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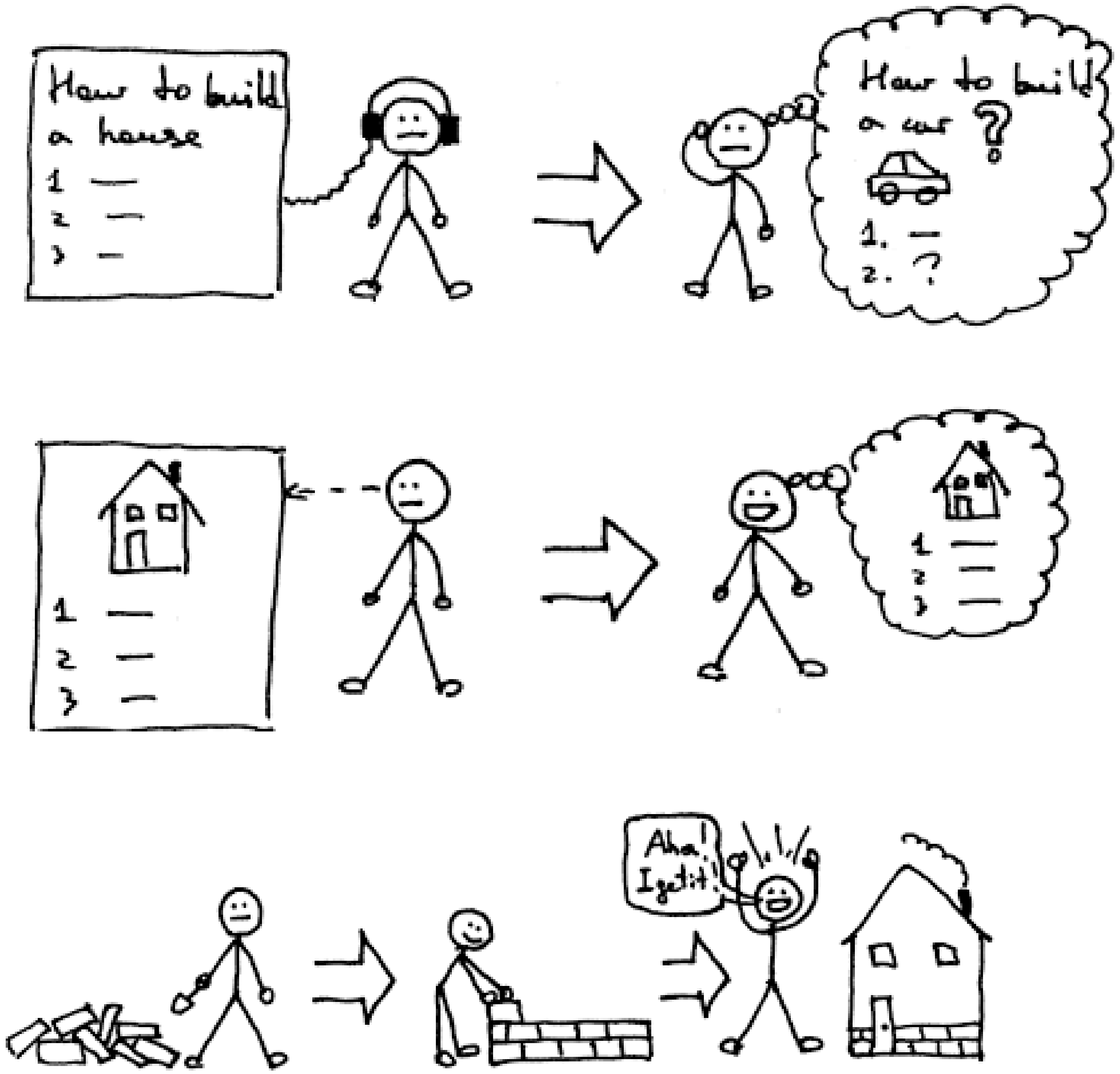
Module 1: Financial Analysis in Excel

Lesson 1: Introduction to Time Value of Money and Excel's Financial functions

Teaching Philosophy – Active Learning



I Hear and I **FORGET**

I See and I **REMEMBER**

I Do and I **UNDERSTAND**

-- Confucius

Introduction to Time Value of Money

Central Concept: Time Value of Money

WHICH OPTION WOULD YOU PREFER:

A. $10,000 TODAY, OR

B. $10,000 TEN YEARS FROM NOW?

Compounding →

← Discounting

Cash Flow Diagrams

WAYS TO REPRESENT CASH FLOWS

Projects generate a set of receipts and payments. We can represent these as the project's *Cash Flow.*

Loan Project Example:

A college student is considering borrowing $25,000 to cover expenses for their upcoming senior year.

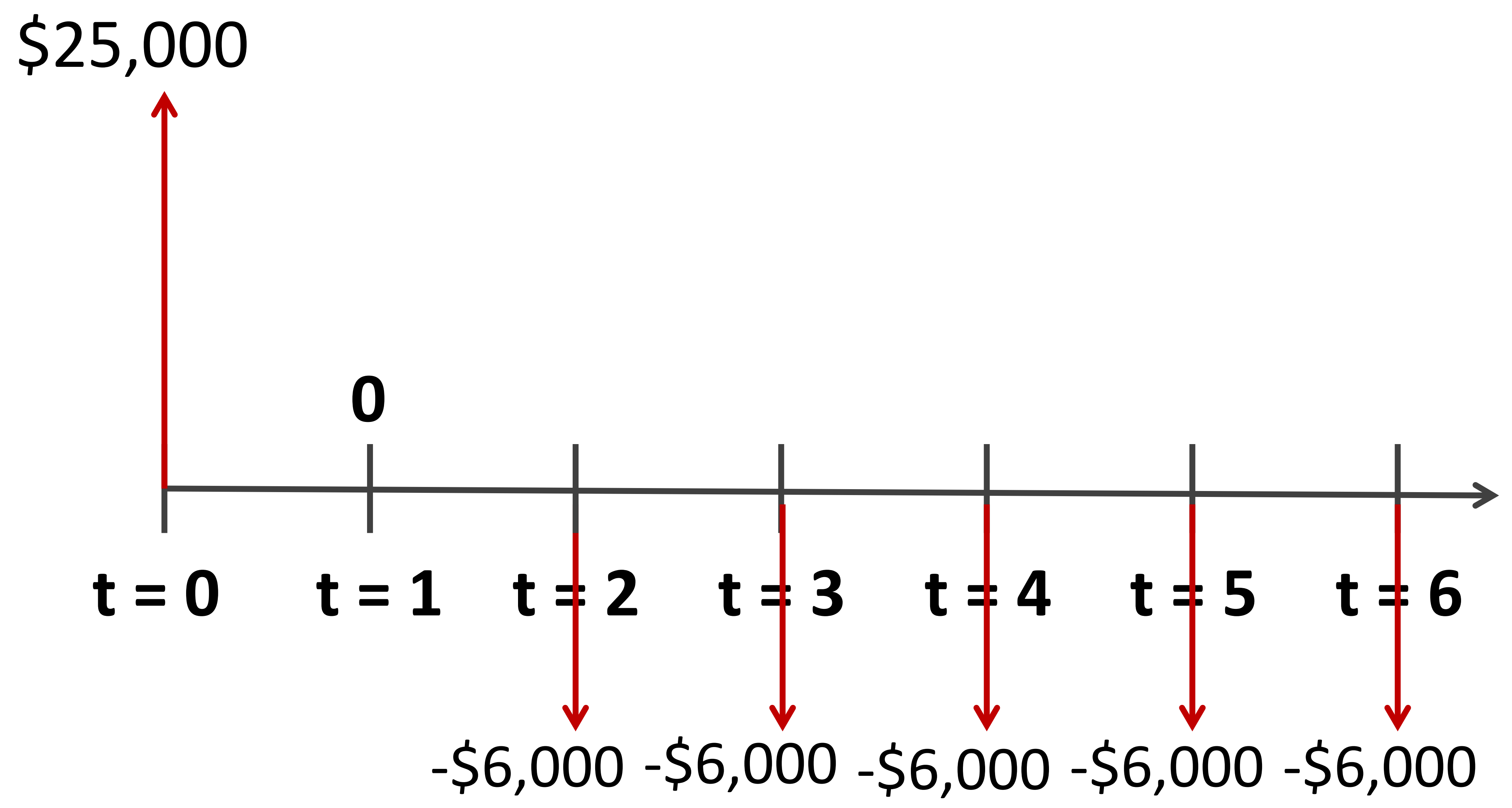
The loan is to be paid back in 5 yearly installments of $6,000 over the first 5 years of the student's professional career.

Financial Evaluation

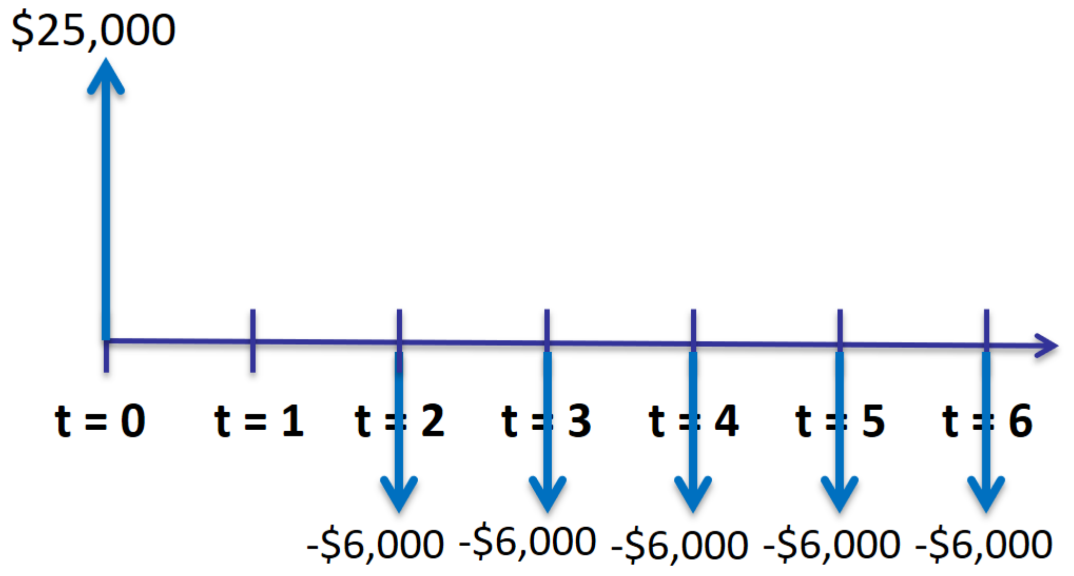
- Conventions and definitions:
  - Planning horizon → Project duration
  - **Start** of the project is labeled **Period 0**
  - **End of Year Convention: Transactions are assumed to occur at end of year/period**
  - **Inflows** (receipts, returns, payoffs) depicted as **positive (+) transactions**
  - **Outflows** (investments, payments) depicted as **negative (-) transactions**

Loan Project Example:

A college student is considering borrowing $25,000 to cover expenses for their upcoming senior year. The loan is to be paid back in 5 yearly installments of $6,000 over the first 5 years of the student's professional career.



