Financial Literacy with Mr. 401(k)
Winter Term 2024 - 2025
February 10, 2025

Time and Money

Class 21: The Power of Time - Compound Interest with Lump Sum Formulas

Practical Application

Jane lends $100 to John for exactly one month. At the end of one month, John repays Jane exactly $100.

Who benefited most from this trade? Why?

Practical Application

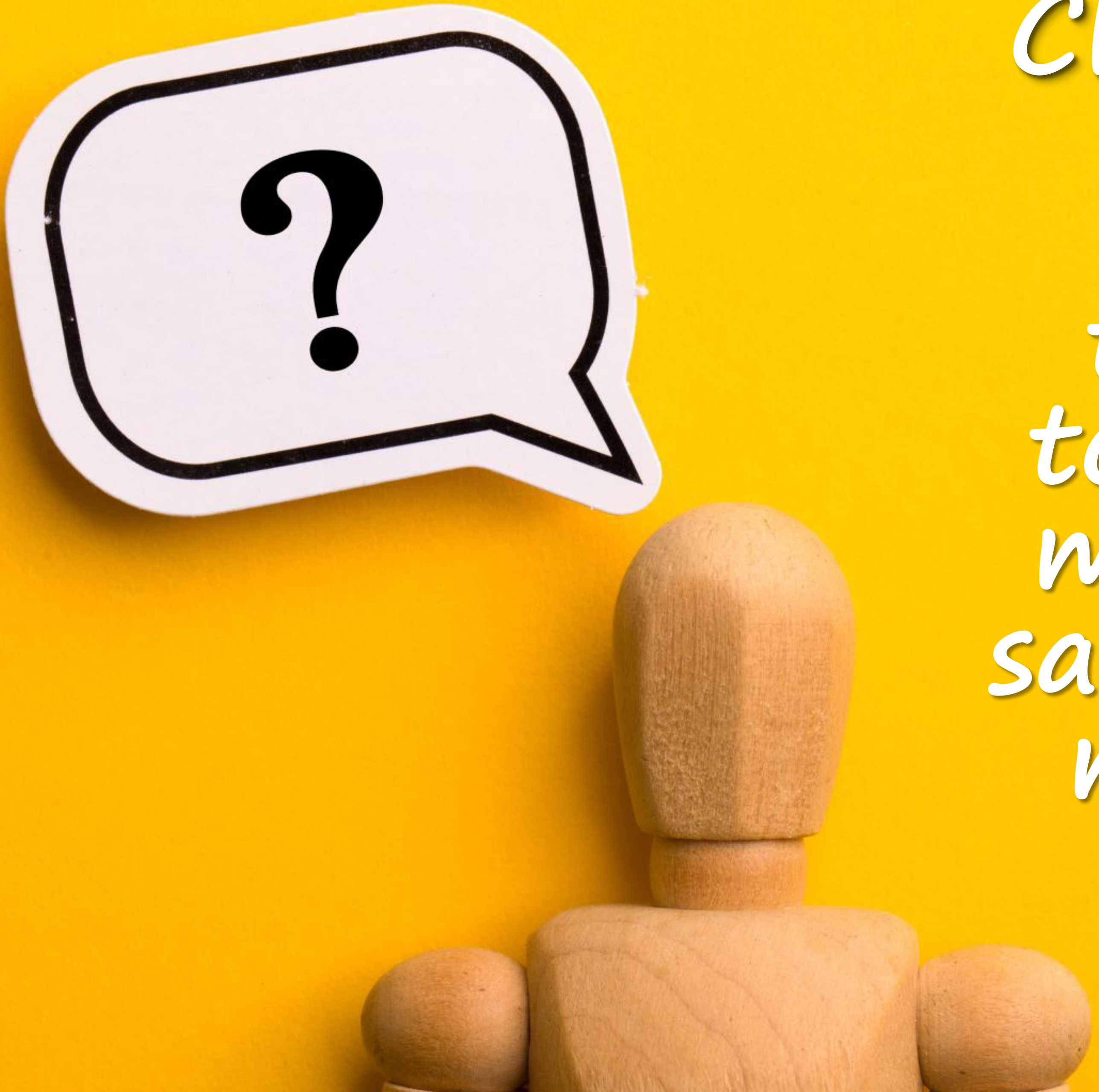
Jane lends $100 to John for exactly one month. At the end of one month, John repays Jane exactly $100.

