# MTH 5000, Lecture 2

## Applied Forecasting of Financial Data

## Topic: Foundations of Time Series Data and Visualization

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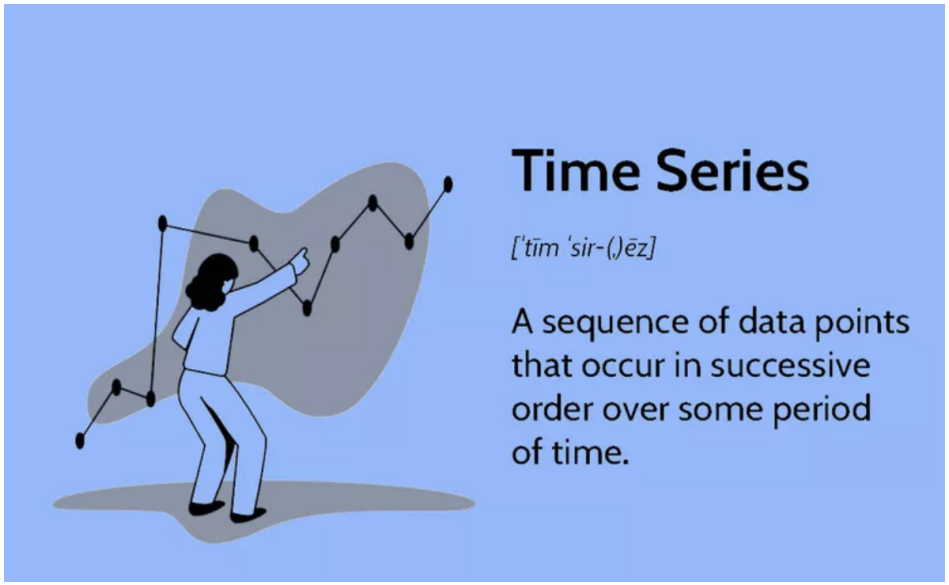
February 10, 2026

# What is Time Series Data?

A time series is a set of measurements that occur at regular time intervals. For this type of analysis, you can think of time as the independent variable, and the goal is to model changes in a characteristic (the dependent variable).




It is characterized by having a timestamp for every value, which is usually appended in chronological order to track trends, patterns, or changes over time.

# Types of Time Series Data

Time series data can be classified into two sections.

**Continuous Time Series:**

Data recorded at regular intervals with a continuous range of values like temperature, stock prices, sensor data, etc.

**Discrete Time Series:**

Data with distinct values or categories recorded at specific time points like counts of events, categorical statuses, etc.

# Some measures of time

- **Time Points / Observations:** Individual moments when data is recorded (e.g., daily, hourly, per transaction).
- **Time Intervals:** Duration between consecutive observations (regular vs. irregular intervals).
- **Time Horizons:** The total length of the series (short-term vs. long-term data).
- **Frequency / Granularity:** How often data is recorded (minute, hour, day, week, month, year).
- **Event Timing:** Specific timestamps of key events or changes (e.g., holidays, system outages).