Financial Evaluation
Cash Flow Representation as Table and Diagram

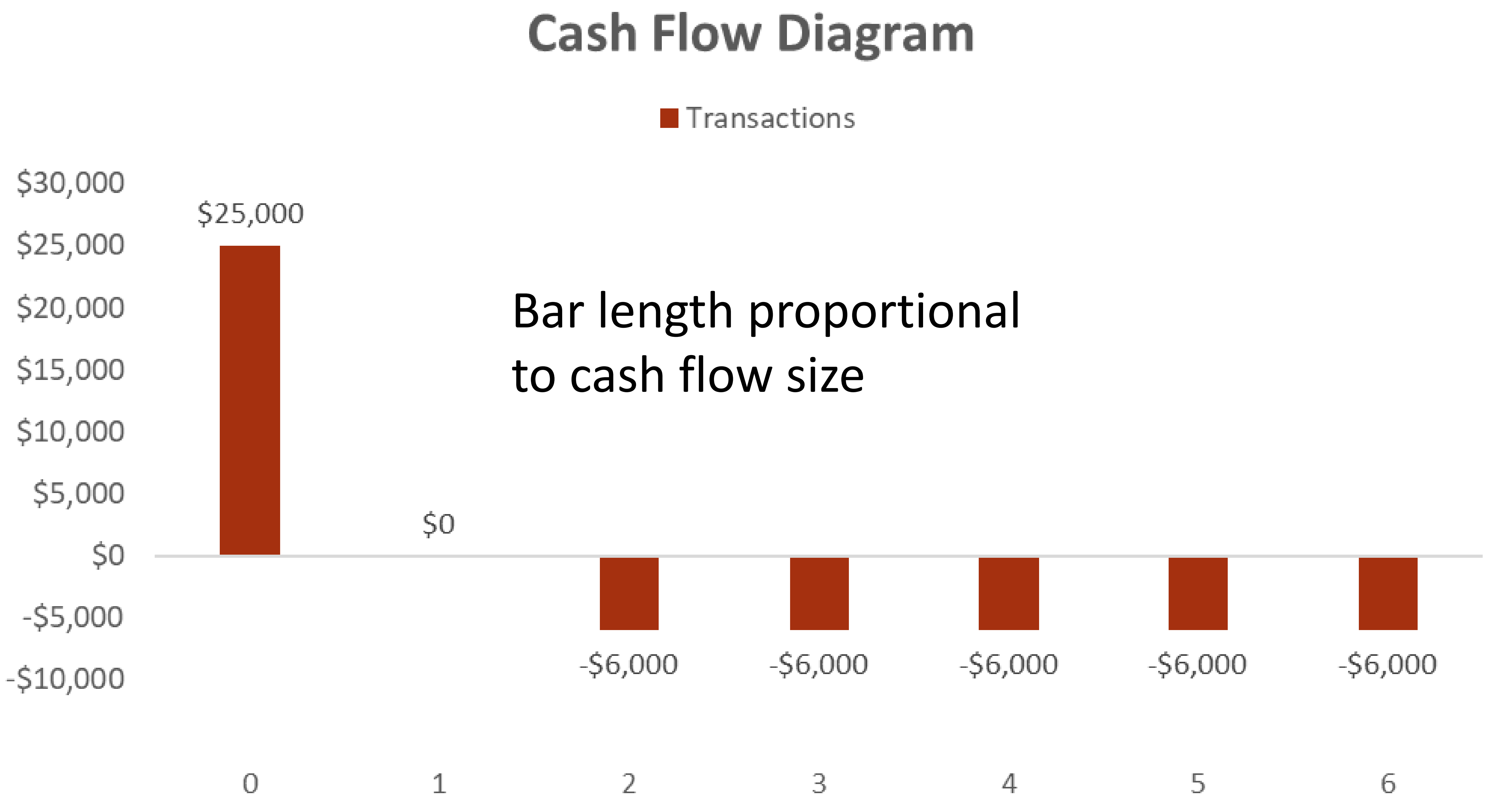


- In practice, Excel spreadsheets are tool of choice – tabular layout lends itself for financial analysis

Timing of transactions

Magnitude of transactions

	A	B	C
1	Cash Flow Table		
2		Project Year	Transaction
3	Start (Now)	0	$25,000
4	Senior Year	1	$0
5	1st year working	2	-$6,000
6		3	-$6,000
7		4	-$6,000
8		5	-$6,000
9	5th year working	6	-$6,000



Types of Interest Rate

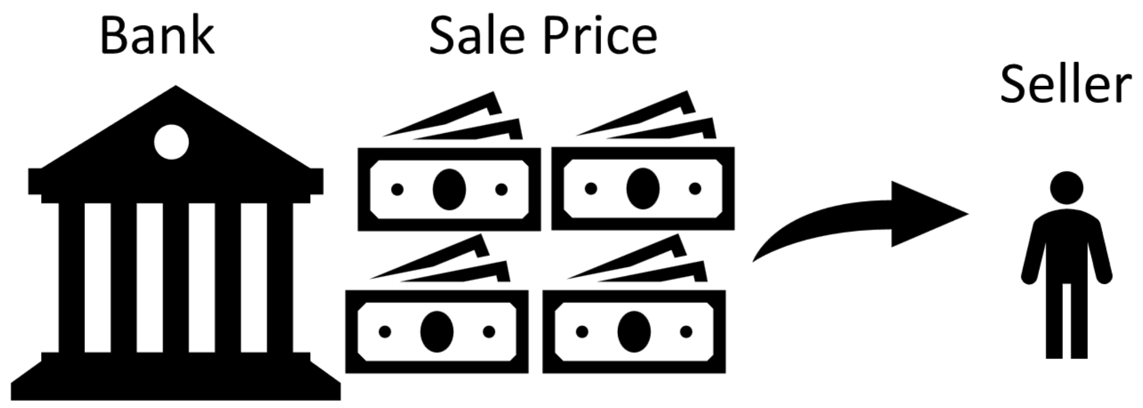
INTEREST RATE IS THE AMOUNT YOU PAY TO BORROW MONEY, OR

THE AMOUNT YOU EARN WHEN YOU INVEST MONEY WITH A BANK

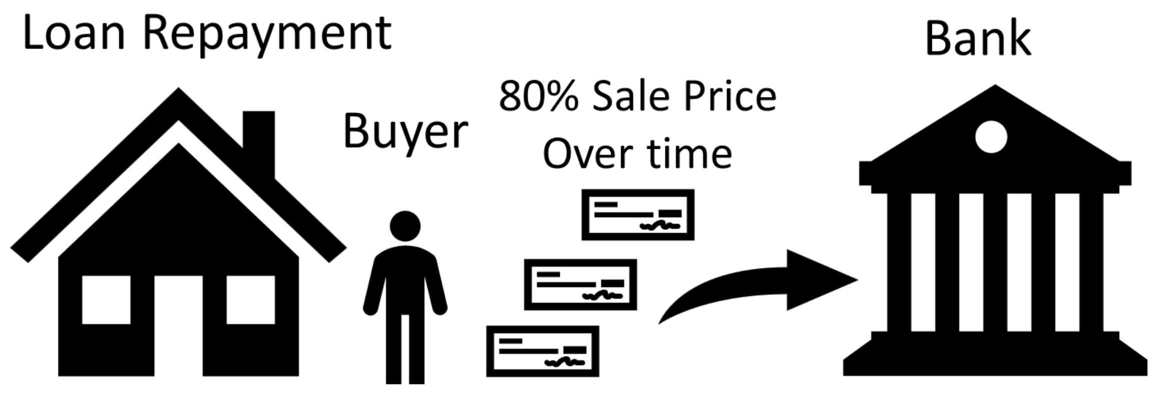
Types of Interest: Simple vs. Compound

- Principal
  - Original amount of loan or Investment (e.g., $25,000 loan student)

- Interest
  - Price borrower pays for use of lender's money
  - "Time value of Money"



- **Two Types of Interest**
  - Simple: Interest only accumulates on principal
  - Compound: Earn interest on interest



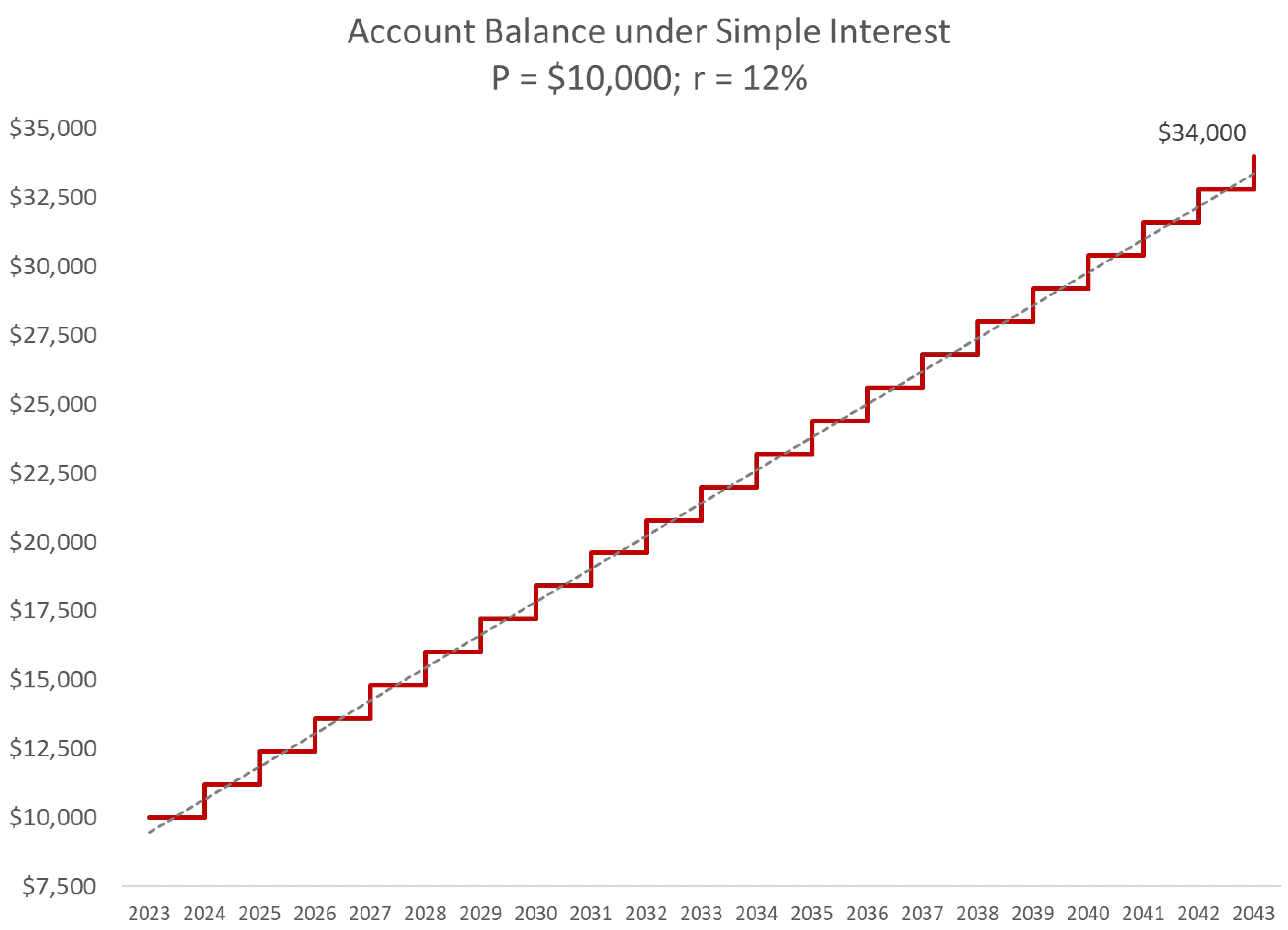
Simple Interest

$$FV = P(1 + rn)$$

- Let P be the investment or loan amount (principal)
- r - nominal (annual) interest rate (per time period)
- n - number of investment periods (years)

P = $10,000; r = 12% (per year)

Period	Balance
2023 (now)	$10,000 1,200
2024 (1)	$10,000+0.12*10,000 = $10,000*(1+0.12*1) = $11,200
2025 (2)	$10,000 +1,200 +0.12*10,000 = $10,000 (1+0.12*2) = $12,400
2026 (3)	$10,000 (1+0.12*3) = $13,600
2027 (4)	$14,800
…	



Account Balance under Simple Interest
P = $10,000; r = 12%
$35,000
$32,500
$30,000
$27,500
$25,000
$22,500
$20,000
$17,500
$15,000
$12,500
$10,000
$7,500
$34,000
2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 2036 2037 2038 2039 2040 2041 2042 2043