What if John paid Jane back $105 instead of $100? How does that change things?

Money today is always worth more than the same amount of money in the future.*

Time Value of Money

* Presuming an inflating monetary unit of account



Class Discussion

Why do you think money today is worth more than the same amount of money in the future?

The Time Value of Money is based on the effects of...

💸

Inflation

*When prices go **UP**, your money buys **LESS.*** 📉 ⬇️

Imagine your favorite snack costs $1 today, but $2 in the future!

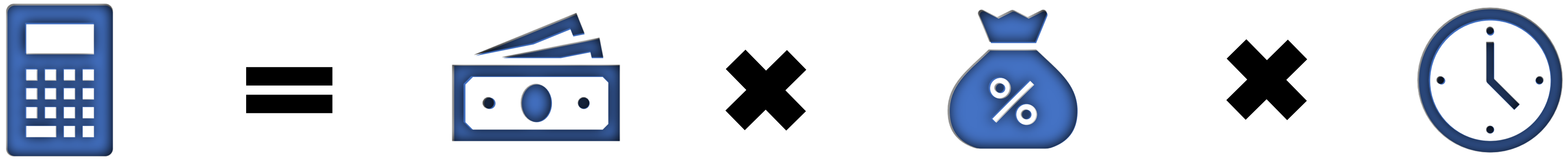
💰

Interest Rates

*When you **SAVE** or **INVEST**, your money can **GROW.*** 📈 ⬆️

Like putting $100 in a bank savings account and earning $5 over time!

