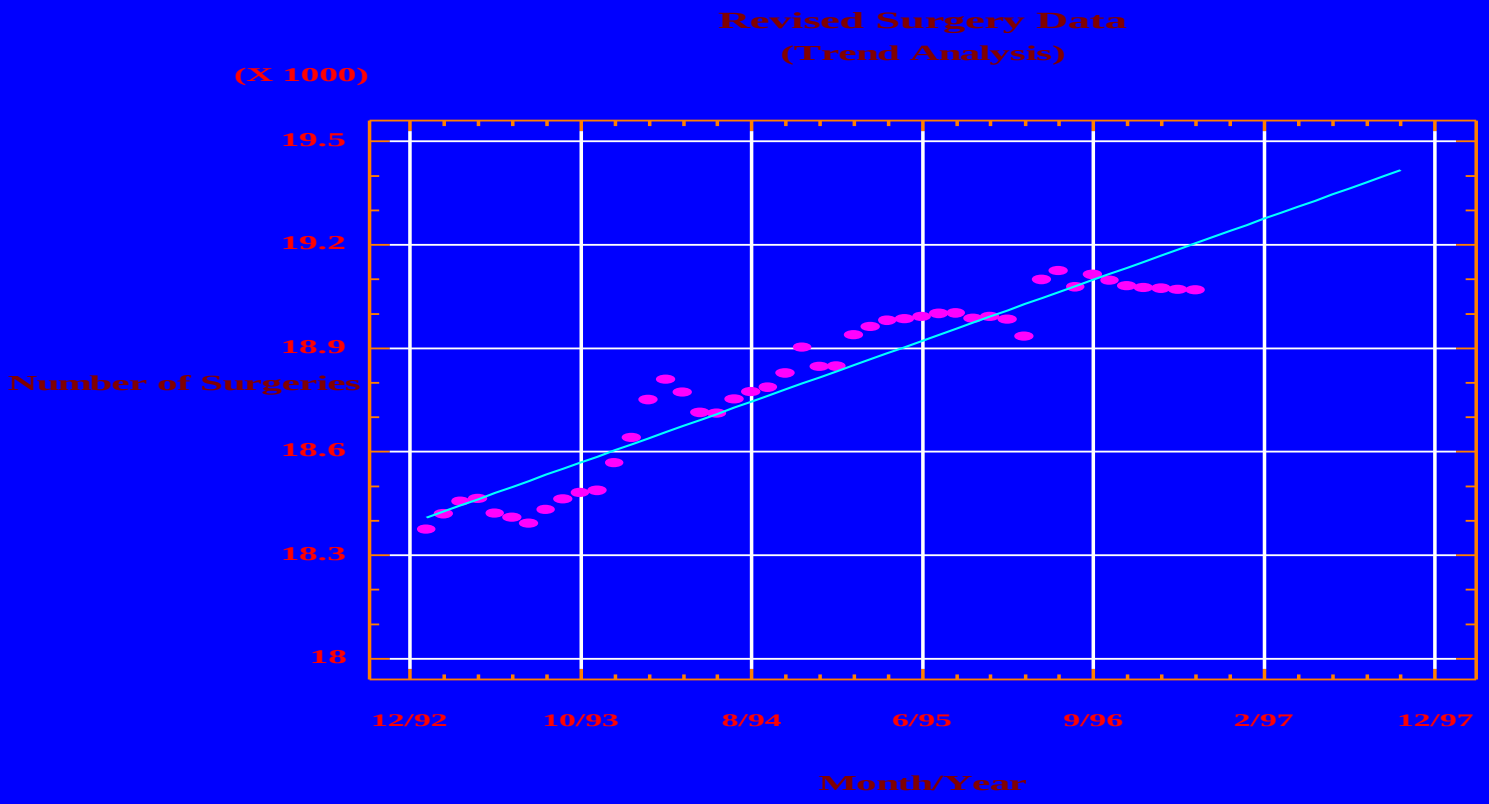
Source: General Hospital, Metropolis

Seasonality Plot



Source: General Hospital, Metropolis

Trend Analysis



Source: General Hospital, Metropolis