ENGINEERING ECONOMY, Sixth Edition

by Blank and Tarquin

CHAPTER I

FOUNDATIONS OF ENGINEERING ECONOMY

McGraw Hill

1. Foundations: Overview

1. Questions
2. Decision Making
3. Study Approach
4. Interest Rate
5. Equivalence
6. Simple and Compound Interest

1. Foundations: Overview

7. Symbols
8. Spreadsheet Functions
9. Minimum Attractive Rate of Return
10. Cash Flows
11. Doubling Time
12. Spreadsheets

Section 1

Why Engineering Economy is Important to Engineers (and other professionals)

Section 1.1 Importance

- Engineers “Design”
- Engineers must be concerned with the economic aspects of designs and projects they recommend and perform
    - Analysis
    - Design
    - Synthesis

Section 1.1 Questions

- Engineers must work within the realm of economics and justification of engineering projects
- Work with limited funds (capital)
- Capital is not unlimited – rationed
- Capital does not belong to the firm
    - Belongs to the Owners of the firm
    - Capital is not “free”…it has a “cost”

Section 1.1 Definition

ENGINEERING ECONOMY IS INVOLVED WITH THE FORMULATION, ESTIMATION, AND EVALUATION OF ECONOMIC OUTCOMES WHEN ALTERNATIVES TO ACCOMPLISHED A DEFINED PURPOSE ARE AVAILABLE.

Section 1.1 Definition

ENGINEERING ECONOMY IS INVOLVED WITH THE APPLICATION OF DEFINED MATHEMATICAL RELATIONSHIPS THAT AID IN THE COMPARISON OF ECONOMIC ALTERNATIVES

Section 1.1 Questions

- Knowledge of Engineering Economy will have a significant impact on you, personally.
  - Make proper economic comparisons
    - In your profession
      - Private sector
      - Public sector
    - In your personal life

Section 1.2
Role of Engineering Economy in Decision Making

- **Remember: People make decisions – not "tools"**
- **Engineering Economy is a set of tools that aid in decision making – but will not make the decision for you**
- **Engineering economy is based mainly on estimates of future events – must deal with the future and risk and uncertainty**

Section 1.2 Role of Engineering Economy

- The parameters within an engineering economy problem can and will vary over time
- Parameters that can vary will dictate a numerical outcome – apply and understand ..
- Sensitivity Analysis

Section 1.2 Role of Engineering Economy

- **Sensitivity Analysis plays a major role in the assessment of most, if not all, engineering economy problems**
- **The use of spreadsheets is now common and students need to master this valuable tool as an analysis aid**

Section 1.2 Problem Solving Approach

1. Understand the Problem
2. Collect all relevant data/information
3. Define the feasible alternatives
4. Evaluate each alternative
5. Select the "best" alternative
6. Implement and monitor

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Major Role of Engineering Economy

Section 1.2 Problem Solving Approach

1. **Understand the Problem**
2. **Collect all relevant data/information**
3. **Define the feasible alternatives**
4. **Evaluate each alternative**
5. **Select the "best" alternative**
6. **Implement and monitor**

One of the more difficult tasks

Section 1.2 Problem Solving Approach

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Where the major tools of Engr. Economy are applied

Section 1.2 Problem Solving Approach

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2. **Collect all relevant data/information**
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Tools

Present Worth, Future Worth
Annual Worth, Rate of Return
Benefit/Cost, Payback,
Capitalized Cost, Value Added

Section 1.2 Time Value of Money

- **Time Value of Money**
  - **Money can "make" money <u>if Invested</u>**
  - **Centers around an *interest rate***

The change in the amount of money over a given time period is called the time value of money; by far, the most important concept in engineering economy

Section 1.3
Performing a Study

- To have a problem, one must have alternatives (two or more ways to solve a problem)
- Alternative ways to solve a problem must first be identified
- Estimate the cash flows for the alternatives
- Analyze the cash flows for each alternative

Section 1.3 Alternatives

- To analyze must have:
  - Concept of the time value of $$
  - An Interest Rate
  - Some measure of economic worth
- Evaluate and weigh
- Factor in noneconomic parameters
- Select, implement, and monitor

Section 1.3 Needed Parameters

- First cost (investment amounts)
- Estimates of useful or project life
- Estimated future cash flows (revenues and expenses and salvage values)
- Interest rate
- Inflation and tax effects

Section 1.3 Cash Flows

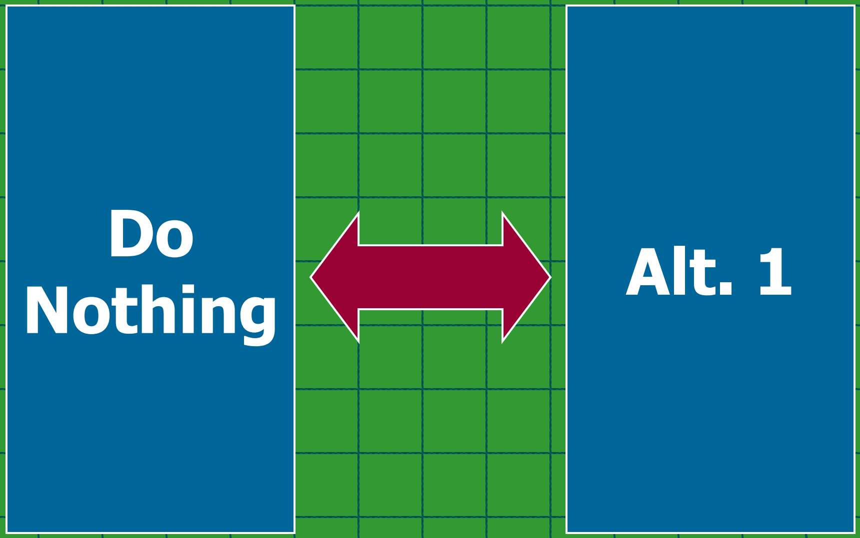
- **Estimate flows of money coming into the firm – revenues salvage values, etc. (magnitude and timing) – positive cash flows**
- **Estimates of investment costs, operating costs, taxes paid – negative cash flows**

Section 1.3 Alternatives

- **Each problem will have at least one alternative – DO NOTHING**
  - **May not be free and may have future costs associated**
  - **Do not overlook this option!**

Section 1.3 Alternatives

- Goal: Define, Evaluate, Select and Execute



The Question:

Which One do we accept?

Section 1.3 Mutually Exclusive

- **Select One and only one from a set of feasible alternatives**
- **Once an alternative is selected, the remaining alternatives are excluded at that point.**

Section 1.3 More Alternatives

- **Goal: Define, Evaluate, Select and Execute**

Do Nothing	Alt. 1	…………	Alt. j

Which one do we accept?