Recap: Simple Interest Formula

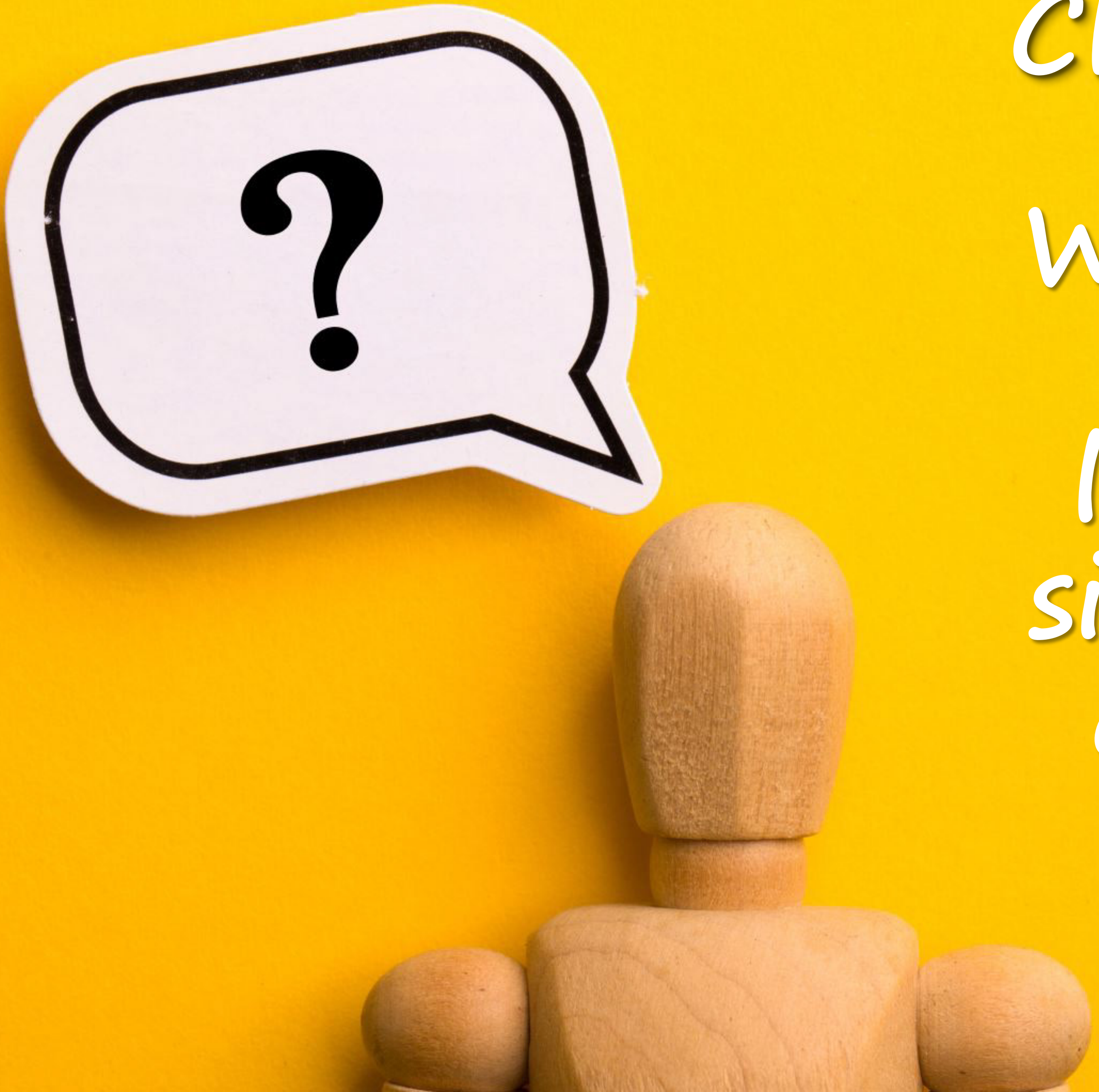


Simple Interest Amount

Principal Amount

Interest Rate

Time in Years



Class Discussion

What might be some of the limitations of simple interest calculations?

The Problems with Simple Interest

Calculation Basis

Only Counts the Original Amount

Simple interest only grows based on the money you started with—not the money you have earned along the way.

Example: If you invest $100, you will only earn interest on that $100—never on the interest you have already earned.

Prior Time Periods

Ignores Past Growth

Simple interest does not care how much interest you earned before. Every year starts fresh, without adding what you made last year.

Example: It is like starting over every time, instead of building on what you already have—kind of like saving money in a jar.

Compounding is a method of calculating the total interest on the principal, where the interest is reinvested. Think of this as "interest on interest."

