



QUANTITATIVE METHODS

CFA[®] Program Curriculum
2027 • LEVEL I • VOLUME 1

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How to Use the CFA Program Curriculum

The CFA[®] Program exams measure your mastery of the core knowledge, skills, and abilities required to succeed as an investment professional. These core competencies are the basis for the Candidate Body of Knowledge (CBOK™). The CBOK consists of four components:

A broad outline that lists the major CFA Program topic areas (www.cfainstitute.org/programs/cfa/curriculum/cbok/cbok)

Topic area weights that indicate the relative exam weightings of the top-level topic areas (www.cfainstitute.org/en/programs/cfa/curriculum)

Learning outcome statements (LOS) that tell you the specific knowledge, skills, and abilities you should gain from each curriculum topic area. You will find these statements at the start of each learning module and lesson. We encourage you to review the information about the LOS on our website (www.cfainstitute.org/programs/cfa/curriculum/study-sessions), including the descriptions of LOS “command words” on the candidate resources page at www.cfainstitute.org/-/media/documents/support/programs/cfa-and-cipm-los-command-words.ashx.

The CFA Program curriculum that candidates receive access to upon exam registration.

Therefore, the key to your success on the CFA exams is studying and understanding the CBOK. You can learn more about the CBOK on our website: www.cfainstitute.org/programs/cfa/curriculum/cbok.

The curriculum, including the practice questions, is the basis for all exam questions. The curriculum is selected/developed specifically to provide candidates with the knowledge, skills, and abilities reflected in the CBOK.

CFA INSTITUTE LEARNING ECOSYSTEM (LES)

Your exam registration fee includes access to the CFA Institute Learning Ecosystem (LES). This digital learning platform provides access to all the curriculum content and practice questions. The LES is organized as a series of learning modules consisting of short online lessons and associated practice questions. This tool is your source for all study materials, including practice questions and mock exams. The LES is the primary method by which CFA Institute delivers your curriculum experience. Here, you will find additional practice questions to test your knowledge, including some interactive questions.

DESIGNING YOUR PERSONAL STUDY PROGRAM

An orderly, systematic approach to exam preparation is critical. You should dedicate a consistent block of time every week to reading and studying. Review the LOS both before and after you study curriculum content to ensure you can demonstrate

the knowledge, skills, and abilities described by the LOS and the assigned learning module. Use the LOS as a self-check to track your progress and highlight areas of weakness for later review.

Successful candidates report an average of more than 300 hours preparing for each exam. Your preparation time will vary based on your prior education and experience, and you will likely spend more time on some topics than on others.

ERRATA

The curriculum development process is rigorous and involves multiple rounds of reviews by content experts. Despite our efforts to produce a curriculum that is free of errors, we must make corrections in some instances. Curriculum errata are periodically updated and posted by exam level and test date on the Curriculum Errata webpage (www.cfainstitute.org/en/programs/submit-errata). If you believe you have found an error in the curriculum, you can submit your concerns through our curriculum errata reporting process found at the bottom of the Curriculum Errata webpage.

OTHER FEEDBACK

Please send any comments or suggestions to info@cfainstitute.org, and we will review your feedback thoughtfully.

Quantitative Methods

LEARNING MODULE

1

Returns of Financial Assets and Instruments

LEARNING OUTCOMES

<i>Mastery</i>	<i>The candidate should be able to:</i>
<input type="checkbox"/>	describe, compare, and interpret returns
<input type="checkbox"/>	describe, compare, and interpret required rates of return, risk-free rates, risk premia, and inflation

INTRODUCTION: RETURNS OF FINANCIAL ASSETS AND INSTRUMENTS

1

The Quantitative Methods learning modules focus on the fundamental building blocks that shape investment decision-making and investment strategies. The first learning module introduces the calculation and interpretation of returns and rates. It then discusses different return measures and demonstrates their calculation approaches.

Subsequent learning modules introduce other key quantitative building blocks: time value of money, statistical properties of financial and economic data, portfolio mathematics, modern portfolio theory, regression analysis, and asset pricing. Practical market examples support these building blocks as they will reappear throughout the three levels of the curriculum.