Compounding Process – Geometric Growth

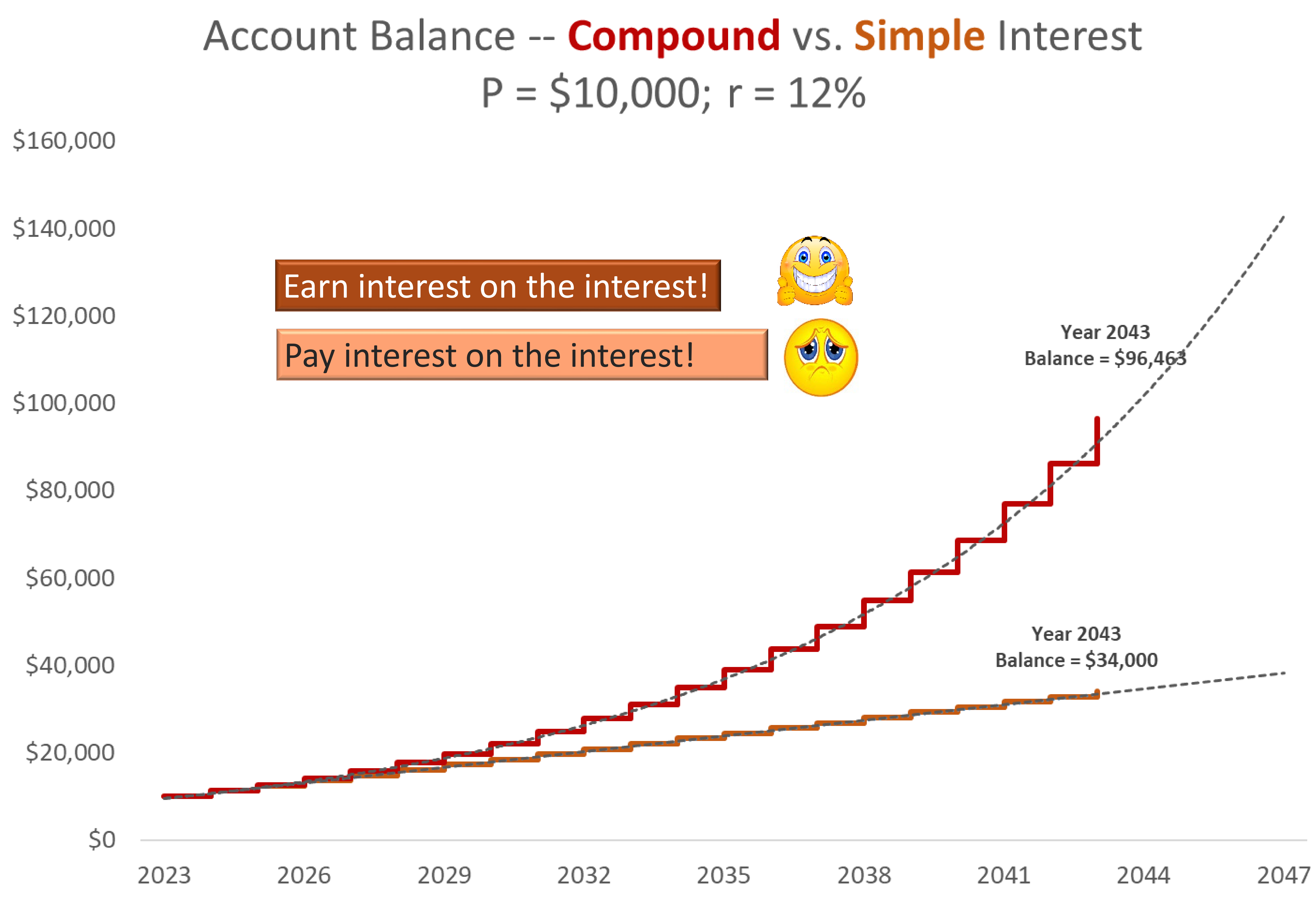
- Given a \$10,000 investment today in an account that earns 12% per year, how much will it be worth in 5 years?
  - It will be worth: $\mathbf{F_5} = 10K\,(1+12\%)^5 = \mathbf{\$17,623.42}$

- Suppose you then invest $\mathbf{F_5}$ for another 5 years. How much will you have then?
  - $\mathbf{F_{10}} = \mathbf{F_5}{*}(1+12\%)^5 = \$17,623.42{*}(1+12\%)^5 = \$31,058.48$

$$\mathbf{F_{10}} = \mathbf{F_5}\ {*}(1+12\%)^5 \qquad \mathbf{F_5} = \mathbf{P}\ {*}(1+12\%)^5$$

$$\frac{\mathbf{F_{10}}}{\mathbf{F_5}} = (1+12\%)^5 \qquad \frac{\mathbf{F_5}}{\mathbf{P}} = (1+12\%)^5$$

Geometric Growth


Account Balance -- Compound vs. Simple Interest
P = $10,000; r = 12%
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$0
2023
2026
2029
2032
2035
2038
2041
2044
2047
Earn interest on the interest!
Pay interest on the interest!
Year 2043
Balance = $96,463
Year 2043
Balance = $34,000

Rule of 72

- The Rule of 72 is a simplified formula that *calculates how long it'll take for an investment to double in value, based on its rate of* return.

$$t \approx \frac{72}{(r \cdot 100)}$$

Actual number of periods, *t*, is given by:

$$2P = (1 + r)^t \cdot P$$
$$2 = (1 + r)^t$$

$$t = \frac{\log(2)}{\log(1 + r)}$$

Nominal vs. Effective Interest Rates

Application: Comparing Investment/Loan Options

Annual Percentage Rate (APR)

- Lending institutions are required to quote interested rates on annual terms
- Nominal interest rate
  - Rate quoted before any compounding of interest
- Compounding periods
  - Fixed time intervals in which banks pay/earn interest

Nominal Rate	Compounding Period	Number Compounding Periods	Annual Percentage Rate (APR)
0.045%	Daily	365	0.045% * 365 = 16.43%
0.08%	Weekly	52	0.08% * 52 = 4.16%
0.75%	Monthly	12	0.75% * 12 = 9.0%
3.00%	Quarterly	4	3.0 % * 4 = 12%

Nominal ↔ APR

$$APR = Quoted\ Period\ Rate \cdot \frac{Compounding\ Periods}{Year}$$

Effective Annual Rate

- Annual interest rate taking into account the effect of compounding during the year
- Annual Percentage Yield (**APY**)

Effective Annual Rate

- Suppose you invest $100 at 12% per year, compounded monthly.
  1. How much will you have after 1 year?
  2. How much would you have if the interest was compounded annually?

$$i_a = \left(1 + \frac{r}{m}\right)^m - 1$$

$$\begin{aligned} &where \\ &r = \ \ nomimal\ annual\ rate \\ &m = number\ of\ compounding\ periods \end{aligned}$$

Nominal and EAR in Excel

- **EFFECT(nominal_rate,npery)**
  - **Nominal_rate** is the nominal interest rate.
  - **Npery** is the number of compounding periods per year.

- **NOMINAL(effect_rate,npery)**
  - **Effect_rate** is the effective interest rate.
  - **Npery** is the number of compounding periods per year.

Terminology: Interest vs. Discount Rate

Finding the Net Present Value (or Worth)

Net Present Value (NPV)

$$\boldsymbol{NPV = PV(receipts) - PV(payments)}, \text{given discount rate, } \boldsymbol{r}$$

If the NPV is positive, then the present value of the future cash inflows is larger than cash outflows, and we should consider taking the project.

Power of Compounding

ROLE OF INTEREST RATE

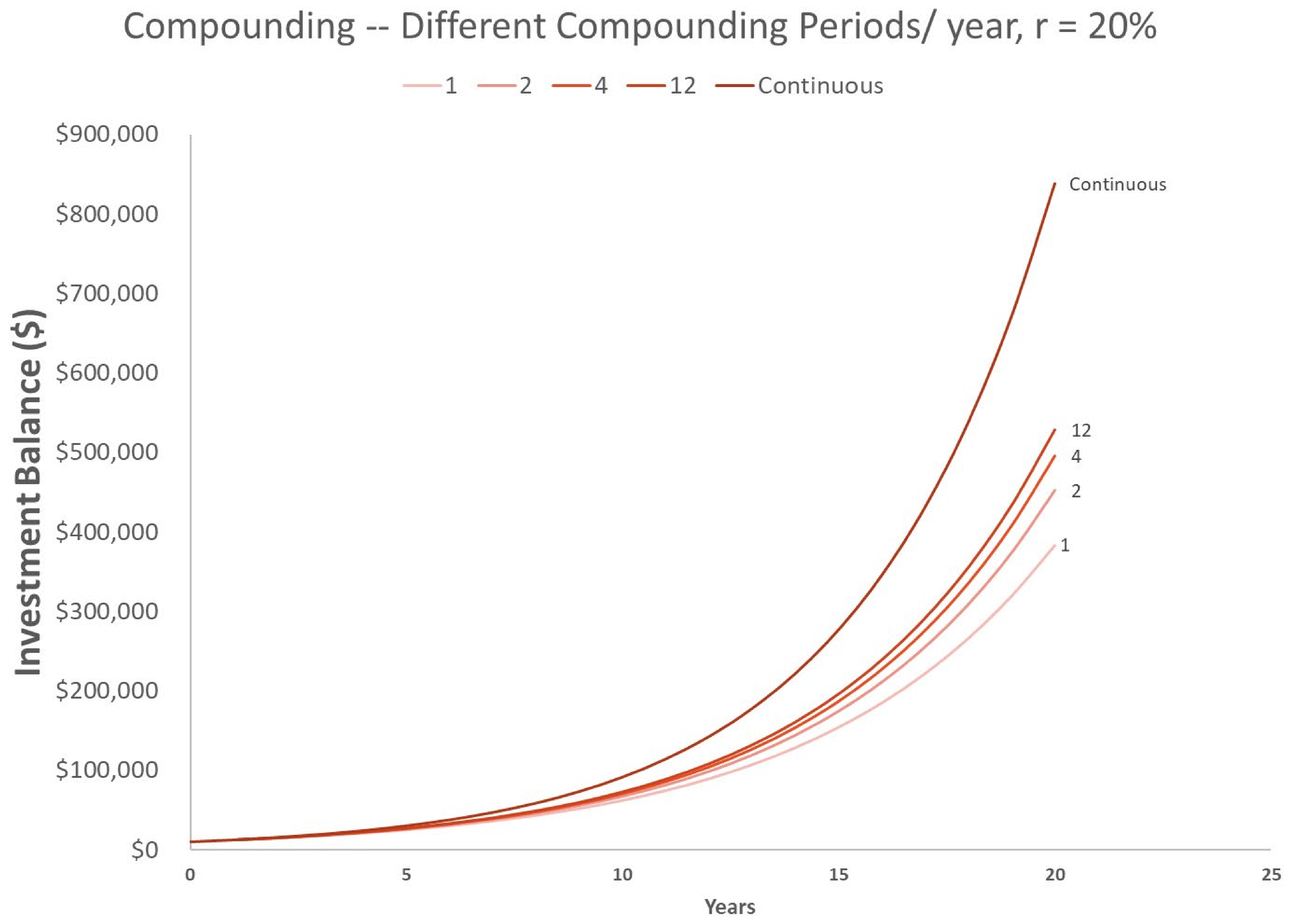
ROLE OF COMPOUNDING PERIODS

Two levers drive effect of Compounding

- Number of Compounding Periods, *m*
  - *P = $10,000*
  - *Investment Horizon = 20 years*
  - *r = APR = 20%*

  - *Varying m*

$$i_a = \left(1 + \frac{r}{m}\right)^{m} - 1$$



$$FV_t = \lim_{m \to \infty} \left(1 + \frac{r}{m}\right)^{mt} \cdot PV = e^{rt} \cdot PV$$

$$i_a = e^{r} - 1$$

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Basic Excel Financial Functions I

BACK TO TIME VALUE OF MONEY

5 Components of Financial Functions in Excel

1. Present Value (**PV**)
2. Future Value (**FV**)
3. Payment amount (**pmt**). The payment made each period and cannot change over the life of the project.
4. Interest rate per payment period (**rate**)
5. Number of payment periods (**nper**)

=FV(rate, nper, pmt, [PV], [type])

=PV(rate, nper, pmt, [FV], [type])

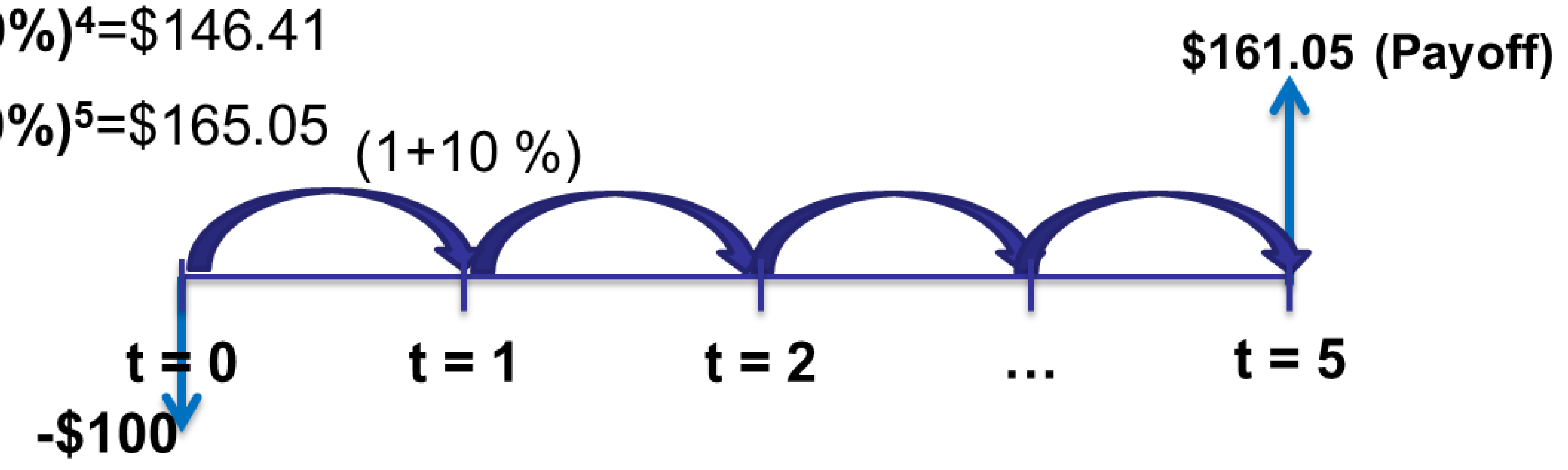
Suppose you invest \$100 today in an account that earns 10% per year, how much will it be worth in 5 years?