Compound Interest

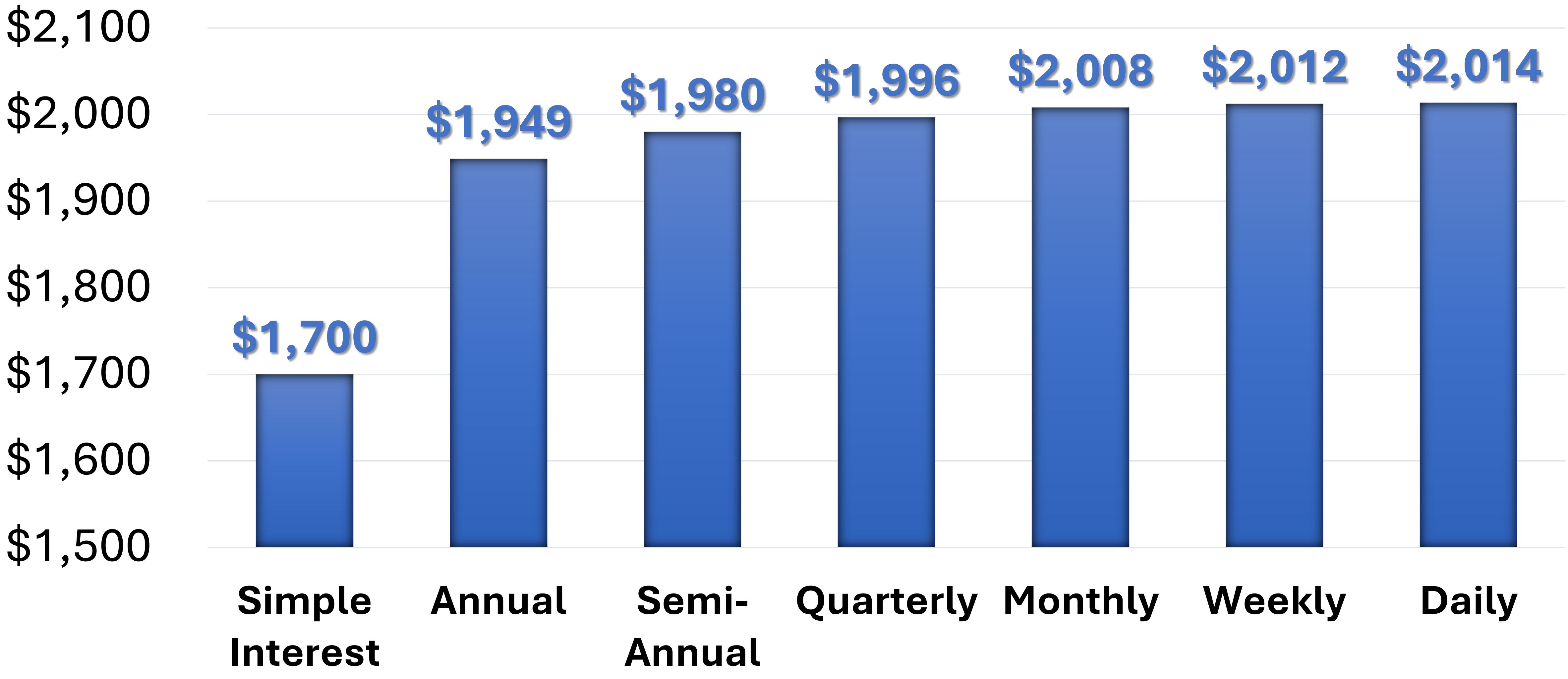
Simple Interest vs. Compound Interest

What happens to $1,000 with 10% interest over 7 years?

End of Year	Interest Earned (Simple)	Total Savings (Simple)	Interest Earned (Compound)	Total Savings (Compound)
1	$100	$1,100	$100	$1,100
2	$100	$1,200	$110	$1,210
3	$100	$1,300	$121	$1,331
4	$100	$1,400	$133	$1,464
5	$100	$1,500	$146	$1,611
6	$100	$1,600	$161	$1,772
7	$100	$1,700	**$177** 🚀	**$1,949** 🚀

Would you rather have $1,700 or $1,949 after 7 years? 🤔

$1,000 invested at a **10% annual interest** rate for **7 years** under simple interest and select compound interest frequencies



The **frequency of compounding** affects investment returns

Interest grows faster when it is added more often. An investment that earns interest every month will grow more than one that earns interest just once a year. **The more often interest is compounded, the more money the investor makes – and continuous compounding grows the fastest.**

Time Value of Money Lump Sum Formulas Can Calculate the...

Future Value

Helps you know how much the money you have today can grow, if you save or invest it.

- **How much will your money grow?**

Present Value

Helps you know how much money you need today to reach a certain amount in the future.

- **How much do you need today?**

Interest Rate

Helps you to know how fast your money will grow, or the interest rate you earn

- What interest rate do I need for my money to reach my goal in the future?

Time

Helps you to know how long it will take to reach a specific savings goal or investment outcome

- How long before I save enough for a big purchase?