PRE-TEST: RETURNS OF FINANCIAL ASSETS AND INSTRUMENTS



1. SolarTech Innovations' shares showed the following total returns:

- Year 1: -10%
- Year 2: 15%
- Year 3: 20%

Over the three-year period, SolarTech shares had a geometric annual return closest to:

- A. 7.49%.

- B.** 8.33%.
C. 14.93%.

Solution

The correct response is A, 7.49%. Geometric mean return accurately captures the compound interest effect over multiple periods:

$$[(1 - 0.10) \times (1 + 0.15) \times (1 + 0.20)]^{\frac{1}{3}} - 1 = 7.49\%.$$

This method accounts for the compounding effect of gains and losses over the years.

Answer B is incorrect. It computes the arithmetic average:

$$\frac{-10\% + 15\% + 20\%}{3} = 8.33\%.$$

Answer C is incorrect. It treats the negative return during the first year incorrectly:

$$[(1 + 0.10) \times (1 + 0.15) \times (1 + 0.20)]^{\frac{1}{3}} - 1 = 14.93\%.$$

2. A stock experiences a continuously compounded return of 10% for the first half of a year and 40% for the second half. Its continuously compounded return for the full year is closest to:

- A.** 50.00%.
B. 54.00%.
C. 56.25%.

Solution

The correct response is A, 50.00%. Continuously compounded returns are additive over time. For each period's return, we directly add them: 10% for the first half and 40% for the second half, 10% + 40% = 50%.

Answer B is incorrect. It does not consider the additive property of continuously compounded returns: $1.1 \times 1.4 - 1 = 54\%$. This treats the returns as if they were realized simple returns for the period and ignores that they are continuously compounded.

Answer C is incorrect. It first averages the continuously compounded returns, $\frac{10\% + 40\%}{2} = 25\%$, before calculating the period returns, $1.25^2 - 1 = 56.25\%$.

3. An investor purchases 1,000 shares at USD100 per share. After she receives a dividend of USD3 per share one year later, she sells the shares for USD120 per share. Her tax rate is 25% on capital gains and 15% on capital distributions. Her after-tax return for the year is closest to:

- A.** 17.25%.
B. 17.55%.
C. 19.25%.

Solution

The correct response is B, 17.55%. The after-tax return can be calculated using the following relationship:

$$r_{net-tax} = r_{price} \times (1 - tax_{capitalgains}) + r_{distributions} \times (1 - tax_{distributions}).$$

First, the price return is calculated:

$$r_{price} = \frac{P_1 - P_0}{P_0} = \frac{\text{USD}120 - \text{USD}100}{\text{USD}100} = 20.0\%.$$

Then, the capital distribution return is calculated:

$$r_{distributions} = \frac{Inc}{P_0} = \frac{\text{USD}3}{\text{USD}100} = 3.0\%.$$

Finally, the respective after-tax returns are calculated:

$$\begin{aligned} & r_{price} \times (1 - tax_{capital\ gains}) + r_{distributions} \times (1 - tax_{distributions}) \\ &= 20.0\% \times (1 - 25\%) + 3.0\% \times (1 - 15\%) = 15.0\% + 2.55\% = 17.55\%. \end{aligned}$$

Answer A is incorrect. It applies the higher capital gains tax rate on both sources of returns:

$$\begin{aligned} & r_{price} \times (1 - tax_{capital\ distributions}) + r_{distributions} \times (1 - tax_{capital\ gains}) \\ &= 20.0\% \times (1 - 25\%) + 3.0\% \times (1 - 25\%) = 15.0\% + 2.25\% = 17.25\%. \end{aligned}$$

Answer C is incorrect. It applies incorrect tax rates; specifically, it reverses the rates.

$$\begin{aligned} & r_{price} \times (1 - tax_{capital\ distributions}) + r_{distributions} \times (1 - tax_{capital\ gains}) \\ &= 20.0\% \times (1 - 15\%) + 3.0\% \times (1 - 25\%) = 17.0\% + 2.25\% = 19.25\%. \end{aligned}$$

4. In investment decisions, the risk premium:

- A. guarantees that expected returns meet actual returns.
- B. compensates investors for uncertainty associated with returns.
- C. ensures that risk-free investments deliver consistent returns over time.