Section 1.3 Default Position

- If all of the proposed alternatives are not economically desirable then…
- One usually defaults to the DO-NOTHING alternative

Section 1.3 Taxes

- Taxes represent a significant negative cash flow to the for-profit firm.
- A realistic economic analysis must assess the impact of taxes
  - Called and **AFTER-TAX** cash flow analysis
- Not considering taxes is called a **BEFORE-TAX** Cash Flow analysis

Section 1.3 Taxes

- A Before-Tax cash flow analysis (while not as accurate) is often performed as a preliminary analysis
- A final, more complete analysis should be performed using an After-Tax analysis
- Both are valuable analysis approached

Section 1.4
Interest Rate

- **INTEREST - MANIFESTATION OF THE TIME VALUE OF MONEY. THE AMOUNT PAID TO USE MONEY.**
  - **INVESTMENT**
    - INTEREST = VALUE NOW - ORIGINAL AMOUNT
  - **LOAN**
    - INTEREST = TOTAL OWED NOW - ORIGINAL AMOUNT

RENTAL FEE PAID FOR THE USE OF SOMEONE ELSES MONEY…EXPRESSED AS A %

1.4 Interest Rate

- **INTEREST RATE** - INTEREST PER TIME UNIT

$$\text{INTEREST RATE} = \frac{\text{INTEREST PER TIME UNIT}}{\text{ORIGINAL AMOUNT}}$$

1.4 Interest Rates and Returns

- Interest can be viewed from two perspectives:
  - 1. Lending situation
  - Investing situation

1.4 Interest - Lending

- You borrow money (renting someone else's money)
- The lender expects a return on the money lent
- The return is measured by application of an interest rate

1.4 Interest – Lending Example 1.3

- **Example 1.3**
- You borrow $10,000 for one full year
- Must pay back $10,700 at the end of one year
- Interest Amount (I) = $10,700 - $10,000
- Interest Amount = $700 for the year
- Interest rate (i) = 700/$10,000 = 7%/Yr

1.4 Interest Rate - Notation

- For 1.3 the interest rate is..
- Expressed as a per cent per year
- Notation
  - **I** = the interest amount is $
  - **i** = the interest rate (%/interest period)
  - **N** = No. of interest periods (1 for this problem)

1.4 Interest – Borrowing (Ex 1.3)

- The interest rate (i) is 7% per year
- The interest amount is $700 over one year
- The $700 represents the return to the lender for this use of his/her funds for one year
- 7% is the interest rate charged to the borrower
- 7% is the return earned by the lender

1.4 Interest – Example 1.4

- Borrow $20,000 for 1 year at 9% interest per year
- i = 0.09 per year and N = 1 Year
- Pay $20,000 + (0.09)($20,000) at end of 1 year
- Interest (I) = (0.09)($20,000) = $1,800
- Total Amt Paid one year hence
    - $20,000 + $1,800 = **$21,800**

1.4 Interest – Example 1.4

- Note the following
- Total Amount Due one year hence is
  - ($20,000) + 0.09($20,000)
  - =$20,000(1.09) = $21,800
  - The (1.09) factor accounts for the repayment of the $20,000 and the interest amount
  - This will be one of the important interest factors to be seen later

1.4 Interest – Investing Perspective

- Assume you invest $20,000 for one year in a venture that will return to you, 9% per year.
- At the end of one year, you will have:
  - Original $20,000 back
  - Plus……..
  - The 9% return on $20,000 = $1,800

We say that you earned 9%/year on the investment! This is your RATE of RETURN on the investment

1.4 Inflation Effects

- A social-economic occurrence in which there is more currency competing for constrained goods and services
- Where a country's currency becomes worth less over time thus requiring more of the currency to purchase the same amount of goods or services in a time period

1.4 Inflation Rate(s)

- Inflation impacts:
  - Purchasing Power (reduces)
  - Operating Costs (increases)
  - Rate of Returns on Investments (reduces)
  - Specifically covered in Chapter 14

Section 1.5 EQUIVALENCE

- Example
  - You travel at **68 miles per hour**
  - Equivalent to **110 kilometers per hour**
- Thus:
  - 68 mph is equivalent to 110 kph
  - Using two measuring scales
  - Miles and Kilometers

1.5 EQUIVALENCE

- Is “68” equal to “110”?
- No, not in terms of absolute numbers
- But they are “equivalent” in terms of the two measuring scales
    - Miles
    - Kilometers

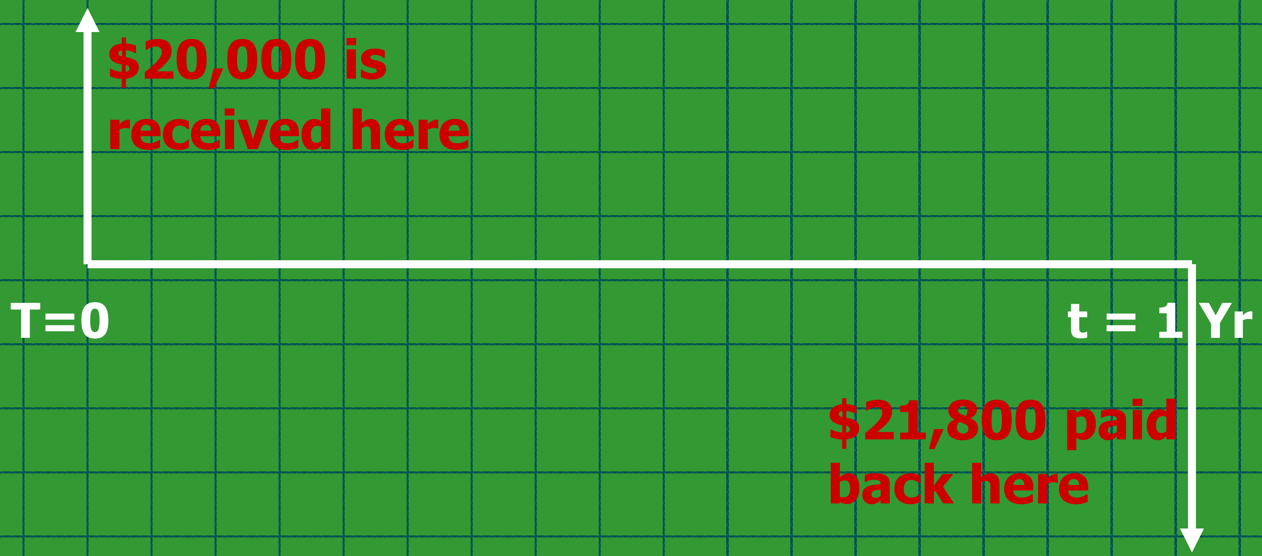
1.5 ECONOMIC EQUIVALENCE

- **Economic Equivalence**
- **Two sums of money at two different points in time can be made economically equivalent if:**
  - **We consider an interest rate and,**
  - **No. of Time periods between the two sums**