Practical Application

John saved $1,000 from summer yard care work. John deposits the $1,000 into a high yield savings account. The high yield savings account pays 4.5% annual interest, compounded monthly. Let’s calculate what the value of this would be after 3 years.

How Much Will Your Money Grow?

The more often your money earns interest, the faster it grows! (That's 'n')

- n = 1: Once a year (**annually**)
- n = 2: Twice a year (**semi-annually**)
- n = 4: Four times a year (**quarterly**)
- n = 12: Every month (**monthly**)
- n = 52: Every week (**weekly**)
- n = 365: Every day (**daily**)

$$FV = PV \times \left(1 + {}^{r}/_{n}\right)^{nt}$$

- **FV (Future Value) =** *Your money in the future*
- **PV (Present Value) =** *The money you start with*
- **r (Interest Rate) =** *How fast your money grows*
- **n (Compounding Frequency) =** *How often your money earns interest*
- **t (Time) =** *How long you are saving or investing*

Time Value of Money:

Future Value of a Lump Sum Formula

Practical Application

John saved $1,000 from summer yard care work. John deposits the $1,000 into a high yield savings account. The high yield savings account pays 4.5% annual interest, compounded monthly. Let's calculate what the value of this would be after 3 years.

$$FV = PV \times (1 + {}^{r}/_{n})^{nt}$$

Practical Application

John saved $1,000 from summer yard care work. John deposits the $1,000 into a high yield savings account. The high yield savings account pays 4.5% annual interest, compounded monthly. Let’s calculate what the value of this would be after 3 years.

$$FV = PV \times (1 + {}^{r}/_{n})^{nt}$$

$$FV = 1{,}000 \times \left(1 + {}^{4.5\%}/_{12}\right)^{12*3}$$

Practical Application

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$$FV = PV \times (1 + {}^{r}/_{n})^{nt}$$

$$FV = 1{,}000 \times \left(1 + {}^{4.5\%}/_{12}\right)^{12*3}$$

$$\boldsymbol{FV = \$1,144.25}$$

Practical Application

Jane wants to purchase a new bicycle in 4 years. Jane expects the bicycle will cost about $800. Jane wants to invest money today toward the purchase. If Jane expects to earn 10% compounded annually on a stock portfolio, how much does Jane need to invest today?

How Much Money do You Need Today?

The more often your money earns interest, the faster it grows! (That's ‘n’)

- n = 1: Once a year (**annually**)
- n = 2: Twice a year (**semi-annually**)
- n = 4: Four times a year (**quarterly**)
- n = 12: Every month (**monthly**)
- n = 52: Every week (**weekly**)
- n = 365: Every day (**daily**)

$$PV = \frac{FV}{\left(1 + {}^{r}/_{n}\right)^{nt}}$$

- **FV (Future Value) =** *Your money in the future*
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- **r (Interest Rate) =** *How fast your money grows*
- **n (Compounding Frequency) =** *How often your money earns interest*
- **t (Time) =** *How long you are saving or investing*

Time Value of Money:

Present Value of a Lump Sum Formula

Practical Application

Jane wants to purchase a new bicycle in 4 years. Jane expects the bicycle will cost about $800. Jane wants to invest money today toward the purchase. If Jane expects to earn 10% compounded annually on a stock portfolio, how much does Jane need to invest today?

$$\boldsymbol{PV = \frac{FV}{(1 + {}^{r}/_{n})^{nt}}}$$

Practical Application

Jane wants to purchase a new bicycle in 4 years. Jane expects the bicycle will cost about $800. Jane wants to invest money today toward the purchase. If Jane expects to earn 10% compounded annually on a stock portfolio, how much does Jane need to invest today?

$$PV = \frac{FV}{(1 + {}^{r}/_{n})^{nt}} = \frac{800}{\left(1 + {}^{10\%}/_{1}\right)^{1*4}}$$

Practical Application

Jane wants to purchase a new bicycle in 4 years. Jane expects the bicycle will cost about $800. Jane wants to invest money today toward the purchase. If Jane expects to earn 10% compounded annually on a stock portfolio, how much does Jane need to invest today?

$$\boldsymbol{PV = \frac{FV}{(1 + {}^{r}/_{n})^{nt}} = \frac{800}{\left(1 + {}^{10\%}/_{1}\right)^{1*4}} = \$546.41}$$

Money Mavericks

Objective: Work within your Money Mavericks Workgroups to solve each problem on the following Practical Applications Slide.