- Want: FV

=FV(rate, nper, pmt , PV)

=FV(10%, 5, 0 , -100)

EOY	Ending Balance
0	\$100
1	$\$100 \cdot (1+10\,\%) = \$110$
2	$\$110 \cdot (1+10\%) = \$100\,(1+10\%) \cdot (1+10\%)$ $\mathbf{= \$100 \cdot (1+10\%)^2}$ $= \$121$
3	$\$121 \cdot (1+10\%) = \$100\,(1+10\%) \cdot (1+10\%) \cdot (1+10\%)$ $\mathbf{= \$100 \cdot (1+10\%)^3}$ $= \$133.10$
4	$\mathbf{\$100 \cdot (1+10\%)^4}$ $= \$146.41$
5	$\mathbf{\$100 \cdot (1+10\%)^5}$ $= \$165.05$



How much is \$100 two years from now worth today, if your discount rate (i.e. opportunity cost) is 5% per year?

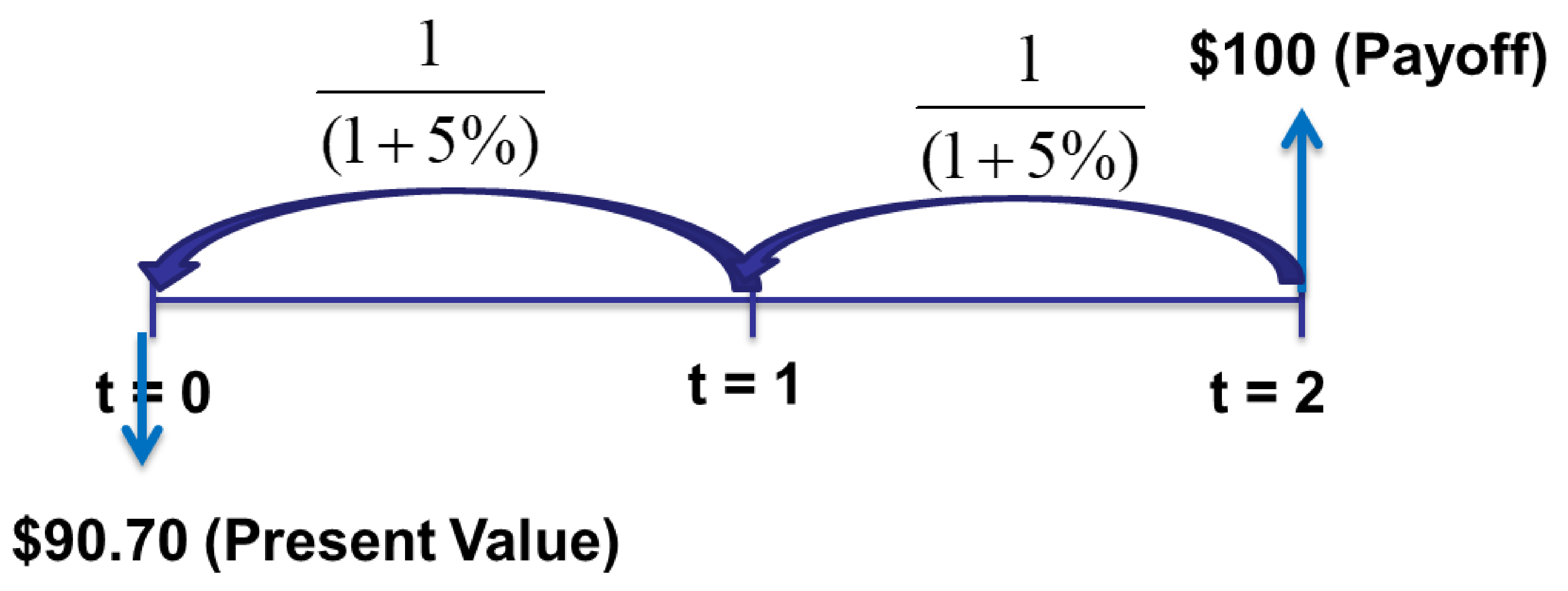
- Want: PV

=PV(rate, nper, pmt, FV)

$$\$X \cdot (1+5\%)^2 = \$100$$

$$\$X = \frac{\$100}{(1+5\%)^2} = \$100(1+5\%)^{-2} = \$90.70$$

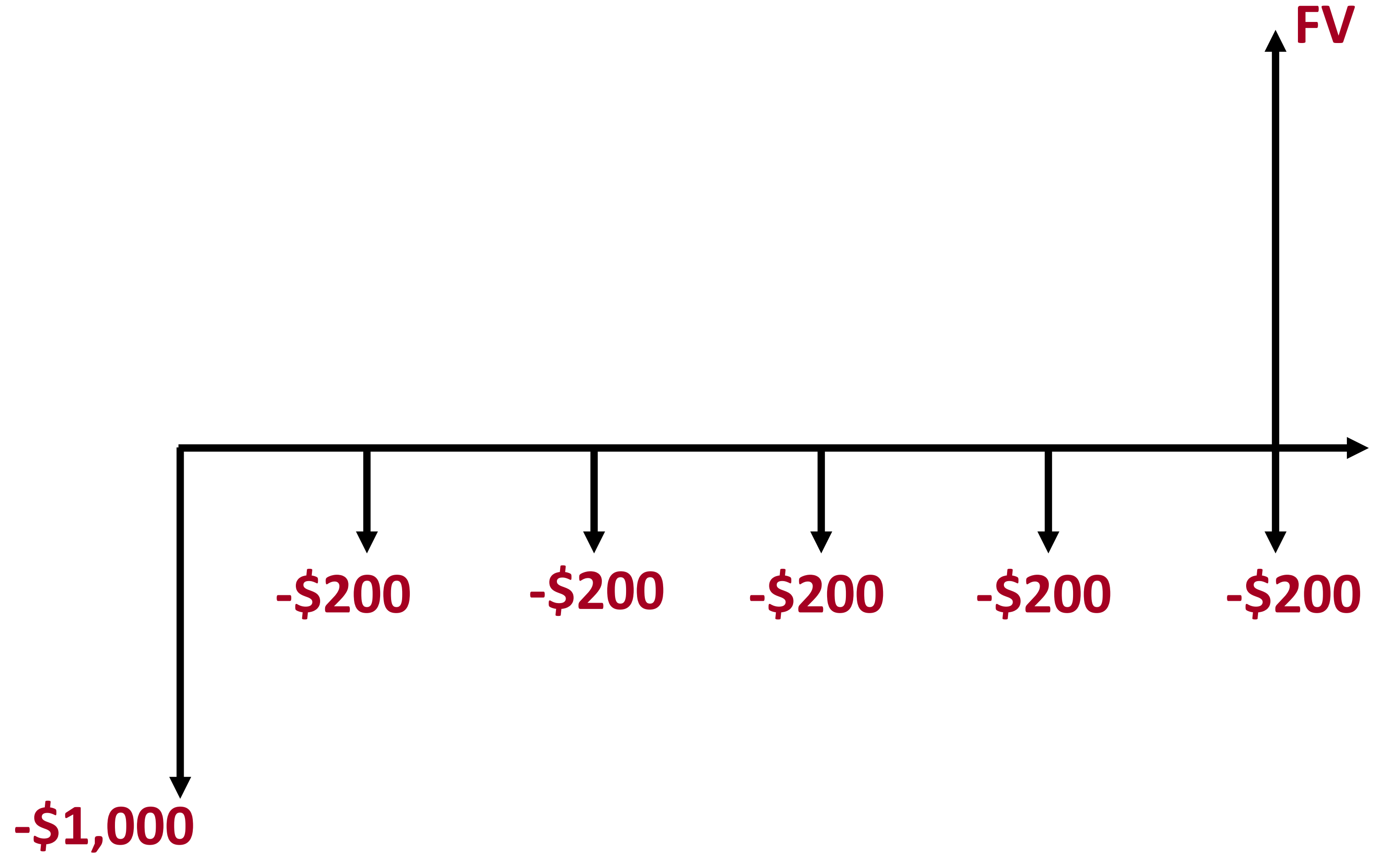
=PV(5%, 2, 0, 100)



Suppose you invest \$1,000 today, plus \$200 annually in an account that earns 10% per year, how much will it be worth in 5 years?

=FV(rate, nper, pmt, PV)

- Want: FV



=FV(10%, 5, -200, -1000)

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Basic Excel Financial Functions II

NPER and Rate Functions

NPER Function…

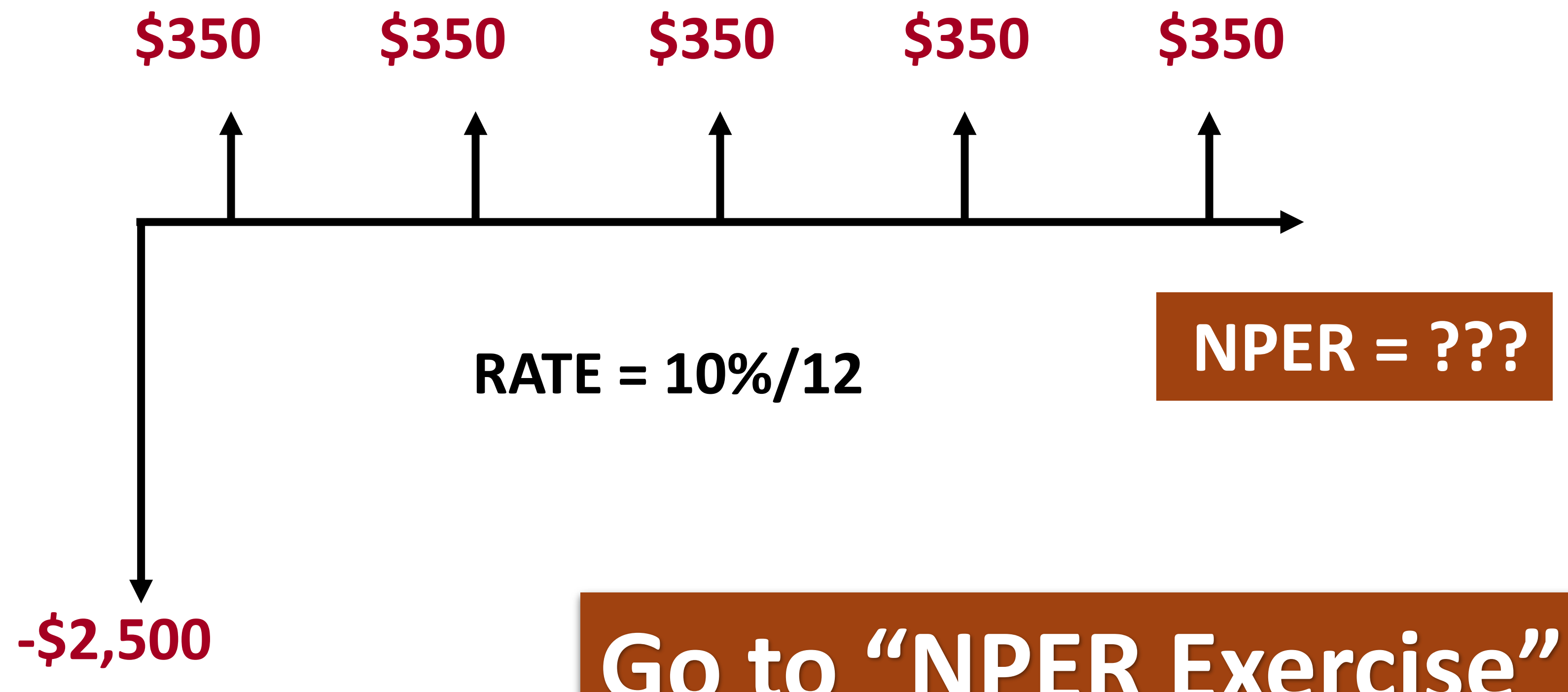
- Returns the **number of periods to pay off a loan** based on regular payments and a constant interest rate.

- Syntax

=NPER(RATE, PMT, PV, [FV], [Type])

How long will it take to pay off a $2,500 loan with an APR of 10%, compounded monthly, if you make monthly payments of $350?