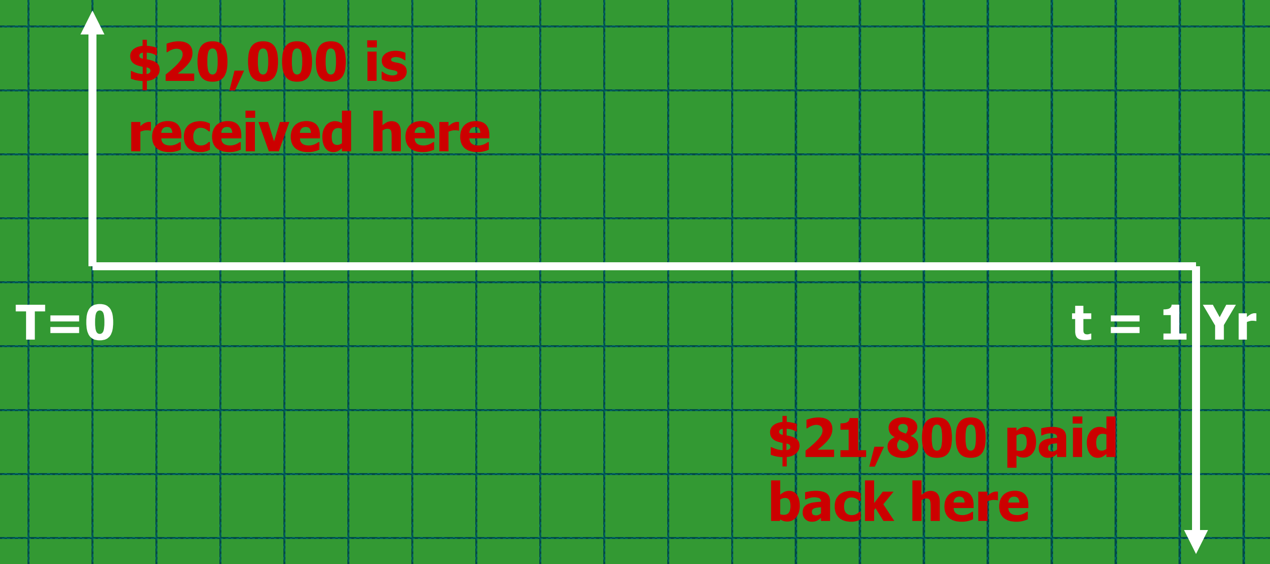
Equality in terms of Economic Value

1.5 Equivalence Illustrated

- Return to Example 1.4
- Diagram the loan (Cash Flow Diagram)
- The company's perspective is shown



1.5 Equivalence Illustrated



$20,000 now is economically equivalent to $21,800 one year from now IF the interest rate is set to equal 9%/year

1.5 Equivalence Illustrated

- $20,000 now is not equal in magnitude to $21,800 1 year from now
- But, $20,000 now is economically equivalent to $21,800 one year from now if the interest rate in 9% per year.
- Another way to put it is ……..

1.5 Equivalence Illustrated

- If you were told that the interest rate is 9%….
- Which is worth more?
  - $20,000 now or
  - $21,800 one year from now?
- The two sums are economically equivalent but not numerically equal!

Read over Example 1.6

1.5 Equivalence Illustrated

- To have economic equivalence you must specify:

Read over Example 1.6

- Timing of the cash flows
- An interest rate (i% per interest period)
- Number of interest periods (N)

Section 1.6
Simple and Compound Interest

- Two “types” of interest calculations
  - Simple Interest
  - Compound Interest
- Compound Interest is more common worldwide and applies to most analysis situations

1.6 Simple and Compound Interest

- **Simple Interest**
- **Calculated on the principal amount only**
- **Easy (simple) to calculate**
- **Simple Interest is:**

(principal)(interest rate)(time)

$$\$I = (P)(i)(n)$$

1.6 Simple and Compound Interest

- Example 1.7
- Borrow $1000 for 3 years at 5% per year
- Let "P" = the principal sum
- i = the interest rate (5%/year)
- Let N = number of years (3)

1.6 Simple and Compound Interest

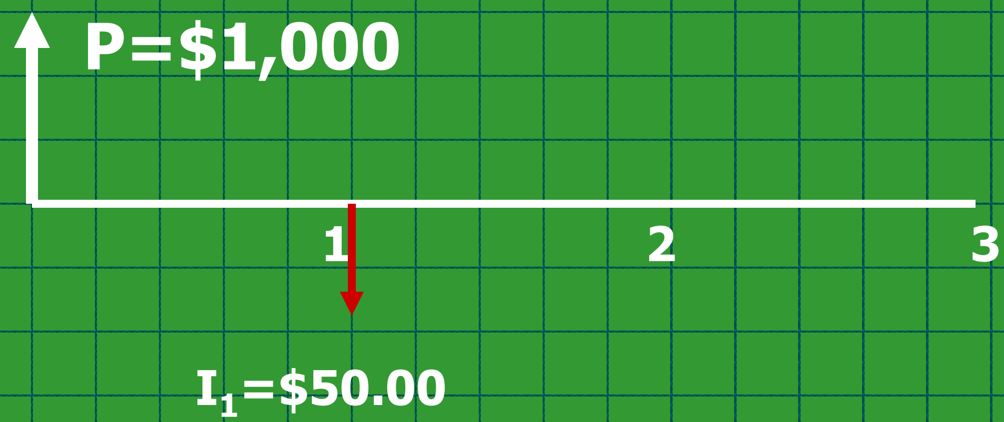
- Simple Interest
- DEFINITION
- I = P(i)(N)
- For Ex. 1.7:
    - I = $1000(0.05)(3) = $150.00
    - Total Interest over 3 Years

1.6 Simple and Compound Interest

- **Year by Year Analysis Simple Interest**
- **Year 1**
  - $I_1 = \$1,000(0.05) = \$50.00$
- **Year 2**
  - $I_2 = \$1,000(0.05) = \$50.00$
- **Year 3**
  - $I_3 = \$1,000(0.05) = \$50.00$

1.6 Accrued Interest Year 1

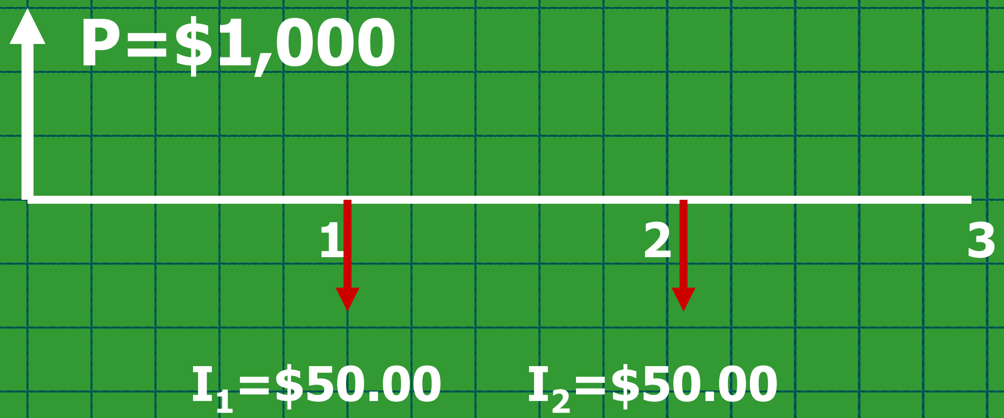
- "Accrued" means "owed but not yet paid"
- First Year:



$50.00 interest accrues but not paid

1.6 Accrued Interest Year 2

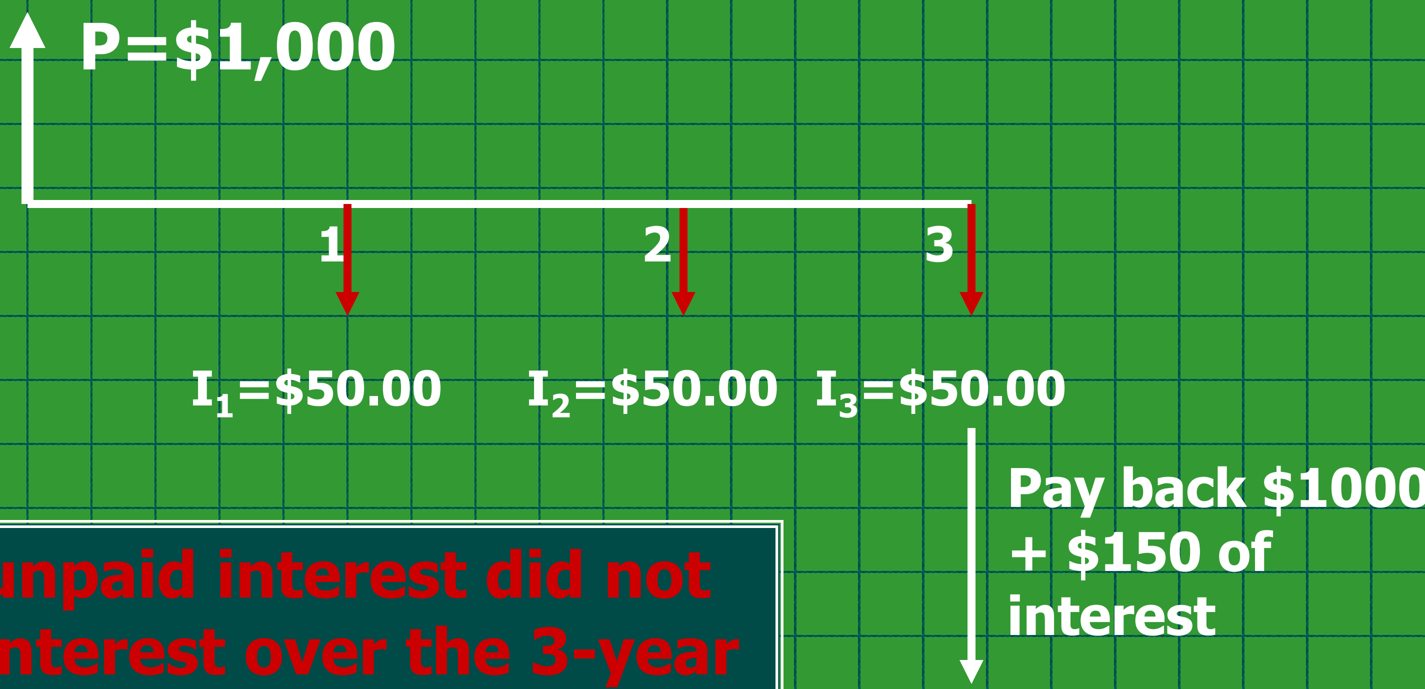
- **Year 2**



$50.00 interest accrues but not paid

1.6 End of 3 Years

- $150 of interest has accrued



The unpaid interest did not earn interest over the 3-year period

1.6 Simple Interest: Summary

- **In a multiperiod situation with simple interest:**
  - **The accrued interest does not earn interest during the succeeding time period**
  - **Normally, the total sum borrowed (lent) is paid back at the end of the agreed time period PLUS the accrued (owed but not paid) interest.**

1.6 Compound Interest

- Compound Interest is much different
- Compound means to stop and compute
- In this application, compounding means to compute the interest owed at the end of the period and then add it to the unpaid balance of the loan
- Interest then "earns interest"

1.6 Compound Interest

- To ***COMPOUND*** – stop and compute the associated interest and add it to the unpaid balance.
- When interest is compounded, the interest that is accrued at the end of a given time period is added in to form a NEW principal balance.
- That new balance then earns or is charged interest in the succeeding time period

1.6 Compound Interest

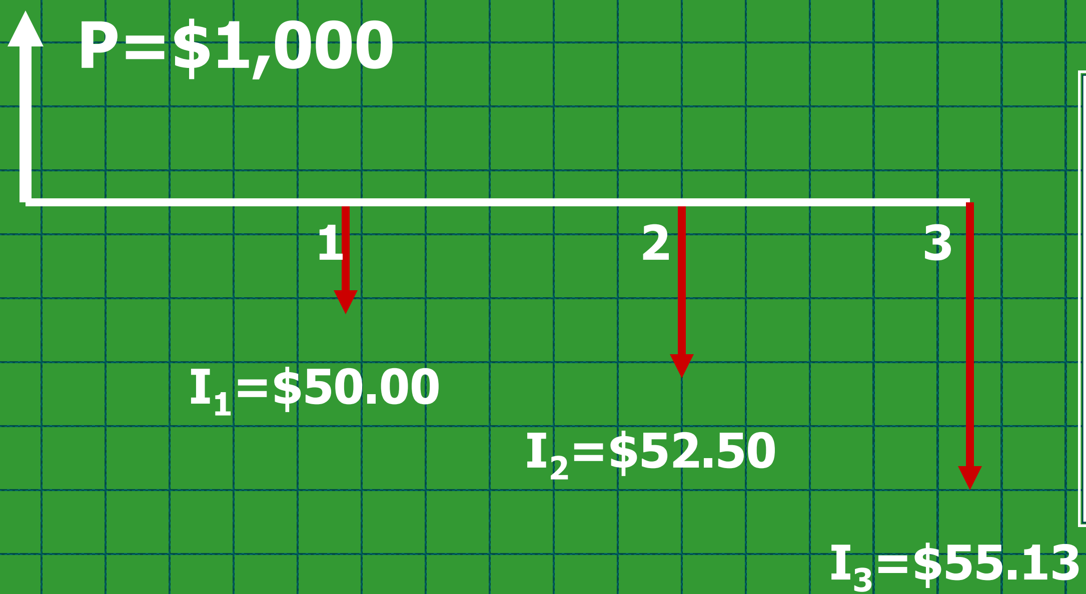
- To ***COMPOUND*** – stop and compute the associated interest and add it to the unpaid balance.
- When interest is compounded, the interest that is accrued at the end of a given time period is added in to form a NEW principal balance.
- That new balance then earns or is charged interest in the succeeding time period

1.6 Compound Interest: Ex. 1.8

- **Assume:**
  - **P = $1,000**
  - **i = 5% per year compounded annually (C.A.)**
  - **N = 3 years**

1.6 Compound Interest Cash Flow

- For compound interest, 3 years, we have:



Owe at t = 3 years:

$1,000 + 50.00 + 52.50 + 55.13 = $1157.63

1.6 Compound Interest: Calculated

- For the example:
- P_0 = +$1,000
- I_1 = $1,000(0.05) = $50.00
- Owe P_1 = $1,000 + 50 = $1,050 (but, we don't pay yet!)
- New Principal sum at end of t = 1: = $1,050.00

1.6 Compound Interest: $t = 2$

- Principal and end of year 1: $1,050.00
- I_1 = $1,050(0.05) = $52.50 (owed but not paid)
- Add to the current unpaid balance yields:
  - $1050 + 52.50 = $1102.50
  - New unpaid balance or New Principal Amount
- Now, go to year 3…….

