Quant Interview Review Sheet

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Contents

1 Preface

test 1.3 This document is intended as a review of the basic topics and tricks needed for a quantitative trading interview. It should be concise enough to be read as a refresher in the 15 minutes before an interview. Alternatively, it may be used as an aid when taking assessments as a reference for commonly used formulas.

2 Probability

2.1 Combinatorics

Useful Combinatorics Identities

- **Pascal's Rule:**
$$\binom{n}{r} = \binom{n-1}{r} + \binom{n-1}{r-1}$$
- **Symmetry:**
$$\binom{n}{r} = \binom{n}{n-r}$$
- **Sum over all combinations:**
$$\sum_{r=0}^{n} \binom{n}{r} = 2^n$$
- **Binomial Theorem:**
$$(x+y)^n = \sum_{k=0}^{n} \binom{n}{k} x^{n-k} y^k$$

Permutations with Identical Items

Formula:

$$\text{Number of distinct permutations of } n \text{ items with repeats:} \quad \frac{n!}{n_1!\, n_2! \cdots n_k!}$$

where $n_1, n_2, \ldots, n_k$ are the counts of identical items.
Use Case: Arranging letters in a word with repeated letters (e.g., `BANANA`).

Stars and Bars

Problem Type: Distributing n identical objects into k distinct bins
Formula:

$$\text{Number of ways} = \binom{n+k-1}{k-1} = \binom{n+k-1}{n}$$

Equivalent Problem: Number of non-negative integer solutions to:

$$x_1 + x_2 + \cdots + x_k = n$$

Variant - With Restrictions: If each bin must have at least m objects:

$$\text{Place } m \text{ in each bin first, then distribute remaining:} \quad \binom{(n-km)+k-1}{k-1}$$

Inclusion-Exclusion Principle

Two Sets:

$$|A \cup B| = |A| + |B| - |A \cap B|$$

Three Sets:

$$\begin{aligned} |A \cup B \cup C| = {} & |A| + |B| + |C| \\ & - |A \cap B| - |A \cap C| - |B \cap C| \\ & + |A \cap B \cap C| \end{aligned}$$

General Form for n Sets:

$$\left| \bigcup_{i=1}^{n} A_i \right| = \sum_{k=1}^{n} (-1)^{k-1} \sum_{1 \le i_1 < \cdots < i_k \le n} |A_{i_1} \cap \cdots \cap A_{i_k}|$$

2.2 Bayes' Theorem and Conditional Probability

Conditional Probability, Bayes, and Law of Total Probability

Consider events $A_1, \ldots, A_n$, which form a partition of the sample space as well as event B. Then,

$$P(A_1 \mid B) = \frac{P(A_1 \cap B)}{P(B)} = \frac{P(B \mid A_1)P(A_1)}{P(B)} = \frac{P(B \mid A_1)P(A_1)}{\sum_{i=1}^{n} P(B \cap A_i)} = \frac{P(B \mid A_1)P(A_1)}{\sum_{i=1}^{n} P(B \mid A_i)P(A_i)}$$

De Morgan's Laws

Set Theory Version:

$$(A \cup B)^c = A^c \cap B^c$$
$$(A \cap B)^c = A^c \cup B^c$$

2.3 Expectation, Variance, Covariance, and Correlation

Law of Total Expectation and Variance

For two random variables X, Y defined on the same sample space,

$$\mathbb{E}[X] = \mathbb{E}[\mathbb{E}[X \mid Y]]$$

$$\text{discrete:} \quad \mathbb{E}[X] = \sum_{i=1}^{\infty} P(Y = y_i)\, \mathbb{E}[X \mid Y = y_i]$$

$$\text{continuous:} \quad \mathbb{E}[X] = \int_{\mathbb{R}} \mathbb{E}[X \mid Y = y] f_Y(y)\, dy$$

In variance,

$$\operatorname{Var}(X) = \operatorname{Var}(\mathbb{E}[X \mid Y]) + \mathbb{E}[\operatorname{Var}(X \mid Y)]$$

where

$$\operatorname{Var}(X \mid Y) = \mathbb{E}[(X - \mathbb{E}[X \mid Y])^2 \mid Y]$$

The Law of Total Expectation says that if we "average over all averages" of X obtained by some information about Y, we obtain the true average. Similarly, the Law of Total Variance says that the true variance comes from two sources: between samples (the first term) and within samples (the second term).