Practical Application

1. Jane invested $1,000 for 1 year at a 10% annual interest rate compounded annually. How much did Jane have after 1 year?
2. John invested $1,000 for 1 year at a 10% interest rate compounded **monthly**. How much did John have after 1 year?
3. Jane invested $1,000 for **10 years** at a 10% interest rate compounded monthly. How much did Jane have after 10 years?
4. John invested $1,000 for 10 years at a 10% interest rate compounded **daily**. How much did John have after 10 years?
5. Jane invested **$5,000** for **25 years** at a 10% interest rate compounded **monthly**. How much did Jane have after 25 years?
6. John invested **$100,000** for **30 years** at a 10% interest rate compounded **monthly**. How much did John have after 30 years?

$$FV = PV \times (1 + {}^{r}/_{n})^{nt}$$

Practical Application Answer Key

Replicate in Microsoft Excel =FV(rate,nper,pmt,[pv],[type])

1. Jane invested $1,000 for 1 year at a 10% annual interest rate compounded annually. How much did Jane have after 1 year? =FV(10%/1,1*1,0,-1000,0) = $1,100
2. John invested $1,000 for 1 year at a 10% interest rate compounded **monthly**. How much did John have after 1 year? =FV(10%/12,1*12,0,-1000,0) = $1,105
3. Jane invested $1,000 for **10 years** at a 10% interest rate compounded monthly. How much did Jane have after 10 years? =FV(10%/12,10*12,0,-1000,0) = $2,707
4. John invested $1,000 for 10 years at a 10% interest rate compounded **daily**. How much did John have after 10 years? =FV(10%/365,10*365,0,-1000,0) = $2,718
5. Jane invested **$5,000** for **25 years** at a 10% interest rate compounded **monthly**. How much did Jane have after 25 years? =FV(10%/12,25*12,0,-5000,0) = $60,285
6. John invested **$100,000** for **30 years** at a 10% interest rate compounded **monthly**. How much did John have after 30 years? =FV(10%/12,30*12,0,-100000,0) = $1,983,740

Reference: Time Value of Money Lump Sum Formulas

Where:

- **FV (Future Value) =** *Your money in the future*
- **PV (Present Value) =** *The money you start with*
- **r (Interest Rate) =** *How fast your money grows*
- **n (Compounding Frequency) =** *How often your money earns interest*
- **t (Time) =** *How long you are saving or investing*

$$FV = PV \times \left(1 + {}^{r}/_{n}\right)^{nt}$$

$$PV = \frac{FV}{\left(1 + {}^{r}/_{n}\right)^{nt}}$$

$$r = n\left[\left({}^{FV}/_{PV}\right)^{\left({}^{1}/_{nt}\right)} - 1\right]$$

$$t = \frac{\ln\left({}^{FV}/_{PV}\right)}{n\left[\ln\left(1 + {}^{r}/_{n}\right)\right]}$$

Three Key Takeaways

1. Money today is worth more than the same amount of money in the future because of inflation and interest rates.
2. Simple interest considers only interest on the principal amount whereas compound interest calculates the interest on interest.
3. One of the most important formulas in finance is $FV = PV \times \left(1 + {}^{r}/_{n}\right)^{nt}$

Where to Learn More

- Time Value of Money Explained with Formula and Examples by Jason Fernado via Investopedia
- Understanding the Time Value of Money by Shauna Carther Heyford via Investopedia
- Video: Time Value of Money, by Khan Academy

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