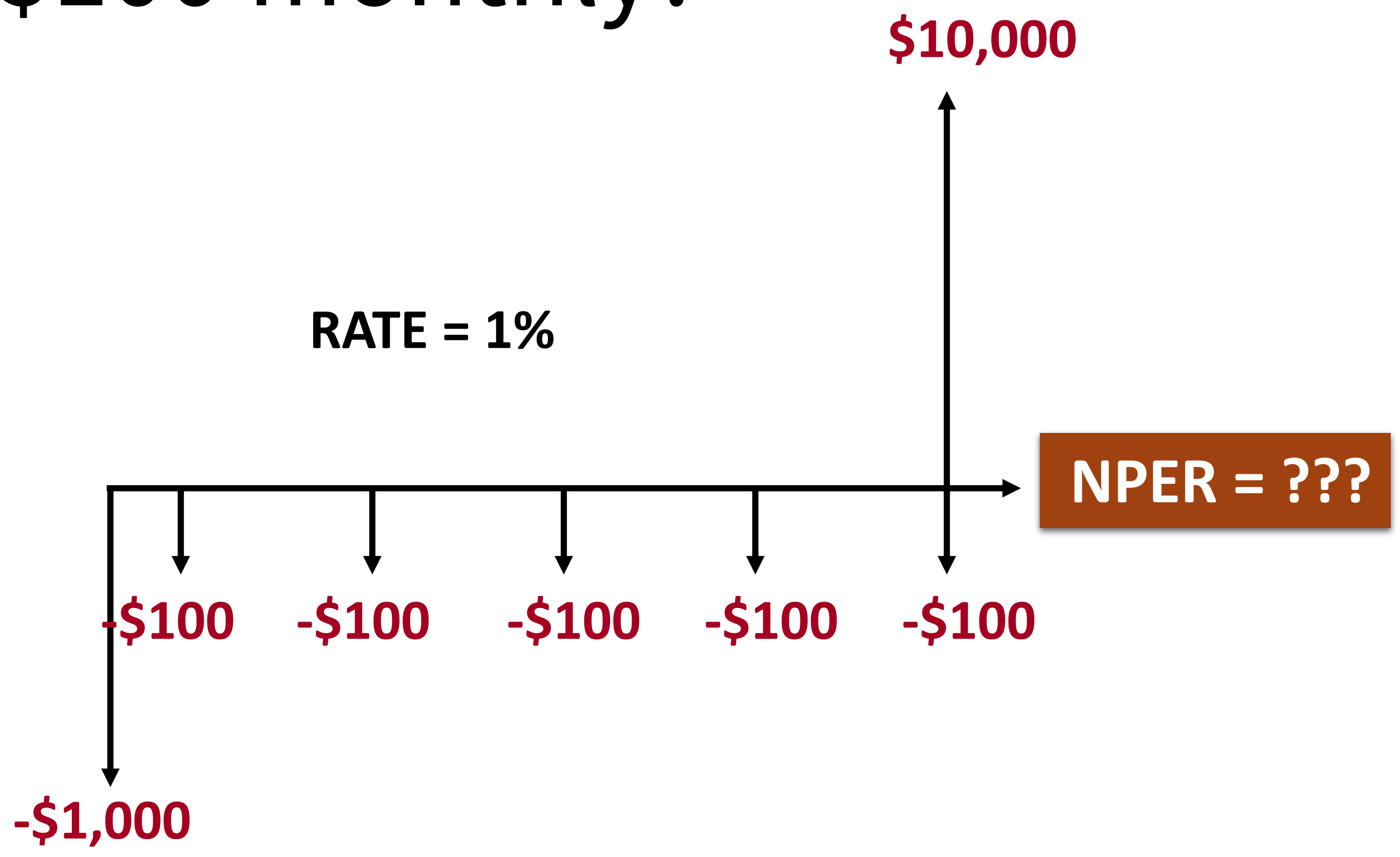
- Cash Flow Depiction



Go to “NPER Exercise” worksheet…

NPER – Example 2

- How long will it take you to save $10,000 if you open a Money Market Account that pays an APR of 12%, compounded monthly, with $1,000 and deposit $100 monthly?



RATE Function

- At what interest rate could one pay off a $25,000 loan in 60 months by paying $475 monthly?

- Syntax

= RATE(nper, pmt, pv, [fv], [type], [guess])

Examples using APR, EAR, FV and PV Functions

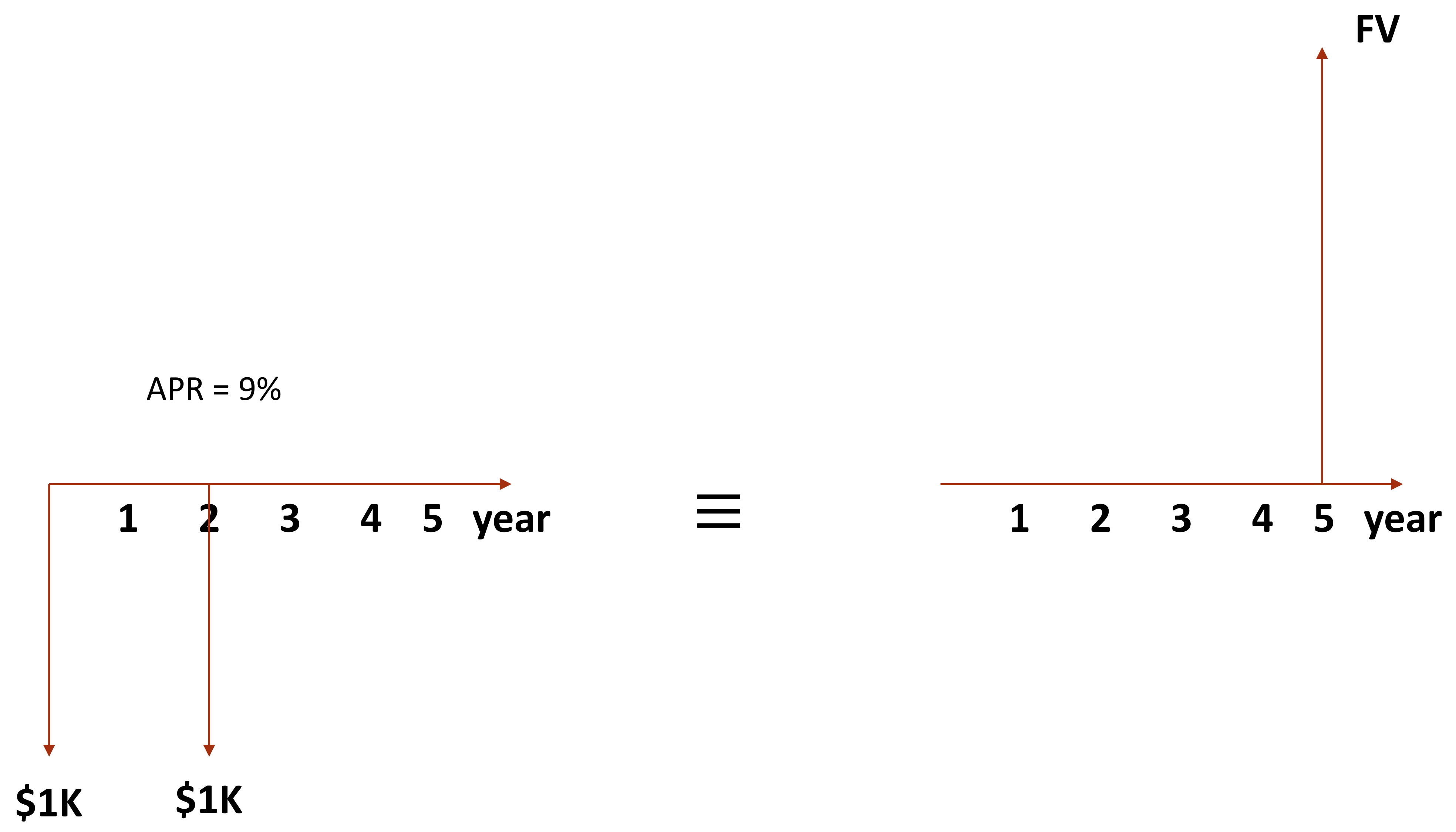
Putting the Basics Together

Example: Quoted ↔ EAR ↔ APR

- Suppose you invest $1,000 in money market account that pays 0.15% weekly.
  - What's the effective annual rate (EAR) of this investment?
  - How much will you have at the end of 20 years?
  - What APR, compounded daily (365 days in a year), would give you the same EAR?

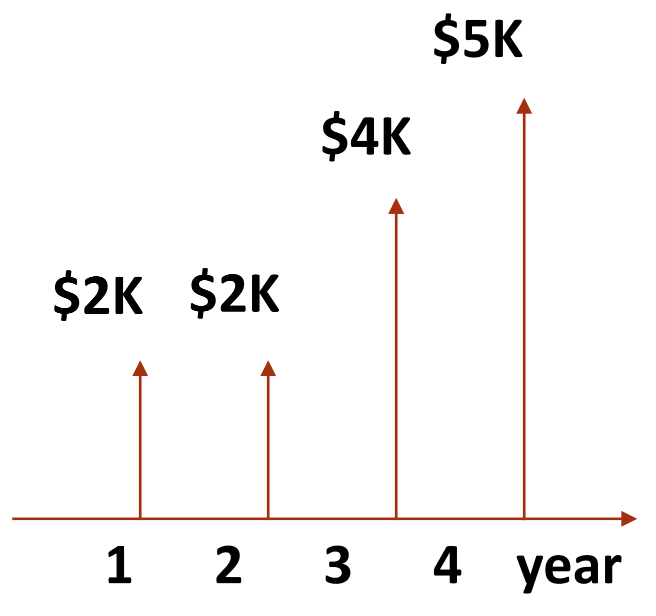
Example: Mismatch in interest and repayment period

- If you invest $1,000 now, and $1,000 at the end of year 2 in an account that pays 9% compounded monthly, how much money will you have after 5 years?

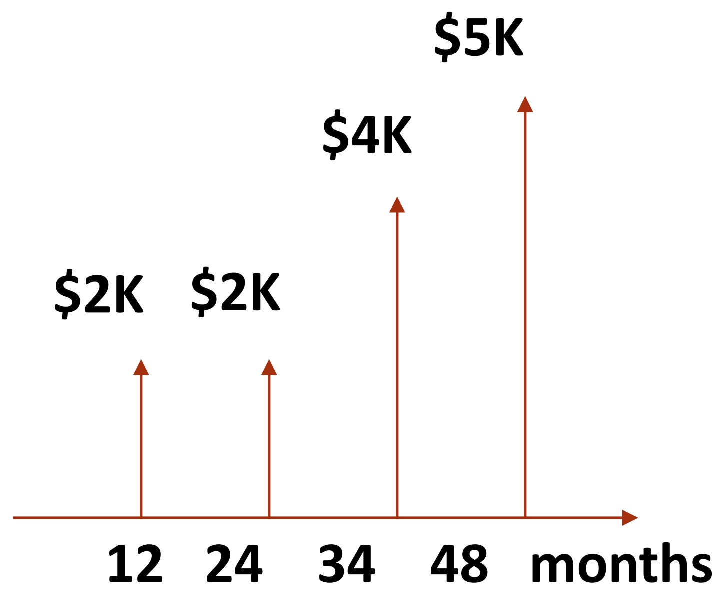


Example: Quoted ⬌ EAR ⬌ APR

- Suppose your firm is trying to evaluate whether to buy an asset. The asset pays off \$2,000 at the end of years 1 and 2, \$4,000 at the end of year 3 and \$5,000 at the end of year 4.
- Your firm uses 0.487% as its monthly discount rate. How much should your firm pay for this investment?



EAR

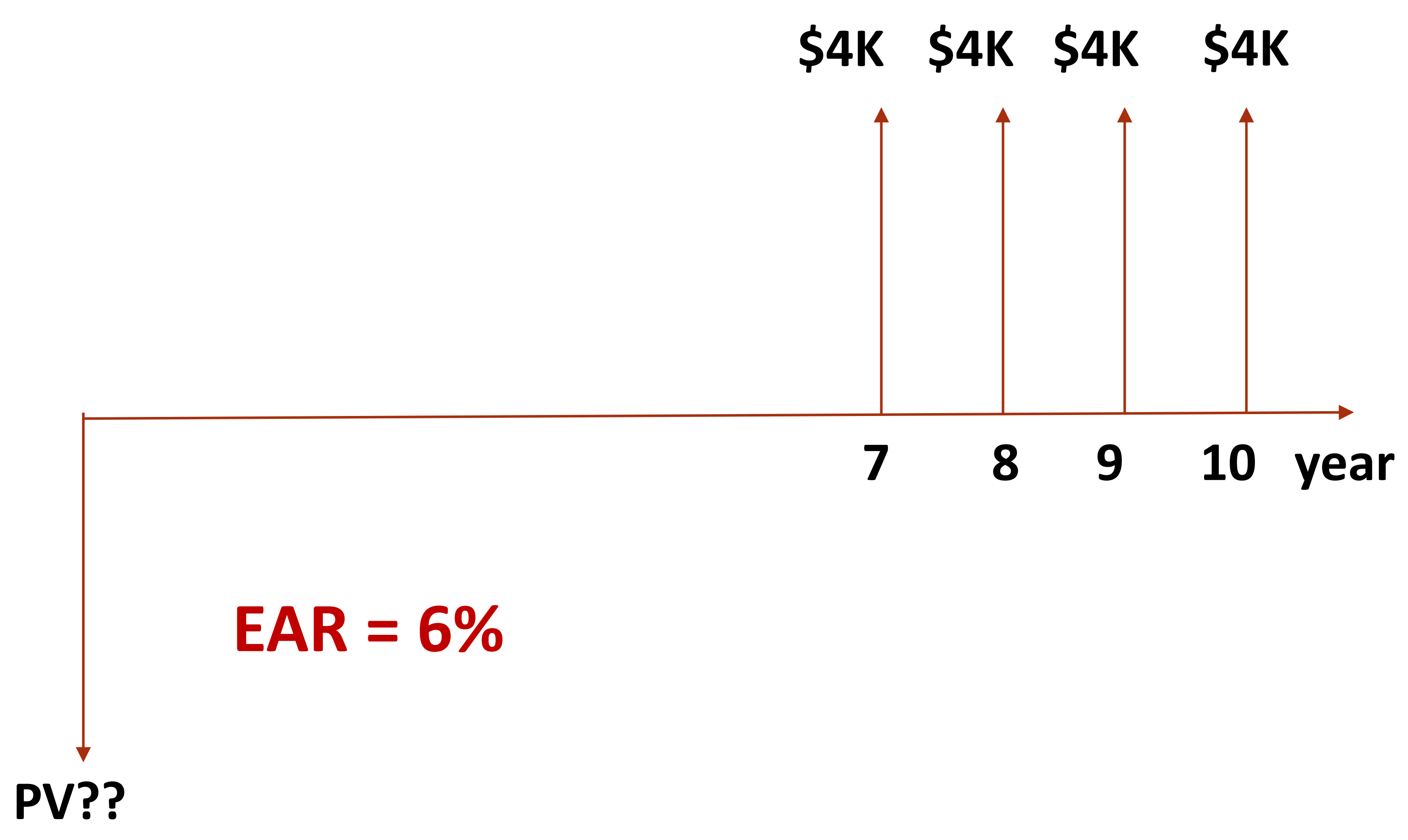


$\text{Rate}_{\text{Month}}$

≡

Example:

- Suppose your firm is trying to evaluate whether to buy another asset. The asset pays off $4,000 at the end of years 7 through 10.
- Your firm uses an EAR of 6% rate. How much should your firm pay for this investment?



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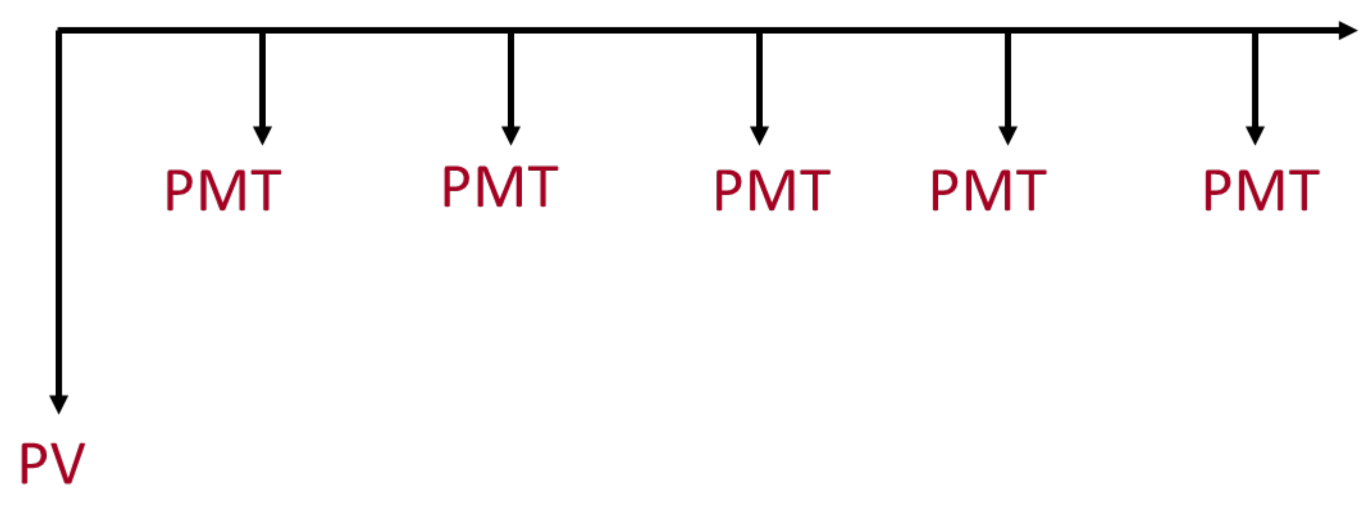
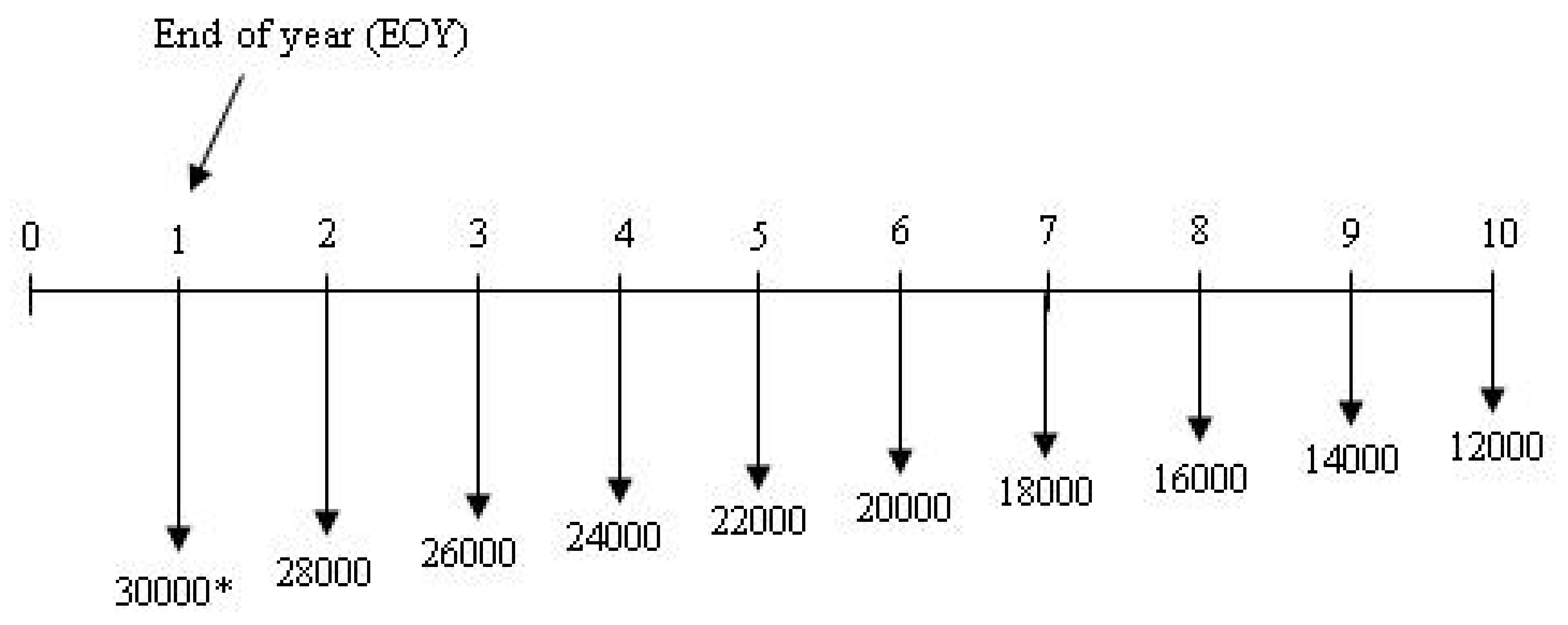
Present Worth Analysis using NPV & XNPV Functions

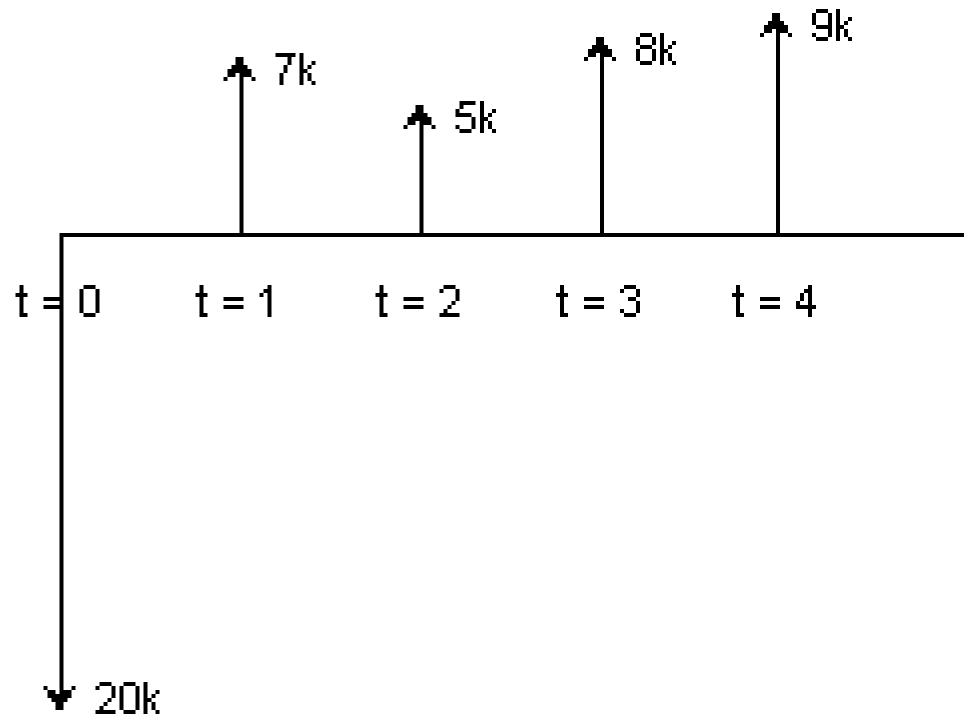
PV of irregular cash flows

Regular Cash Flow



Irregular Cash Flows





NPV *(Net Present Value) Function*

- **NPV** is used to find the **present value** of an investment with ***varying*** cash flows

- Efficient alternative to discounting individual cash flows
  - Do it using algebraic manipulation
  - Do it using PV function

$$\frac{Cash\ Flow_t}{(1+r)^t}$$

$$PV\ (r, t, 0, Cash\ Flow_t)$$

- NPV Syntax:

=NPV(*rate, value 1, [value 2, value 3…]*)

=NPV(6%, 0, 21000, 30000, 42000)

=NPV(6%, C7:C11)

Important Caveats about NPV Function

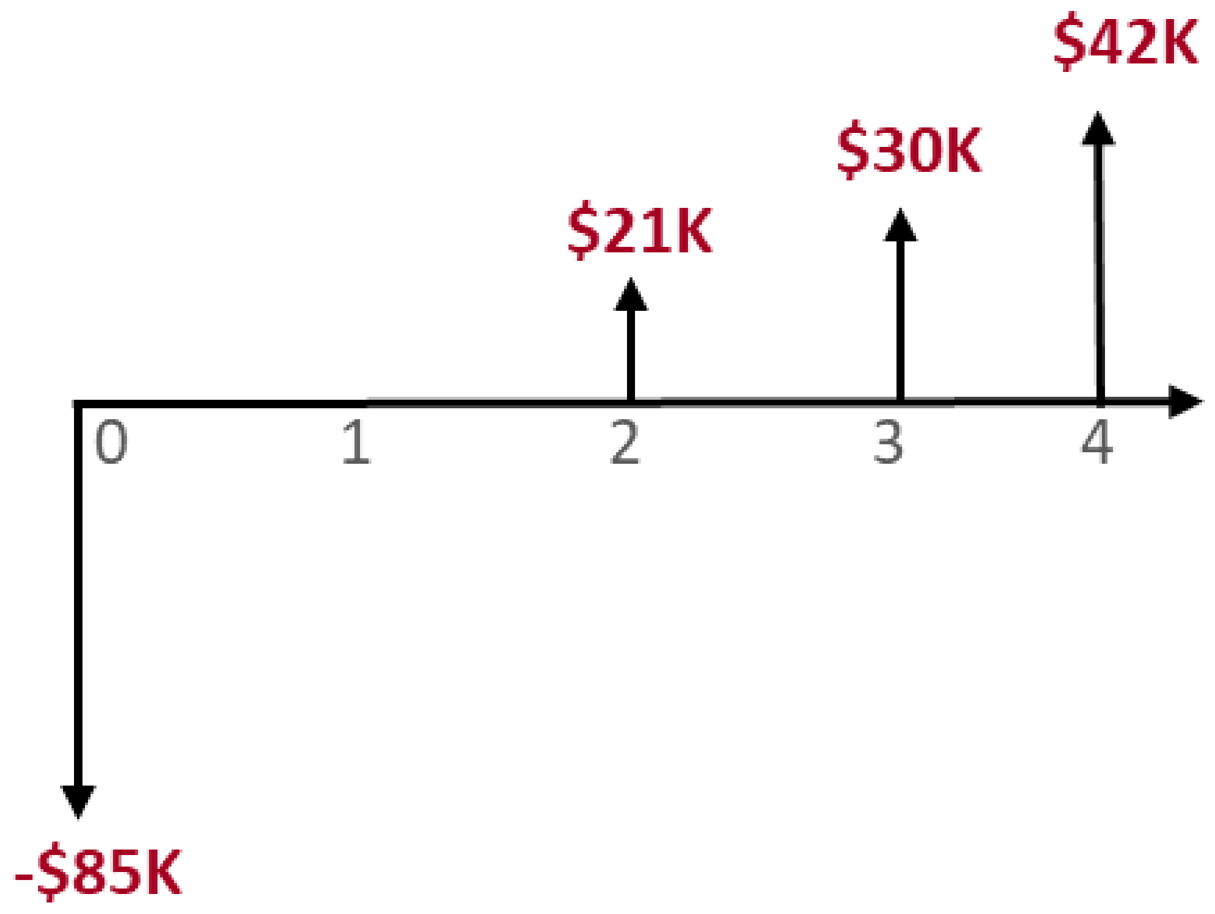
- NPV Syntax:

  =NPV(*rate, value 1, [value 2, value 3…]*)

- NPV assumes that:
  - User must enter the per period discount ***rate***
  - All cash flows are made at the end of the period
  - <u>First cash flow occurs at end of period 1</u>
  - Periods are evenly spaced
  - Cash flows are positive *unless otherwise indicated*

Example: NPV *(Net Present Value) Function*

- A company is considering the purchase of the patent rights from an inventor, what's the net present value of the patent?
  - The cost of the patent now (Year 0) is $85,000
  - There will be no returns from the patent in Year 1
  - Year 2: $21,000 in incremental revenue
  - Year 3: $30,000 in incremental revenue
  - Year 4: $42,000 in incremental revenue



Should they purchase the patent rights?