Covariance and Correlation

$$\operatorname{Cov}(X, Y) = \mathbb{E}[XY] - \mathbb{E}[X]\mathbb{E}[Y]$$

$$\operatorname{Corr}(X, Y) = \frac{\operatorname{Cov}(X, Y)}{\sigma_X \sigma_Y}$$

Covariance and correlation are measurements of linear association of X and Y. An example of uncorrelated but not independent random variables are Z and Z^2, where $Z \sim N(0, 1)$.

Properties of Expectation, Variance, and Covariance

Let a, b, c, d be real constants and X and Y be random variables with finite mean and variance. Then all of the following hold:

1. $\mathbb{E}[aX + bY + c] = a\mathbb{E}[X] + b\mathbb{E}[Y] + c$
2. $\mathrm{Var}(aX + b) = a^2 \,\mathrm{Var}(X)$
3. $\mathrm{Cov}(aX + b, cY + d) = ac \,\mathrm{Cov}(X, Y)$
4. $\mathrm{Var}(X + Y) = \mathrm{Var}(X) + \mathrm{Var}(Y) + 2\,\mathrm{Cov}(X, Y)$
5. If X and Y are independent and have finite mean, then X and Y are uncorrelated.
6. $\mathrm{Corr}(aX + b, cY + d) = \mathrm{sign}(ac)\,\mathrm{Corr}(X, Y)$
7. $\mathrm{Cov}(X, X) = \mathrm{Var}(X)$
8. The correlation and covariance matrices are both positive semidefinite. ($\forall \mathbf{x} \in \mathbb{R}^n, \quad \mathbf{x}^\top A\mathbf{x} \geq 0.$)
9. $|\mathrm{Corr}(X, Y)| \leq 1$

2.4 Order Statistics

2.5 Distributions

Name	Modeling Intuition	PMF/PDF	CDF	MGF	μ	σ^2
Bernoulli	Toss a coin, 1 if heads, else 0, coin lands heads with probability p	$P(X = x) = \begin{cases} p & \text{if } x = 1 \\ 1-p & \text{if } x = 0 \end{cases}$	$P(X \leq x) = \begin{cases} 0 & \text{if } x < 0 \\ 1-p & \text{if } 0 \leq x < 1 \\ 1 & \text{if } x \geq 1 \end{cases}$	$pe^\theta + (1-p)$	p	$p(1-p)$
Binomial	Toss a coin n times, probability of x heads, coin lands heads with probability p	$P(X = x) = \binom{n}{x} p^x (1-p)^{n-x}$	$P(X \leq x) = \sum_{k=0}^{\lfloor x \rfloor} \binom{n}{k} p^k (1-p)^{n-k}$	$\left[pe^\theta + (1-p)\right]^n$	np	$np(1-p)$
Geometric	Probability of tossing coin x times until first heads, coin lands heads with probability p	$P(X = x) = p(1-p)^{x-1}$	$P(X \leq x) = 1 - (1-p)^x$	$\frac{pe^\theta}{1-(1-p)e^\theta}$	$\frac{1}{p}$	$\frac{1-p}{p^2}$
Poisson	Probability of x occurrences within a fixed time interval or space; parameter λ represents average number of occurrences	$P(X = x) = \frac{\lambda^x e^{-\lambda}}{x!}$	$P(X \leq x) = \sum_{k=0}^{\lfloor x \rfloor} \frac{\lambda^k e^{-\lambda}}{k!}$	$e^{\lambda(e^\theta - 1)}$	λ	λ
Exponential	Probability distribution of time between events in a Poisson process occurring with rate λ	$f(x) = \lambda e^{-\lambda x}$ for $x \geq 0$	$P(X \leq x) = 1 - e^{-\lambda x}$ for $x \geq 0$	$\frac{\lambda}{\lambda - \theta}$ for $\theta < \lambda$	$\frac{1}{\lambda}$	$\frac{1}{\lambda^2}$
Uniform	Uniform distribution on interval $[a, b]$	$f(x) = \frac{1}{b-a}$ for $x \in [a, b]$	$P(X \leq x) = \begin{cases} 0 & \text{if } x < a \\ \frac{x-a}{b-a} & \text{if } a \leq x \leq b \\ 1 & \text{if } x > b \end{cases}$	$\frac{e^{b\theta} - e^{a\theta}}{\theta(b-a)}$ for $\theta \neq 0$	$\frac{a+b}{2}$	$\frac{(b-a)^2}{12}$
Normal	Continuous distribution with bell curve shape, parameterized by mean μ and variance σ^2	$f(x) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$	$P(X \leq x) = \Phi\left(\frac{x-\mu}{\sigma}\right)$	$e^{\mu\theta + \frac{1}{2}\sigma^2\theta^2}$	μ	σ^2