Solution

The correct answer is B. The risk premium compensates for the risk associated with the variance between expected, *ex ante*, and actual, *ex post*, returns. It compensates for the uncertainty between expected and realized returns. The size of the compensation reflects the increased uncertainty about expected returns: The higher the uncertainty, the higher the risk premium.

Answer A is incorrect. The risk premium cannot guarantee that expected returns will always meet realized returns. The risk premium compensates for the inherent uncertainty between expectations and outcomes.

Answer C is incorrect. The risk premium is not intended to make risk-free investments deliver consistent returns over time. Risk-free investments do not face default or reinvestment risk.

FINANCIAL RETURNS

2

- describe, compare, and interpret returns

Returns are a critical component of understanding the financial markets, yet returns cannot be distilled into one easily defined concept. The different types of **financial assets** and instruments bundle series of cash flows that provide distinctly different returns to investors. This first learning module provides a brief overview of the types of returns provided by financial assets and instruments. The next learning module will discuss the source of their returns and their historical performance.

- Financial assets include cash, such as coins and bills; equity or ownership interest; debt, a liability of the debtor to the creditor or investor, which is an asset of the creditor or investor; and hybrid securities that combine these characteristics. These assets represent various forms of value held by individuals or entities and play crucial roles in investment and financing activities.
- Financial instruments include equity and debt and different types of standardized and tradable contractual relationships that reflect value, such as rights or derivatives. Both debt and equity are well-defined, highly standardized financial assets that are traded as financial instruments. Financial instruments bundle different patterns of cash flows and payoffs together into a single security or contract. This standardization and tradability facilitate the efficient exchange of these instruments between investors in financial markets.
- **Financial indicators** are observable but not directly tradable indicators of value and include exchange rates, interest rates, and market indexes. Unlike financial assets and instruments, financial indicators do not generate cash flows.

The distinction between financial assets and financial instruments is nuanced. **Financial instruments** are the means through which financial assets are standardized, packaged, and traded in financial markets. Other alternative approaches exist to group and define investments.

This section covers the basics of return on debt and equity investments, which account for the bulk of investable assets. Although other asset classes, such as commodities, alternative assets, and digital assets, are not specifically covered, the building blocks described below are generally applicable to them as well.

Total Return

Financial assets, instruments, and indicators are frequently defined in terms of their return and risk characteristics. Returns are normally generated in two ways.

Capital appreciation return, or price return, is the change in the price between two different points of time, where P_0 denotes the price when the initial investment is made and P_1 represents the price at a later valuation date:

$$r_{price} = \frac{P_1 - P_0}{P_0}. \quad (1)$$

Capital distribution return is income through cash dividends, interest payments, or other types of capital distributions, denoted here as Inc and expressed in terms of the initial investment made in the asset:

$$r_{distribution} = \frac{Inc}{P_0}. \quad (2)$$

For capital distributions on equities, we focus on the dividend yield; for bonds, we look at current yield. **Dividend yield** is calculated as the annual dividends paid by a company divided by its share price at the beginning of the period, or P_0 . **Current yield** is calculated as the annual coupon payments divided by the market price of the bond.

Financial Returns

The **total return** encompasses both sources of return, capital appreciation and capital distributions, and is integral in assessing the performance of an investment:

$$\begin{aligned}
 r &= r_{price} + r_{distribution} \\
 &= \frac{P_1 - P_0}{P_0} + \frac{Inc}{P_0} \\
 &= \frac{P_1 - P_0 + Inc}{P_0}.
 \end{aligned} \tag{3}$$

Some financial assets provide return through only one of these mechanisms. Investors in non-dividend-paying stocks obtain return only from price movements. Investors in **annuity contracts**, a financial product that pays out a fixed stream of payments during the life of the contract, do not receive any other income or distributions.

Whether investors measure returns over a single period or over multiple periods, returns are expressed as decimals (0.09), fractions (9/100), and percentages (9.0%). This simplifies comparison across different investments and time periods. Calculating single period returns is straightforward, as they measure the change in an asset's value and capital distribution return over a single period: a day, a month, a quarter, or a year. Multi-period returns, assessing long-term value accumulation of capital relevant to investment management, are more complicated and will be covered later in this module.

