The Quant Cheetsheet:

Quant Specific Concepts:

A

- **Alpha (α):** The excess return of an investment relative to its benchmark, after accounting for its risk. It is often considered the measure of a portfolio manager's "skill."
- **Arbitrage:** The practice of simultaneously buying and selling an asset in different markets to profit from a price discrepancy, with no net investment and no risk. In theory, these opportunities should not exist in an efficient market.
- **ARIMA Model:** Autoregressive Integrated Moving Average. A classic statistical model for analyzing and forecasting time series data.
- **Autocorrelation:** The correlation of a time series with a delayed copy of itself. It is a measure of how much the past values of the series influence its future values.

B

- **Backtesting:** The process of testing a trading strategy on historical data to determine how it would have performed in the past.
- **Bayes' Theorem:** A mathematical formula for determining conditional probability. It describes how to update the probability of a hypothesis based on new evidence.
- **Beta (β):** A measure of a stock's volatility or systematic risk in relation to the overall market. A beta of 1 means the stock moves with the market; >1 is more volatile, <1 is less volatile.
- **Binomial Tree:** A model that represents the possible paths an asset's price could take over a period. It's a

fundamental tool for pricing options, especially American-style options.

- **Black-Scholes Model:** A mathematical model that provides a theoretical price for European-style options. It's based on the principle of no-arbitrage and assumes stock prices follow a Geometric Brownian Motion.
- **Brownian Motion (Wiener Process):** A mathematical model for a random walk. It's the "random" component (`dW`) in the Stochastic Differential Equations used to model asset prices.
- **Bid-Ask Spread:** The difference between the highest price a buyer is willing to pay for an asset (the bid) and the lowest price a seller is willing to accept (the ask). It represents the basic cost of trading.

C

- **Calibration:** The process of tuning the parameters of a financial model so that its outputs match observed market prices (e.g., adjusting volatility inputs so a model's option prices match the market's option prices).
- **Cointegration:** A statistical property of two or more time series that tend to move together in the long run, even if they are non-stationary individually. This is the statistical foundation for pairs trading.
- **Convexity:** In bonds, it's the measure of the curvature in the relationship between bond prices and bond yields. In options, it's measured by Gamma.
- **Correlation:** A statistical measure of the degree to which two variables move in relation to each other, ranging from -1 (perfectly opposite) to +1 (perfectly together).
- **Covariance:** A measure of the joint variability of two random variables. It's similar to correlation but is not

standardized. The covariance matrix is a key input for portfolio optimization.
- **Cross-Validation:** A technique for assessing how the results of a statistical analysis or machine learning model will generalize to an independent data set. It's a key tool for fighting overfitting.
- **CVaR (Conditional Value at Risk):** Also known as Expected Shortfall. A risk measure that calculates the expected loss on a bad day, given that the loss is already exceeding the VaR threshold. It's considered superior to VaR as it quantifies the "tail risk."

D

- **Delta (Δ):** An option Greek that measures the rate of change of an option's price with respect to a $1 change in the underlying asset's price.
- **Diversification:** The strategy of investing in a variety of assets to reduce the overall risk of a portfolio.
- **Drawdown:** The measure of a portfolio's decline from a historical peak in value to a trough. The "Max Drawdown" is the largest such decline observed.

E

- **Efficient Frontier:** A curve in portfolio theory that represents the set of optimal portfolios that offer the highest expected return for a defined level of risk.
- **Eigenvalue / Eigenvector:** A core concept in linear algebra. For a given matrix (like a covariance matrix), an eigenvector is a direction that is only stretched by the transformation, and the eigenvalue is the factor by which it is stretched. They are the foundation of Principal Component Analysis (PCA).

- **Execution Algorithm:** An automated algorithm designed to execute a large order without causing significant market impact (e.g., VWAP, TWAP).
- **Expected Value:** The long-run average value of a random variable. It is calculated as the weighted average of all possible values.
- **Exotic Option:** A type of option that has more complex features than standard "vanilla" call and put options (e.g., Asian options, barrier options).

F

- **Factor Model:** A model that seeks to explain asset returns through their exposure to a set of common risk factors, such as the market, size, value, momentum, etc.
- **Fama-French Three-Factor Model:** A well-known asset pricing model that expands on the CAPM by adding size risk (SMB) and value risk (HML) factors to the market risk factor.
- **Futures Contract:** A standardized legal agreement to buy or sell a particular commodity or financial instrument at a predetermined price at a specified time in the future. It is an obligation, not a right.

G

- **Gamma (Γ):** An option Greek that measures the rate of change in an option's Delta per $1 change in the underlying asset's price. It measures the convexity of an option's value.
- **GARCH Model:** Generalized Autoregressive Conditional Heteroskedasticity. A time series model used to forecast volatility, based on the observation that volatility tends to occur in clusters.

- **Geometric Brownian Motion (GBM):** A stochastic process used as the standard model for stock prices in the Black-Scholes formula. It assumes returns are normally distributed.
- **Greeks:** A set of risk measures, based on partial derivatives, that indicate how sensitive an option's price is to changes in various parameters like the underlying's price, volatility, or time.

H

- **Hedging:** The practice of taking an offsetting position in a related security to reduce the risk of adverse price movements in an asset.
- **Historical Volatility:** The volatility of an asset calculated from its historical price data, typically by taking the standard deviation of its returns over a period.