# What Makes Time Series Data Special?

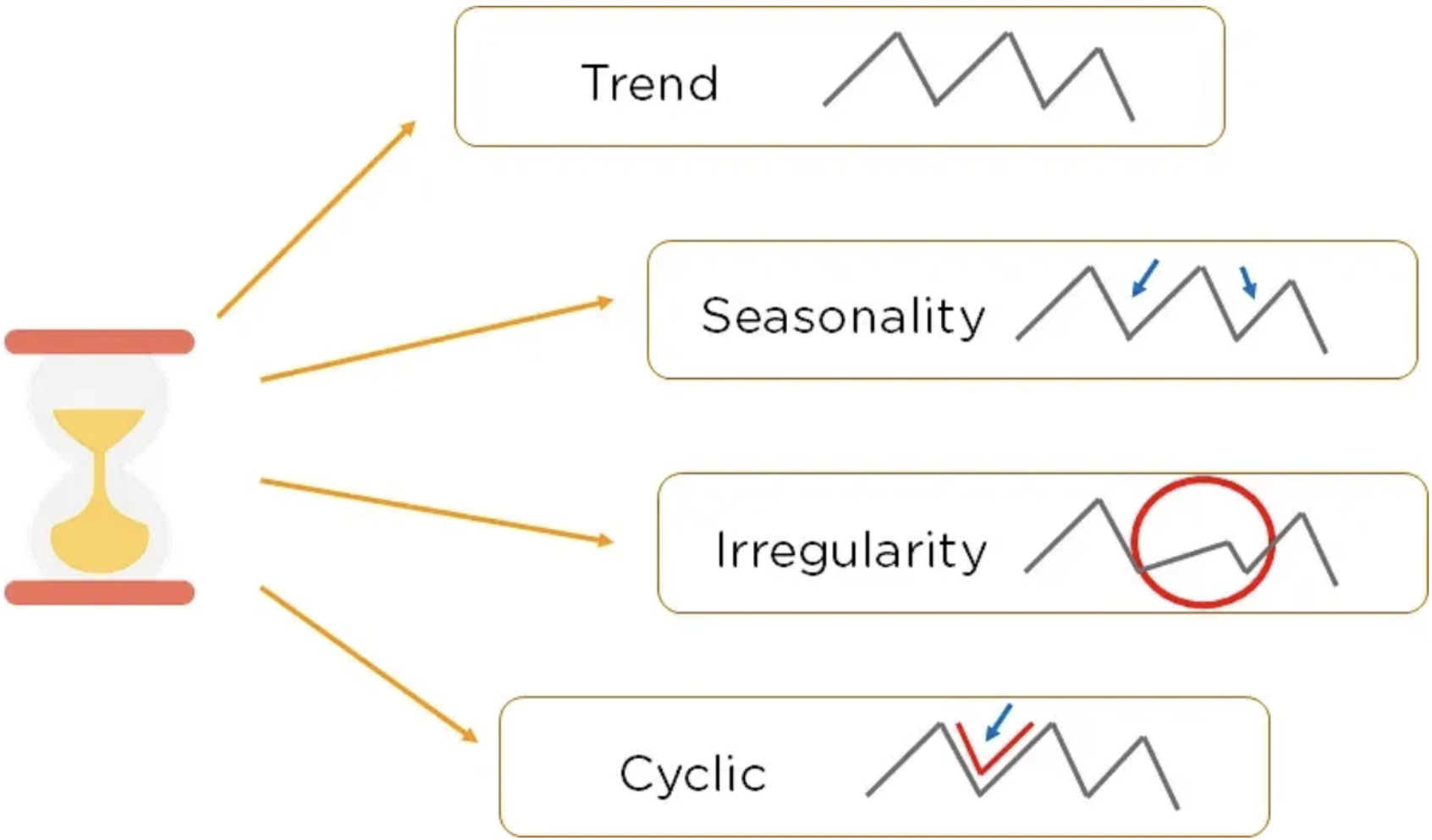
- **Forecasting the Future:** Predict sales, stock prices, weather, or demand to make informed decisions.
- **Understanding Patterns:** Detect trends, seasonal behaviors, and anomalies over time.
- **Risk Management:** Identify potential risks early in finance, healthcare, and operations.
- **Optimization:** Improve resource allocation in logistics, energy, and production.
- **Data-Driven Decisions:** Many modern AI and ML applications rely on time-dependent data for accuracy.

# Applications of Time Series Data

Examples of time series data include:

- Annual Google Profits
- Quarterly Sales for Amazon
- Monthly rainfall
- Weekly retail sales
- Daily IBM stock prices
- Hourly electricity demand
- 5-minute traffic counts
- Stock transactions

# Time Series Components



# Challenges in Time Series Analysis

- **Non-Stationarity:** Mean, variance, or patterns may change over time, making standard regression unsuitable.
- **Autocorrelation Violates Regression Assumptions:** Most regression models assume independent residuals; in time series, residuals are often correlated.
- **Feature Engineering is Different:** Time lags, rolling statistics, and seasonal indicators are commonly needed.
- **Model Choice is Specialized:** Requires models like ARIMA, Exponential Smoothing, or Prophet rather than standard linear regression.

# Goals in Time Series Analysis

- **Forecasting:** Predict future values based on past observations.
- **Understanding Patterns:** Identify trends, seasonality, and cyclic behavior in data.
- **Anomaly Detection:** Detect unusual or unexpected behavior over time.
- **Decision Support:** Provide insights to inform business, scientific, or operational decisions.
- **Modeling Dependencies:** Understand how past values influence the present and future.

# Takeaways

Time series data is everywhere, appearing in fields like finance, weather, healthcare, and web analytics. What makes it unique is the order and time dependency of the past values often influence future values, which distinguishes it from regular datasets. By analyzing time series, we can gain valuable insights into trends and patterns, and use this understanding for forecasting, helping to make informed decisions and plan for the future.