Returns can be expected returns and actual returns. **Expected returns**, or ex ante returns, are the anticipated returns on an investment over a specified period. They are not guaranteed but are estimated based on historical data, current market conditions, and analysis of the asset or investment. Expected returns feed into the investment management and decision-making process, representing the investor's forecasts before the investment's outcome is known. **Actual returns**, or ex post returns, are the returns on an investment after the investment period has ended. They may differ from expected returns due to unforeseen market movements, changes in economic conditions, or specific events affecting the asset or market.

The concept of risk and risk premia, which we will discuss later, primarily revolves around compensating for the difference between expected returns, or ex ante, and actual returns, or ex post. This distinction highlights the inherent **risk** in investment decision making: Decisions are based on expected returns but ultimately deliver actual returns. The greater the likelihood that actual returns will fall short of expected returns, the greater the compensation investors will demand.

While an investor holds an investment, changes in value represent **unrealized returns**. These are gains and losses that would be realized if the investment were sold at the current market value. These unrealized profits are also called "paper gains." When the investment is ultimately sold, these returns become **realized returns**. Capital distributions, such as dividends or interest while the investment is held, are also realized returns that are generally recognized in the period in which they are received. In most cases, taxes are applied only when gains are realized.

The following case study analyzes the performance of Ørsted A/S, a renewable energy company based in Denmark.

CASE STUDY



Calculating Ørsted A/S Bond and Equity Returns

Ørsted A/S, www.orsted.com, a Danish company, operates in the renewable energy sector, including the development, construction, and operation of offshore and onshore wind farms, bioenergy plants, solar farms, energy storage facilities. It also engages in waste-to-energy solutions and smart energy products. The company's equity is traded on the NASDAQ Copenhagen, formerly known as

the Copenhagen Stock Exchange, <https://www.nasdaqomxnordic.com/>. Exhibit 1 shows the long-term performance of the stock in a Bloomberg screenshot using the ORSTED DC Equity GP <GO> function (in Danish krone, DKK).

Exhibit 1: Ørsted A/S Equity Performance 1 January 2016–29 December 2023 (in DKK)



Source: Bloomberg.

Exhibit 2 provides the year-end prices and dividends for Ørsted A/S shares from 2017–2023, with values denominated in DKK.

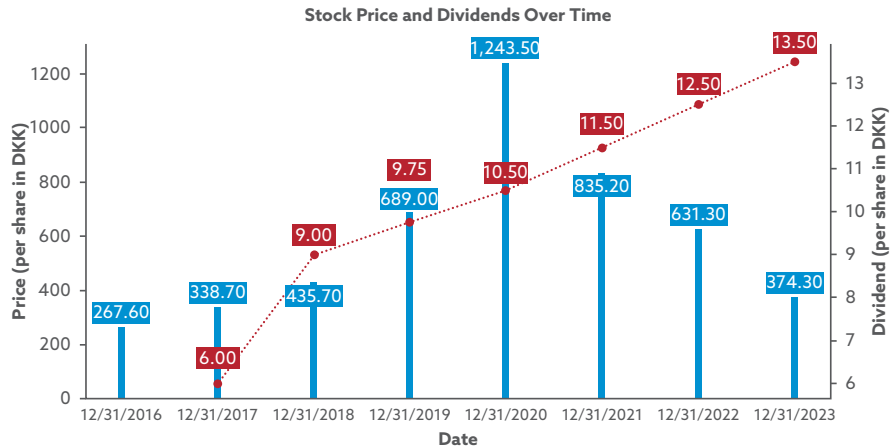
Exhibit 2: Ørsted A/S Equity Year-End Prices and Annual Dividends, 2017–2023 (in DKK)

Date	Price (per share in DKK)	Dividend (per share in DKK)
31 December 2016*	267.60	---
31 December 2017	338.70	6.00
31 December 2018	435.70	9.00
31 December 2019	689.00	9.75
31 December 2020	1,243.50	10.50
31 December 2021	835.20	11.50
31 December 2022	631.30	12.50
31 December 2023	374.30	13.50

*The 31 December 2016 price, or year-end price, is used as the starting value for the year 2017.