1.6 Compound Interest: $t = 3$

- New Principal sum: $1,102.50
- I_3 = $1102.50(0.05) = $55.125 = $55.13
- Add to the beginning of year principal yields:
  - $1102.50 + 55.13 = $1157.63
  - This is the loan payoff at the end of 3 years
- Note how the interest amounts were added to form a new principal sum with interest calculated on that new amount

1.6 Example 1.9

- Five plans are shown that will pay off a loan of $5,000 over 5 years with interest at 8% per year.
- Plan1. Simple Interest, pay all at the end
- Plan 2. Compound Interest, pay all at the end
- Plan 3. Simple interest, pay interest at end of each year. Pay the principal at the end of N = 5
- Plan 4. Compound Interest and part of the principal each year (pay 20% of the Prin. Amt.)

1.6 Example 1.9: 5 Plans

- **Plan 5. Equal Payments of the compound interest and principal reduction over 5 years with end of year payments.**

Note: The following tables will show the five approaches. For now, do not try to understand how all of the numbers are determined (that will come later!) Focus on the methods and these table illustrate economic equivalence

1.6 Plan 1: @ 8% Simple Interest

- **Simple Interest: Pay all at end on $5,000 Loan**

(1) End of Year	(2) Interest Owed for Year	(3) Total Owed at End of Year	(4) End-of-Year Payment	(5) Total Owed after Payment
Plan 1: Simple Interest, Pay All at End				
0				$5000.00
1	$400.00	$5400.00	—	5400.00
2	400.00	5800.00	—	5800.00
3	400.00	6200.00	—	6200.00
4	400.00	6600.00	—	6600.00
5	400.00	7000.00	$7000.00	
Totals			$7000.00	

1.6 Plan 2: Compound Interest 8%/yr

- **Pay all at the End of 5 Years**

(1) End of Year	(2) Interest Owed for Year	(3) Total Owed at End of Year	(4) End-of-Year Payment	(5) Total Owed after Payment
0				$5000.00
1	$400.00	$5400.00	—	5400.00
2	432.00	5832.00	—	5832.00
3	466.56	6298.56	—	6298.56
4	503.88	6802.44	—	6802.44
5	544.20	7346.64	$7346.64	
Totals			$7346.64	

1.6 Plan 3: Simple Interest Pd. Annually

- **Principal Paid at the End (balloon Note)**

(1) End of Year	(2) Interest Owed for Year	(3) Total Owed at End of Year	(4) End-of-Year Payment	(5) Total Owed after Payment
0				$5000.00
1	$400.00	$5400.00	$400.00	5000.00
2	400.00	5400.00	400.00	5000.00
3	400.00	5400.00	400.00	5000.00
4	400.00	5400.00	400.00	5000.00
5	400.00	5400.00	5400.00	
Totals			$7000.00	

1.6 Plan 4 Compound Interest

- **20% of Principal Paid back annually**

(1) End of Year	(2) Interest Owed for Year	(3) Total Owed at End of Year	(4) End-of-Year Payment	(5) Total Owed after Payment
0				$5000.00
1	$400.00	$5400.00	$1400.00	4000.00
2	320.00	4320.00	1320.00	3000.00
3	240.00	3240.00	1240.00	2000.00
4	160.00	2160.00	1160.00	1000.00
5	80.00	1080.00	1080.00	
Totals			$6200.00	

1.6 Plan 5: Equal Repayment Plan

- **Equal Annual Payments (Part Principal and Part Interest**

(1) End of Year	(2) Interest Owed for Year	(3) Total Owed at End of Year	(4) End-of-Year Payment	(5) Total Owed after Payment
0				$5000.00
1	$400.00	$5400.00	$1252.28	4147.72
2	331.82	4479.54	1252.28	3227.25
3	258.18	3485.43	1252.28	2233.15
4	178.65	2411.80	1252.28	1159.52
5	92.76	1252.28	1252.28	
Totals			$6261.41	

1.6 Comparisons – 5 Plans

- **Plan 1 Simple interest = (original principal)(0.08)**
- **Plan 2 Compound interest = (total owed previous year)(0.08)**
- **Plan 3 Simple interest = (original principal)(0.08)**
- **Plan 4 Compound interest = (total owed previous year)(0.08)**
- **Plan 5 Compound interest = (total owed previous year)(0.08)**

1.6 Analysis

- Note that the amounts of the annual payments are different for each repayment schedule and that the total amounts repaid for most plans are different, even though each repayment plan requires exactly 5 years.
- The difference in the total amounts repaid can be explained (1) by the time value of money, (2) by simple or compound interest, and (3) by the partial repayment of principal prior to year 5.

Section 1.7
Terminology and Symbols

- Specific symbols and their respective definitions has been developed for use in engineering economy
- Symbols tend to be standard in most engineering economy texts world-wide
- Mastery of the symbols and their respective meanings is most important in understanding of the subsequent material!

1.7 Terminology and Symbols

- P = value or amount of money at a time designated as the present or time 0.

- Also P is referred to as present worth (PW), present value (PV), net present value (NPV), discounted cash flow (DCF), and capitalized cost (CC); dollars

1.7 Terminology and Symbols

- **F = value or amount of money at some future time.**
- **Also F is called future worth (FW) and future value (FV); dollars**

1.7 Terminology and Symbols

- A = series of consecutive, equal, end-of-period amounts of money.
- Also A is called the annual worth (AW) and equivalent uniform annual worth (EUAW); dollars per year, dollars per month
- n = number of interest periods; years, months, days