It depends on the Discount Rate!

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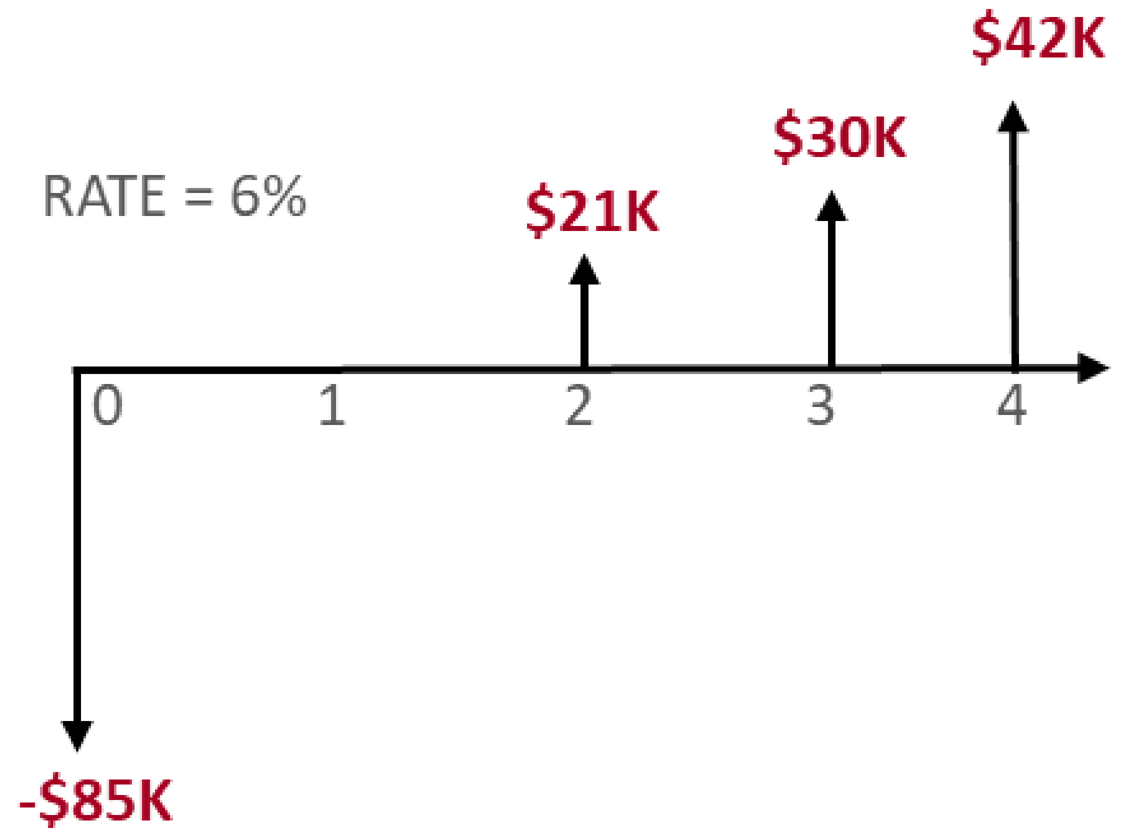
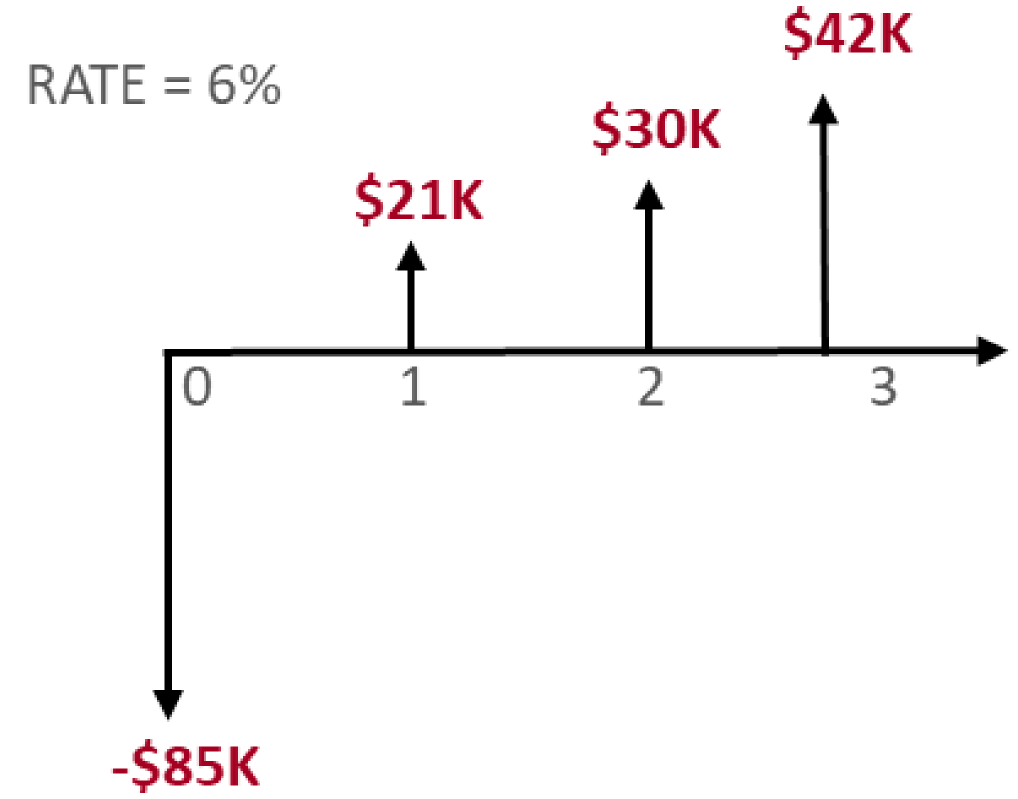
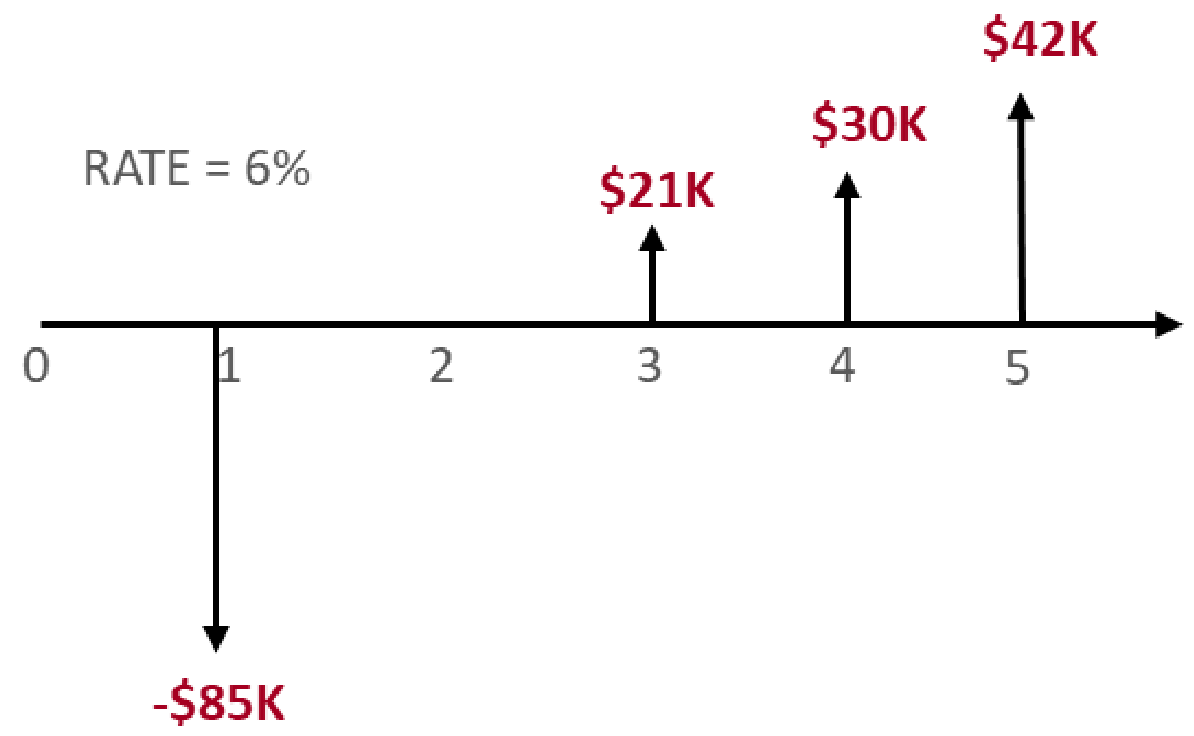
NPV – Common Errors…



- **<u>Not *Explicitly* including $0</u>** cash flows



- ***<u>Including Cash Flows in Period 0</u>*** in NPV function



XNPV Function

- XNPV function allows the user to input specific dates that correspond to discounted cash flows in the series.
  - When using a ledger with actual dates.

- XNPV Syntax:

  =XNPV(*rate, values, dates)*

$$XNPV = \sum_{t=1}^{T} \frac{CF_t}{(1 + r_{daily})^{(d_t - d_1)}}$$

Date	Cash Flows
1/1/2023	-$85,000
12/31/2023	$0
12/31/2024	$21,000
12/31/2025	$30,000
12/31/2026	$42,000

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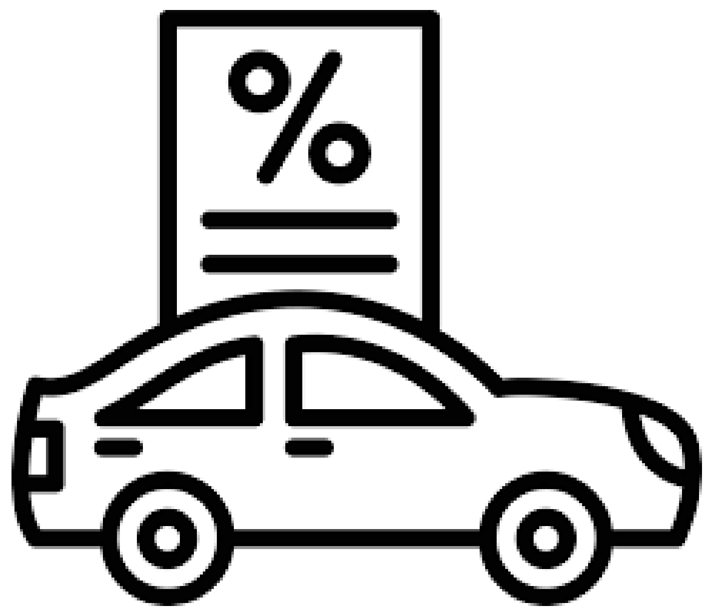
Annuities and Perpetuities