Table 1: Key Distributions and Their Properties

3 Statistics

3.1 Normal Distribution and Related Properties

3.2 Linear Regression

3.3 Hypothesis Testing

3.4 Confidence Intervals

3.5 Maximum Likelihood Estimation (MLE)

4 Stochastic Processes

4.1 Markov Chains

4.2 Martingales

Martingales, Submartingales, Supermartingales

Let $(\mathcal{F}_n)$ be a filtration and (X_n) an adapted process.

$$\text{Martingale:} \quad \mathbb{E}[X_{n+1} \mid \mathcal{F}_n] = X_n$$

$$\text{Submartingale:} \quad \mathbb{E}[X_{n+1} \mid \mathcal{F}_n] \geq X_n$$

$$\text{Supermartingale:} \quad \mathbb{E}[X_{n+1} \mid \mathcal{F}_n] \leq X_n$$

Optimal Stopping Times

A stopping time τ with respect to $(\mathcal{F}_n)$ is a random time such that:

$$\{\tau \leq n\} \in \mathcal{F}_n \quad \text{for all } n$$

The optimal stopping problem seeks τ to maximize:

$$\mathbb{E}[X_\tau]$$

for a given process (X_n). The optimal stopping theorem provides conditions under which:

$$\mathbb{E}[X_\tau] \leq \mathbb{E}[X_0]$$

for all stopping times τ, if (X_n) is a supermartingale.

4.3 Random Walks

Birth and Death Chains

A birth and death chain is a Markov chain on $\mathbb{N}$ with transitions:

$$P(i, i+1) = \lambda_i \quad \text{(birth)}, \quad P(i, i-1) = \mu_i \quad \text{(death)}$$

$$P(i, i) = 1 - \lambda_i - \mu_i$$

with $\lambda_i, \mu_i \geq 0$ and $\lambda_i + \mu_i \leq 1$.

4.4 Dynamic Programming

5 Finance

5.1 Options

5.2 Derivatives

5.3 Portfolio Theory

5.4 Arbitrage and Pricing

6 Brainteasers

6.1 Mathematical Sequences

Common Sequences in Quantitative Reasoning

Arithmetic Sequence: constant difference

$$a_n = a + (n-1)d \quad \text{e.g. } 2, 5, 8, 11, \ldots \quad (d = 3)$$

Geometric Sequence: constant ratio

$$a_n = ar^{n-1} \quad \text{e.g. } 3, 6, 12, 24, \ldots \quad (r = 2)$$

Mixed Operations:

- $n^2 + 1$: 2, 5, 10, 17, 26, ...
- $\times 2 + 1$: 1, 3, 7, 15, 31, ...
- $n(n+1)$: 2, 6, 12, 20, 30, ...

Powers and Factorials:

- Squares: $1, 4, 9, 16, 25, \ldots$
- Cubes: $1, 8, 27, 64, \ldots$
- Factorials: $1, 2, 6, 24, 120, \ldots$ ($n!$)

Prime Numbers:

$$2, 3, 5, 7, 11, 13, 17, 19, 23, 29, \ldots$$

Alternating Patterns:

- Alternate +3 and −1: $1, 4, 3, 6, 5, 8, \ldots$

Fibonacci-Type Recurrences:

- $f_n = f_{n-1} + f_{n-2}$: $0, 1, 1, 2, 3, 5, 8, \ldots$
- $f_n = 3f_{n-1} + f_{n-2}$: $2, 5, 17, 56, 185, 611$

7 Algorithms and Data Structures

References

[1] The quant interview cheat sheet. https://www.quantguide.io/Cheat-Sheet.pdf. Accessed: August 14, 2025.

[2] Quant Insider. Probability & statistics cheatsheet (linkedin post). https://www.linkedin.com/posts/quant-insider_probability-statistics-cheatsheet-activity-7133740570425835522-60QN/. Accessed: August 14, 2025.