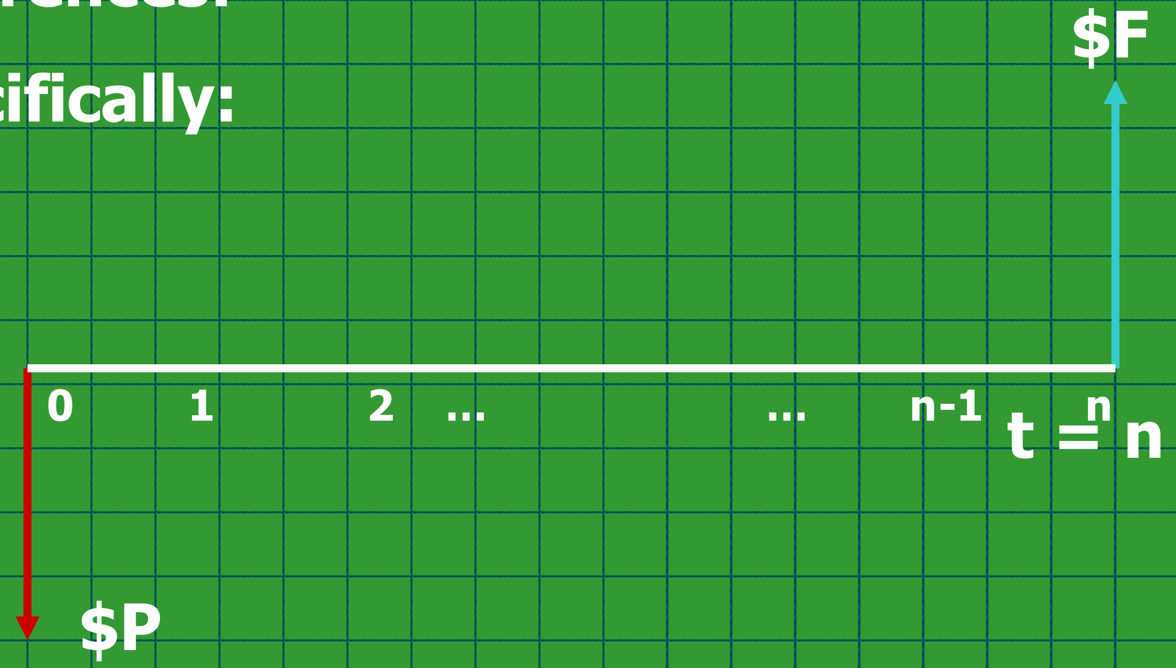
1.7 Terminology and Symbols

- **i = interest rate or rate of return per time period; percent per year, percent per month**

- **t = time, stated in periods; years, months, days, etc**

1.7 P and F

- The symbols P and F represent one-time occurrences:
- Specifically:



1.7 P and F:

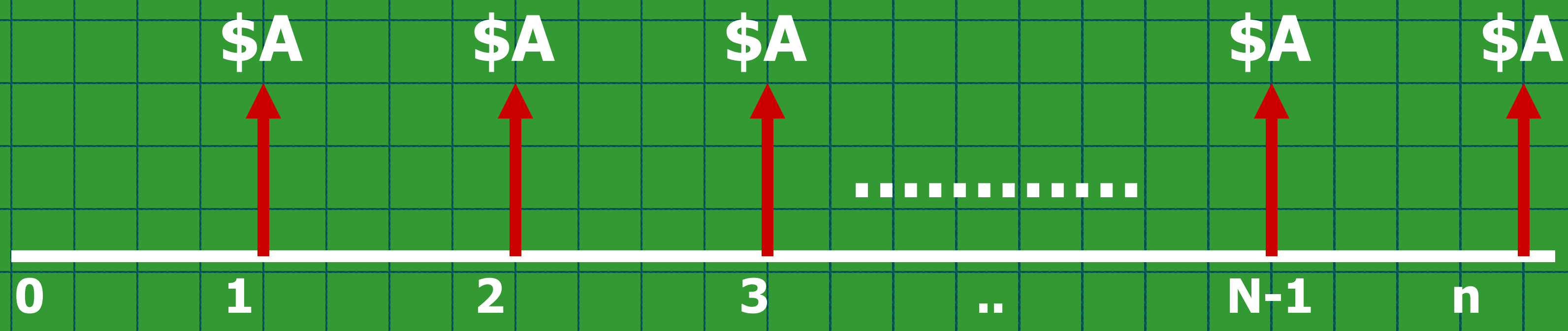
- It should be clear that a present value **P** represents a single sum of money at some time prior to a future value **F**
- This is an important basic point to remember

1.7 Annual Amounts

- **It is important to note that the symbol A always represents a uniform mount (i.e., the same amount each period) that extends through consecutive interest periods.**

1.7 Annual Amounts

- Cash Flow diagram for annual amounts might look like the following:



A = equal, end of period cash flow amounts

1.7 Interest Rate – i% per period

- The interest rate **i** is assumed to be a compound rate, unless specifically stated
- As "simple interest"

- The rate **i** is expressed in percent per interest period, for example, 12% per year.

1.7 Terminology and Symbols

- **For many engineering economy problems:**
  - **Involve the dimension of time**
  - **At least 4 of the symbols { P, F, A, i% and n }**
  - **At least 3 of 4 are either estimated or assumed to be know with certainty.**

Section 1.8
Intro to Solution by Computer

- Use of a spreadsheet similar to Microsoft's Excel is fundamental to the analysis of engineering economy problems.
- Appendix A of the text presents a primer on spreadsheet use
- All engineers are expected by training to know how to manipulate data, macros, and the various built-in functions common to spreadsheets

1.8 Spreadsheets

- Excel supports (among many others) six built-in functions to assist in time value of money analysis
- Master each on your own and set up a variety of the homework problems (on your own)

1.8 Excel's Financial Functions

- To find the present value P: **PV(i%,n,A,F)**
- To find the future value F: **FV(i%,n,A,P)**
- To find the equal, periodic value A: **PMT(i%,n,P,F)**

1.8 Financial Functions - continued

- **To find the number of periods n:**

  NPER(i%,A,P,F)

- **To find the compound interest rate i:**

  RATE(n,A,P,F)

- **To find the compound interest rate i:**

  IRR(first_ cell:last_ cell)

1.8 Financial Functions - continued

- To find the present value P of any series:

NPV(i%,second_cell_last cell) + first cell

- These built-in Excel functions support a wide variety of spreadsheet models that are useful in engineering economy analysis.

- Study Examples 1.10 and 1.11

Section 1.9
Minimum Attractive Rate of Return (MARR)

- **Firms will set a minimum interest rate that the financial managers of the firm require that all accepted projects must meet or exceed.**
- **The rate, once established by the firm is termed the Minimum Attractive Rate of Return (MARR)**
- **The MARR is expressed as a per cent per year**
- **Numerous models exist to aid the financial managers is estimating what this rate should be in a given time period.**

1.9 Minimum Attractive Rate of Return

- An investment is a commitment of funds and resources in a project with the expectation of earning a return over and above the worth of the resources that were committed.
- Economic Efficiency means that the returns should exceed the inputs.
- In the for profit enterprise, economic efficiencies greater than 100% are required!

1.9 MARR – Hurdle Rate

- In some circles, the MARR is termed the **Hurdle Rate**
- Capital (investment funds) is not free
- It costs the firm money to raise capital or to use the owners of the firm's capital.
- This cost is often expressed as a % per year

1.9 Cost of Capital: Personal Example

- Assume you want to purchase a new computer
- Assume you have a charge card that carries a 18% per year interest rate.
- If you charge the purchase, YOUR cost of capital is the 18% interest rate.
- Very high!

1.9 Cost to a Firm

- **Firm's raise capital from the following sources**
  - **•Equity – using the owner's funds (retained earnings, cash on hand)belongs to the owners)**
  - **•Owners expect a return on their money and hence, there is a cost to the firm**

•DEBT – the firm borrows from outside the firm and pays an interest rate on the borrowed funds

1.9 Costing Capital

- **Financial models exist that will approximate the firm's weighted average cost of capital for a given time period.**
- **Once this "cost" is approximated, then, new projects up for funding MUST return at least the cost of the funds used in the project PLUS some additional per cent return.**
- **The cost is expressed as a % per year just like an interest rate.**

1.9 Setting the MARR: Safe Investment

- First, start with a “safe” investment possibility
- A firm could always invest in a short term CD paying around 4-5%
  - But investors will expect more that that!
- The firm should compute it’s current weighted average cost of capital (See Chapter 10)
  - This cost will almost always exceed a “safe” external investment rate!