I

- **Implied Volatility (IV):** The market's forecast of the likely volatility of an asset's price. It is the volatility value that, when input into an option pricing model, returns the current market price of the option.
- **Itô's Lemma:** A fundamental theorem in stochastic calculus that allows one to find the differential of a time-dependent function of a stochastic process. It's the "chain rule" for SDEs and is used to derive the Black-Scholes equation.

K

- **Kalman Filter:** A powerful algorithm that uses a series of measurements observed over time, containing statistical noise and other inaccuracies, to produce estimates of

unknown variables that tend to be more precise than those based on a single measurement alone. Used in signal processing and time series analysis.
- **Kurtosis:** A measure of the "tailedness" of a probability distribution. Financial returns often exhibit high kurtosis ("fat tails"), meaning extreme events are more likely than a normal distribution would predict.

L

- **Leverage:** The use of borrowed capital to increase the potential return of an investment. It magnifies both gains and losses.
- **Limit Order Book (LOB):** A record of all outstanding limit orders for a particular security, organized by price level. It represents the live supply and demand for the asset.
- **Lookahead Bias:** A common backtesting error where the simulation uses information that would not have been available at the time the decision was being made.

M

- **Market Maker:** A firm or individual who quotes both a buy and a sell price in a financial instrument, hoping to make a profit on the bid-ask spread. They provide liquidity to the market.
- **Martingale:** A stochastic process where the conditional expectation of the next value, given all past values, is equal to the present value. In a risk-neutral world, discounted asset prices are martingales.
- **Mean Reversion:** A theory suggesting that asset prices and historical returns eventually revert to their long-run mean or average level.

- **Momentum:** The tendency for assets that have performed well in the recent past to continue performing well, and for assets that have performed poorly to continue performing poorly.
- **Monte Carlo Simulation:** A computational technique that uses random sampling to obtain numerical results, often used for pricing complex derivatives or simulating portfolio outcomes.

O

- **Optimization:** The process of finding the best possible solution from a set of available alternatives, usually by maximizing or minimizing an objective function subject to a set of constraints.
- **Overfitting:** A modeling error where a model is too closely fit to its training data, capturing noise instead of the underlying signal. It performs well on past data but fails on new, unseen data.
- **Ornstein-Uhlenbeck Process:** A stochastic process that describes a mean-reverting variable. It's often used to model interest rates or volatility.

P

- **p-value:** In hypothesis testing, the probability of obtaining test results at least as extreme as the results actually observed, assuming that the null hypothesis is correct. A small p-value is evidence against the null hypothesis.
- **PCA (Principal Component Analysis):** A statistical procedure that uses linear algebra (eigenvectors) to convert a set of observations of possibly correlated variables into a set of values of linearly uncorrelated

variables called principal components. It is a common technique for dimensionality reduction.

Q

- **Quantile:** A cut-off point dividing the range of a probability distribution into continuous intervals with equal probabilities. The median is the 0.5 quantile.
- **Quasi-Monte Carlo:** An advanced simulation method that uses low-discrepancy sequences instead of random numbers, often leading to faster convergence.

R

- **R-squared (R2):** A statistical measure that represents the proportion of the variance for a dependent variable that's explained by an independent variable or variables in a regression model.
- **Random Walk:** A mathematical object that describes a path that consists of a succession of random steps. The idea that stock prices follow a random walk is central to the Efficient Market Hypothesis.
- **Regularization:** A technique used to combat overfitting by adding a penalty term to the objective function, which discourages overly complex models. L1 (Lasso) and L2 (Ridge) are common types.
- **Risk-Neutral Valuation:** The fundamental concept that one can price a derivative by calculating its expected payoff in a hypothetical "risk-neutral world" and then discounting it back to the present at the risk-free rate.

S

- **Sharpe Ratio:** A measure of risk-adjusted return, calculated as the excess return of a portfolio over the risk-free rate, divided by its standard deviation (volatility).
- **Skewness:** A measure of the asymmetry of a probability distribution. Negative skew indicates a longer left tail, meaning large negative returns are more likely.
- **Slippage:** The difference between the expected price of a trade and the price at which the trade is actually executed. It is a form of transaction cost.
- **SDE (Stochastic Differential Equation):** A differential equation in which one or more of the terms is a stochastic process, thus resulting in a solution which is itself a stochastic process. Used to model asset prices.
- **Stationarity:** A property of a time series whose statistical properties such as mean, variance, and autocorrelation are all constant over time. Most financial price series are not stationary, but their returns often are.
- **Survivorship Bias:** A form of selection bias where the results of a study are skewed because only the "surviving" subjects (e.g., companies that didn't go bankrupt) are included in the historical data.

T

- **Theta (Θ):** An option Greek that measures the rate of decline in the value of an option due to the passage of time. It's also known as time decay.
- **Transaction Costs:** The expenses incurred when buying or selling securities, including broker commissions and the bid-ask spread. Ignoring these can make an unprofitable strategy look profitable.

V

- **Value at Risk (VaR):** A risk metric that estimates the minimum potential loss for a portfolio over a given time period with a certain confidence level. For example, a 95% 1-day VaR of $1M means there is a 5% chance of losing at least $1M on any given day.
- **Vega (v):** An option Greek that measures the sensitivity of an option's price to a 1% change in the implied volatility of the underlying asset.
- **Volatility Smile/Smirk:** A common graphical pattern that results from plotting the implied volatility of options with the same expiration date against their strike prices. It shows that IV is not constant across strikes, contradicting the basic Black-Scholes model.