Exhibit 3 shows the same information as that in Exhibit 2 graphically. It depicts the appreciation of the stock price from year end 2016–2020 and its subsequent decline from 2020 to 2023. At the same time, it depicts how dividends have increased steadily.

Exhibit 3: Ørsted A/S Equity Year-End Prices and Annual Dividends, 2016–2023 (in DKK)



Note: The 31 December 2016 price, or year-end price, is used as the starting value for the year 2017.

On 24 November 2017, Ørsted A/S entered the Green Bond market with its EUR750 million Senior Unsecured Bond listed on the London Stock Exchange. This bond, with a fixed annual coupon rate of 1.5%, is set to mature on 26 November 2029. It pays an annual coupon of EUR15 per EUR1,000 principal, with the first payment made on 18 November 2018. The bond's proceeds are allocated to finance offshore wind, bioenergy, and smart grid projects. These investments aim to facilitate a transition to a low-carbon, climate-resilient, and sustainable economy, potentially reducing emissions by 104,000 metric tons of CO₂ per year. Exhibit 4 shows the long-term performance of this bond issue in a Bloomberg screenshot using the ORSTED 1 ½ 11/26/29 Corp GP <GO> function.

Exhibit 4: Ørsted A/S Bond Performance, 1 December 2017–29 December 2023 (in EUR)



Source: Bloomberg.

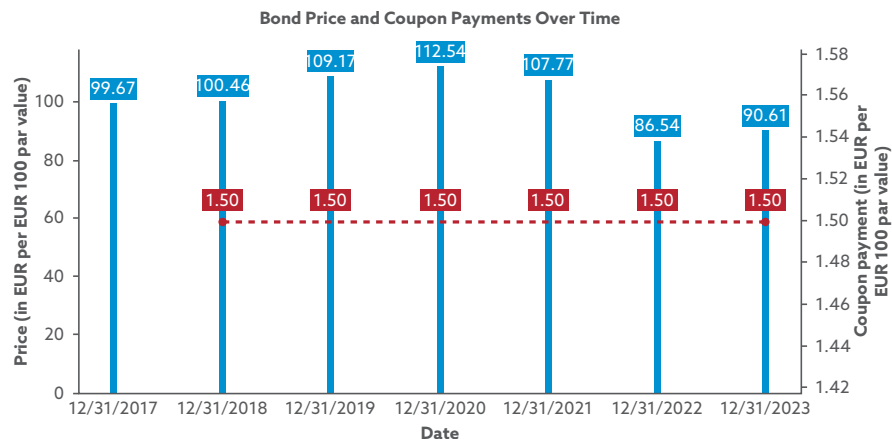
Exhibit 5 provides the year-end price of the bond from 2018–2023 and its annual coupon payments in EUR. Note that the coupon payments occurred earlier in the year, sometime in November.

Exhibit 5: Ørsted A/S EUR750 Million Senior Unsecured Bond Year-End Prices and Annual Coupon Payments, 2017–2023 (in EUR)

Date	Price (in EUR per EUR 100 par value)	Annual Coupon Payment (in EUR per EUR 100 par value)
31 December 2017	99.672	---
31 December 2018	100.462	1.50
31 December 2019	109.173	1.50
31 December 2020	112.540	1.50
31 December 2021	107.769	1.50
31 December 2022	86.536	1.50
31 December 2023	90.614	1.50

Note: The 31 December 2017 price, or year-end price, is used as the starting value for the year 2018.

Exhibit 6 presents the same information as in Exhibit 5 graphically. It shows the variability in the price of the bond and the steady fixed annual coupon payment investors receive.

Exhibit 6: Ørsted A/S EUR750 Million Senior Unsecured Bond Year-End Prices and Annual Coupon Payments (in EUR)


Note: The 31 December 2017 price, or year-end price, is used as the starting value for the year 2018.

1. Calculate the price return, dividend yield, and total return, for Ørsted A/S equity in 2020.

Solution

In 2020, the equity of Ørsted A/S had a price return of 80.48% and a dividend yield of 1.52%, resulting in a total return of 82.00%. To arrive at this result, there are three steps: Calculate the price return, then determine the capital distribution return, and finally add these two returns together.

1. Price return