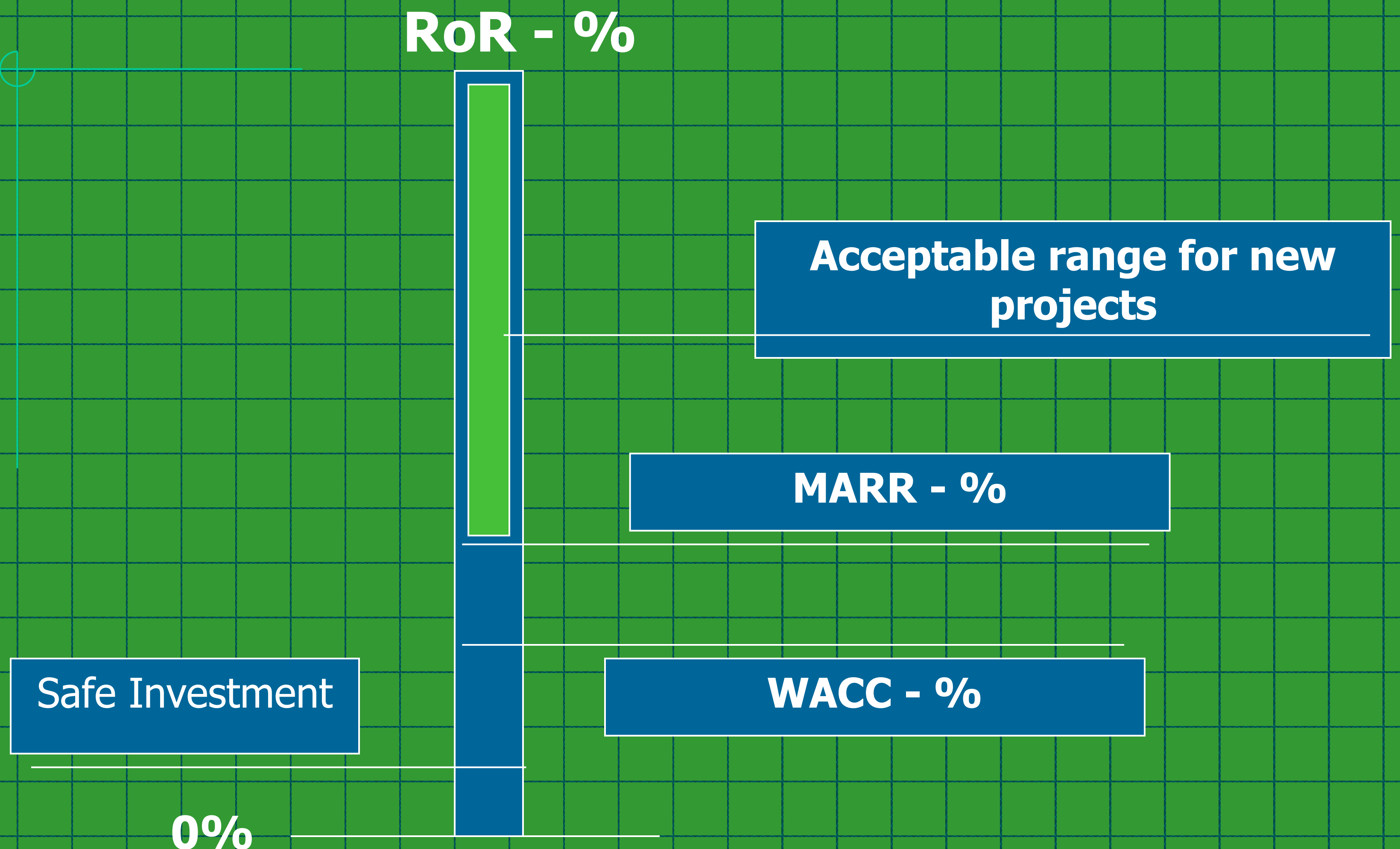
1.9 Setting the MARR - continued

- Assume the weighted average cost of capital (WACC) is say, 10.25% (for the sake of presentation)
- Certainly, the MARR must be greater than the firms cost of capital in order to earn a "profit" or "return" that satisfies the owners!
    - Thus, some additional "buffer" must be provided to account for risk and uncertainty!

1.9 Setting a MARR

- Start with the WACC…
- Add a buffer percent (?? Varies from firm to firm)
- This yields an approximation to a reasonable MARR
- This becomes the Hurdle Rate that all prospective projects should earn in order to be considered for funding.

1.9 Graphical Presentation: MARR



1.9 Opportunity forgone

- Assume a firm's MARR = 12%
- Two projects, A and B
- A costs $400,000 and presents an estimated 13% per year.
- B cost $100,000 with an estimated return of 14.5%

1.9 Opportunity Forgone

- What if the firm has a budget of say $150,000
- A cannot be funded – not sufficient funds!
- B is funded and earns 14.5% return or more
- A is not funded, hence, the firm looses the OPPORTUNITY to earn 13%
- This often happens!

Section 1.10
Cash Flow Diagramming

- **Engineering Economy has developed a graphical technique for presenting a problem dealing with cash flows and their timing.**
- **Called a CASH FLOW DIAGRAM**
- **Similar to a free-body diagram in statics**
- **First, some important TERMS . . . .**

1.10 Important TERMS

- **CASH INFLOWS**
  - **Money flowing INTO the firm from outside**
  - **Revenues, Savings, Salvage Values, etc**
- **CASH OUTFLOWS**
  - **Disbursements**
  - **First costs of assets, labor, salaries, taxes paid, utilities, rents, interest, etc**

1.10 Cash Flows

- For many practical engineering economy problems the cash flows must be:
  - Assumed know with certainty
  - Estimated
  - A range of possible realistic values provided
  - Generated from an assumed distribution and simulated

1.10 Net Cash Flows

- A **NET CASH FLOW** is
  - Cash Inflows – Cash Outflows
    - (for a given time period)
- We normally assume that all cash flows occur:
  - At the **END** of a given time period
  - End-of-Period Assumption

1.10 End of Period Assumption

- **END OF PERIOD convention**

ALL CASH FLOWS ARE ASSUMED TO OCCUR AT THE END OF AN INTEREST PERIOD EVEN IF THE MONEY FLOWS AT TIMES WITHIN THE INTEREST PERIOD.