PMT Function

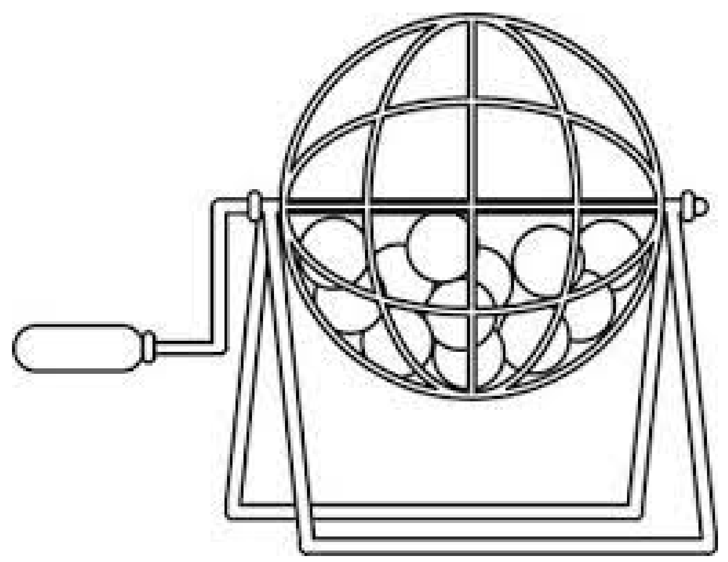
College Savings Plan

Pension

Mortgage



Car Loan

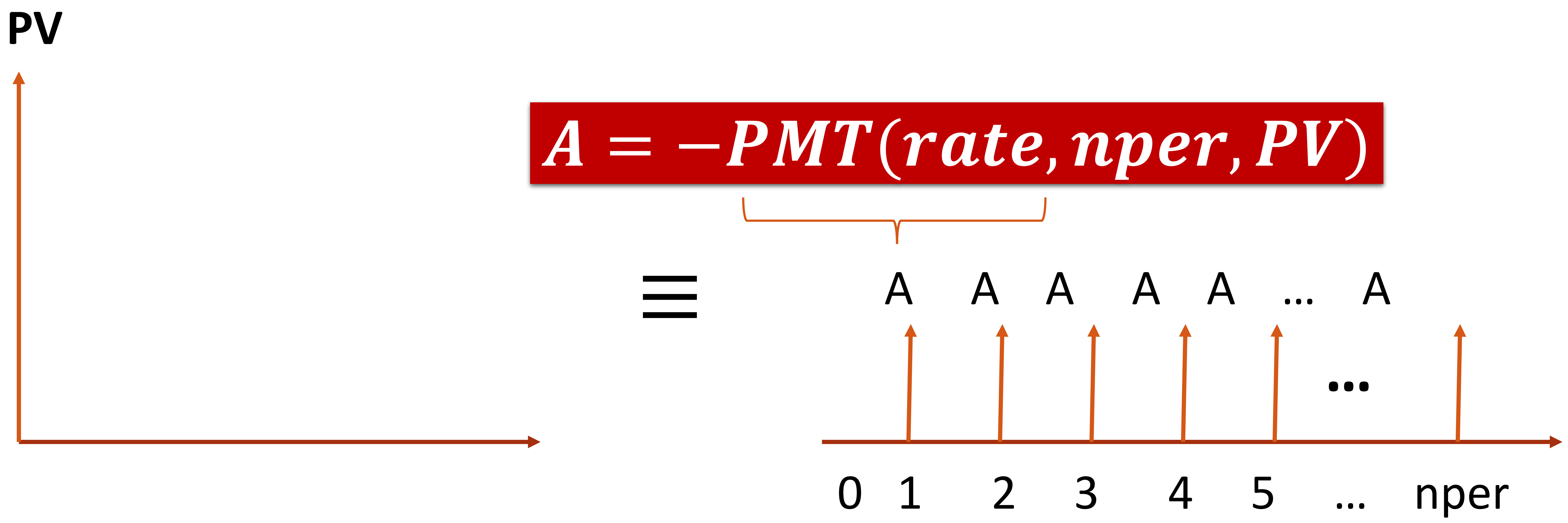


Lottery

Annuity Calculation

- Needed when we want to find annuity that is equivalent to a given Present Value
  - An annuity is a fixed sum of money paid (received) each period, for some fixed time horizon

$$A = -PMT(rate, nper, PV)$$



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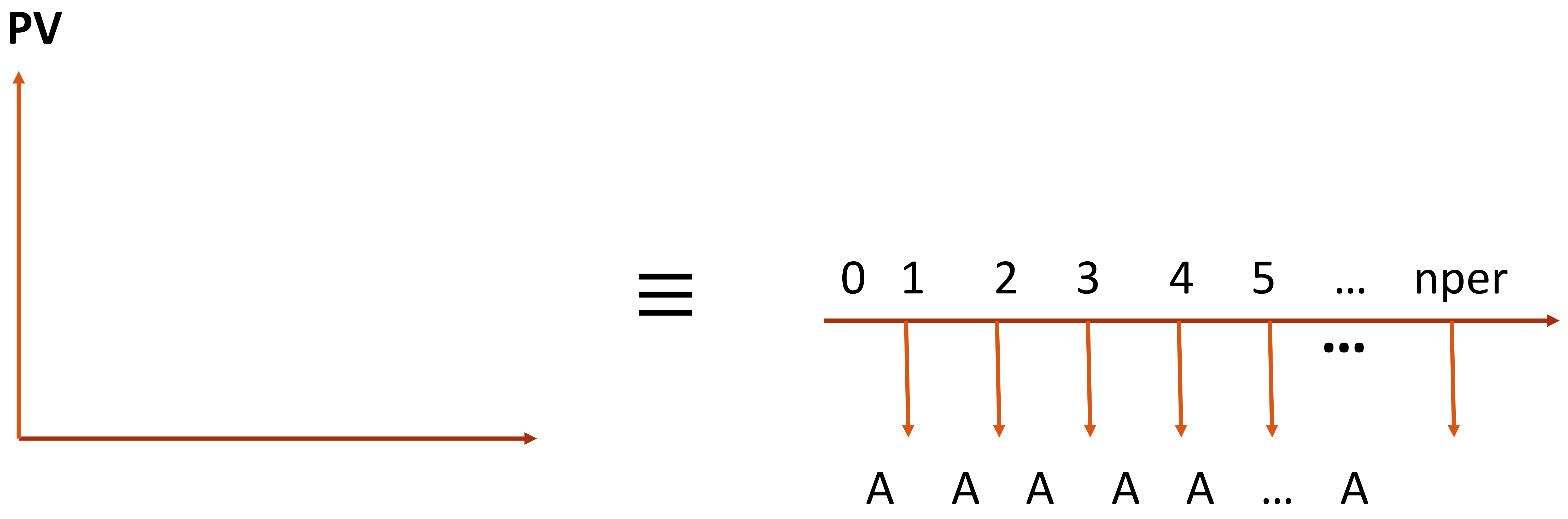
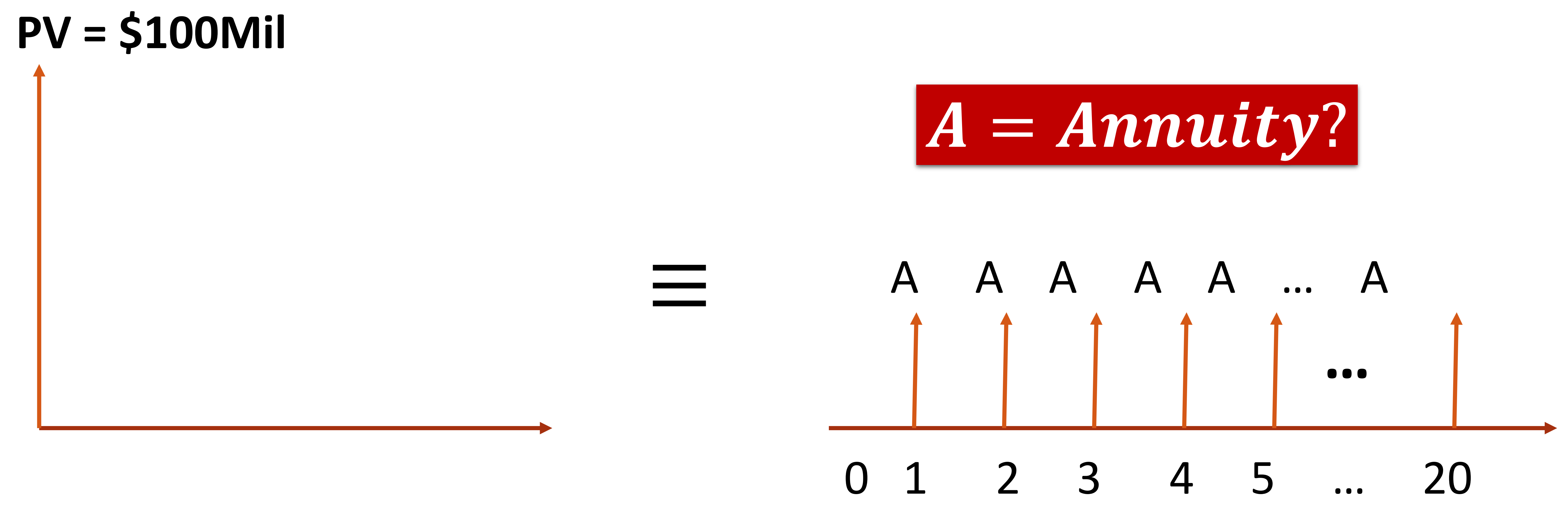


$$\boldsymbol{A = PMT(rate, nper, PV)}$$

Example: Lottery

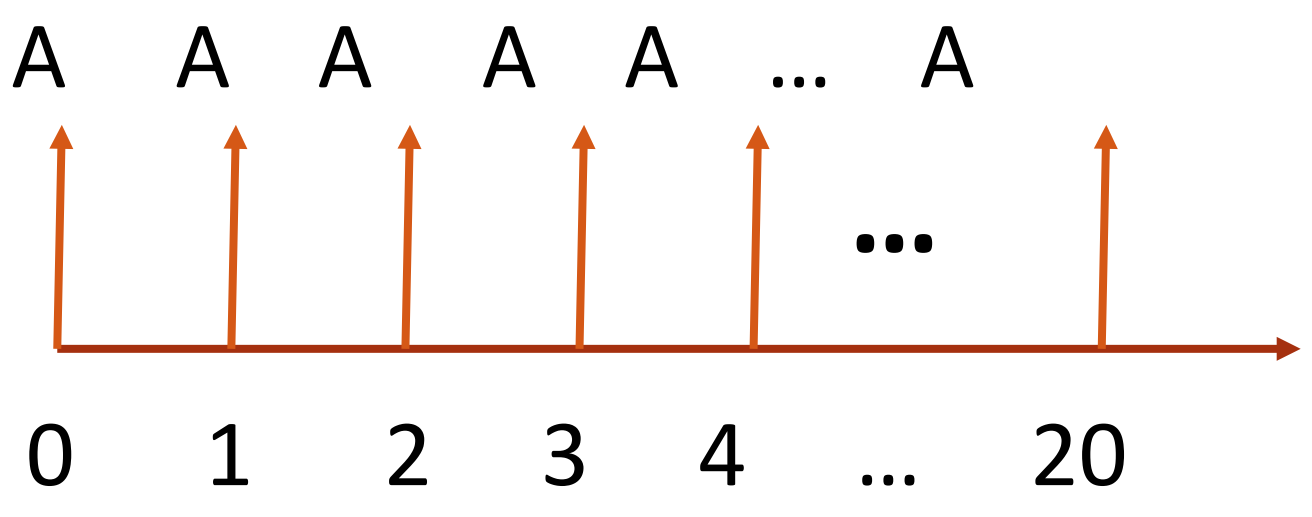
- Your friend Rachel won $100 million in this week's Powerball! If the Powerball uses an annual discount rate of 5%, what would Rachel receive annually if she chose the 20-year annuity option?



Example: Lottery

- A major lottery advertises that it pays the winner \$10 million. However, the prize money is paid at the rate of \$500,000 each year (with the first payment being immediate) for a total of 20 payments.
- The annual interest rate is r = 10%. What is the present value of the prize?

$A = \$500K$



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Example: Down Payment Savings

- You want to save to $100,000 to purchase a home.
- If your local credit union pays an APR of 8.5% compounded monthly, how much would you have to save every month, if you plan to purchase the home in 3 years? What about if your horizon was 5 years?

Perpetuities

- **Perpetuity** is an annuity that has no end
- Model is reasonable for long-lived projected

  - How much could I take from account with a balance of $P annually if the account that pays an i% interest annually?

$$\text{At time } 0 = \$P$$

$$\text{At time } 1 = \$P + \boxed{\$P \cdot i} = A$$

- $P is called the **Capitalized Value**
- The capitalized value formula is: ***P = A/i***

Example: Scholarship

- After a long and successful career, that in no small part is due to the amazing education you received at Illinois Tech, you want to endow a fund to support scholarships for approximately 10 students.
- You feel that $750,000 annually would be sufficient to cover the tuition and living expenses.
- How much should you leave to Illinois Tech?
  - What if the university gets 10% annual return on its investment?
  - What if the university gets 5% annual return on its investment?