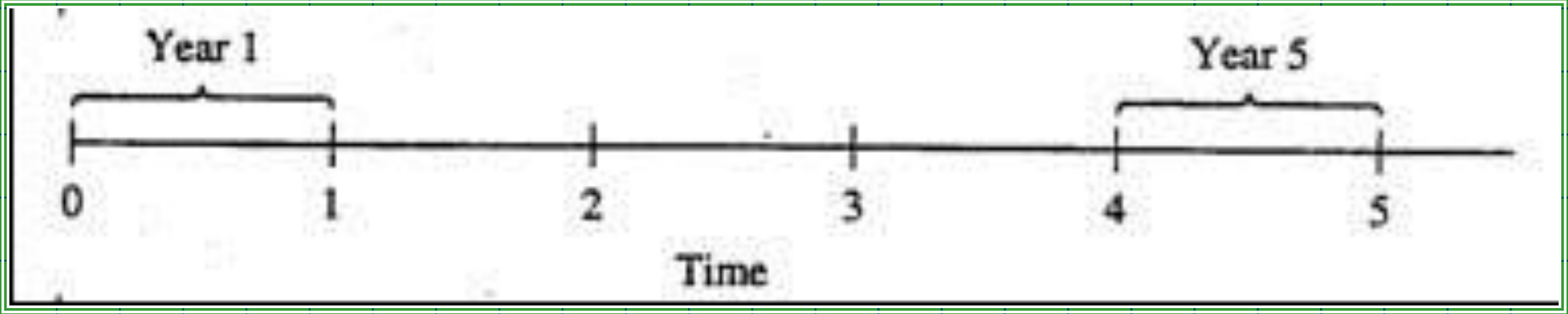
THIS IS FOR SIMPLIFICATION PURPOSES

1.10 The Cash Flow Diagram: CFD

- Extremely valuable analysis tool
- First step in the solution process
- Graphical Representation on a time scale
- Does not have to be drawn “to exact scale”
  - But, should be neat and properly labeled
  - Required on most in class exams and part of the grade for the problem at hand

1.10 Example Cash Flow diagrams

- Assume a 5-year problem
- The basic time line is shown below



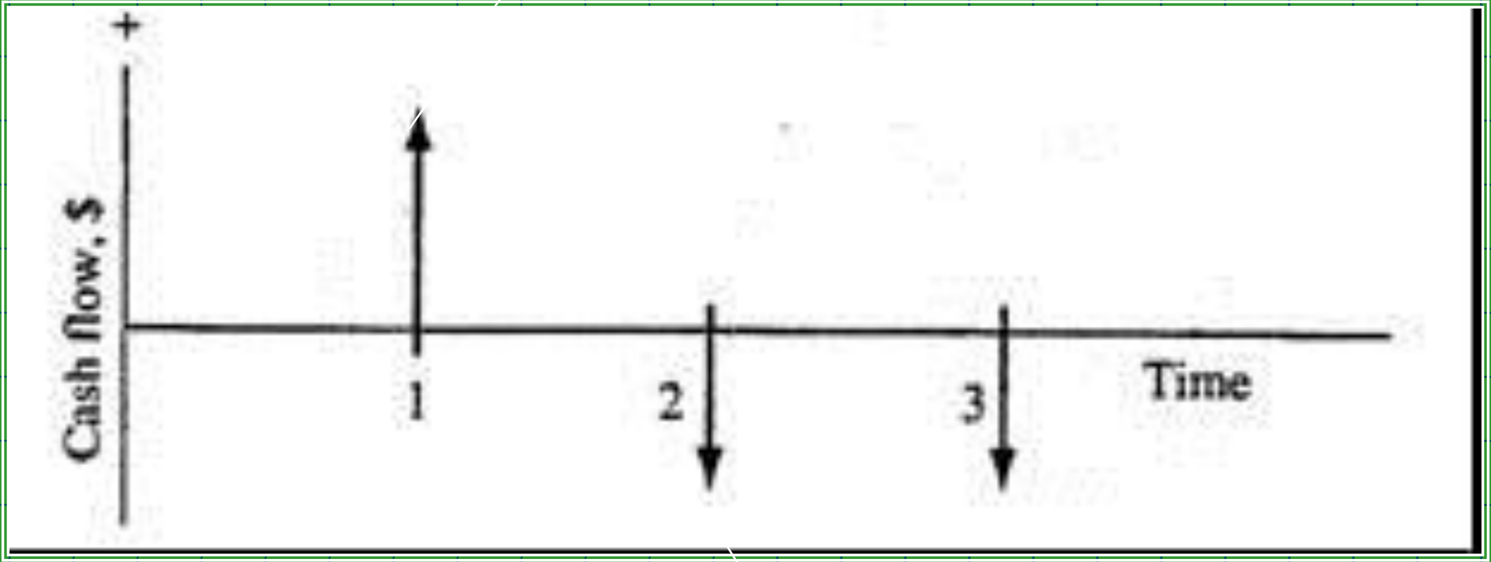
- "Now" is denoted as t = 0

1.10 Displaying Cash Flows

- **A sign convention is applied**
  - **Positive cash flows are normally drawn upward from the time line**
  - **Negative cash flows are normally drawn downward from the time line**

1.10 Sample CF Diagram

Positive CF at t = 1



Negative CF's at t = 2 & 3

1.10 Problem Perspectives

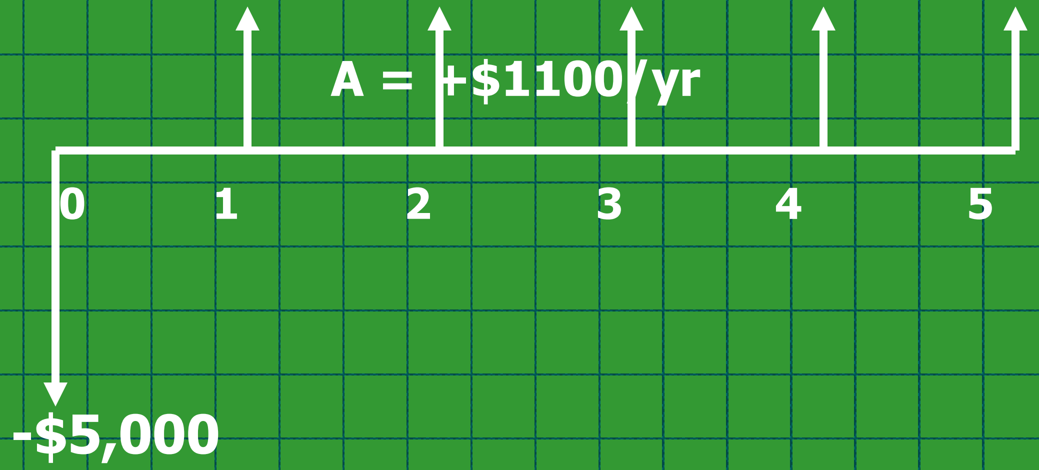
- Before solving, one must decide upon the perspective of the problem
- Most problems will present two perspectives
- Assume a borrowing situation for example
  - Perspective 1: From the lender's view
  - Perspective 2: From the borrower's view
  - Impact upon the sing convention

1.10 Lending – Borrowing Example

- **Assume $5,000 is borrowed and payments are $1100 per year.**
- **Draw the cash flow diagram for this**
  - **First, whose perspective will be used?**
  - **Lender's or the Borrower's ? ? ?**
  - **Problem will "infer" or you must decide….**

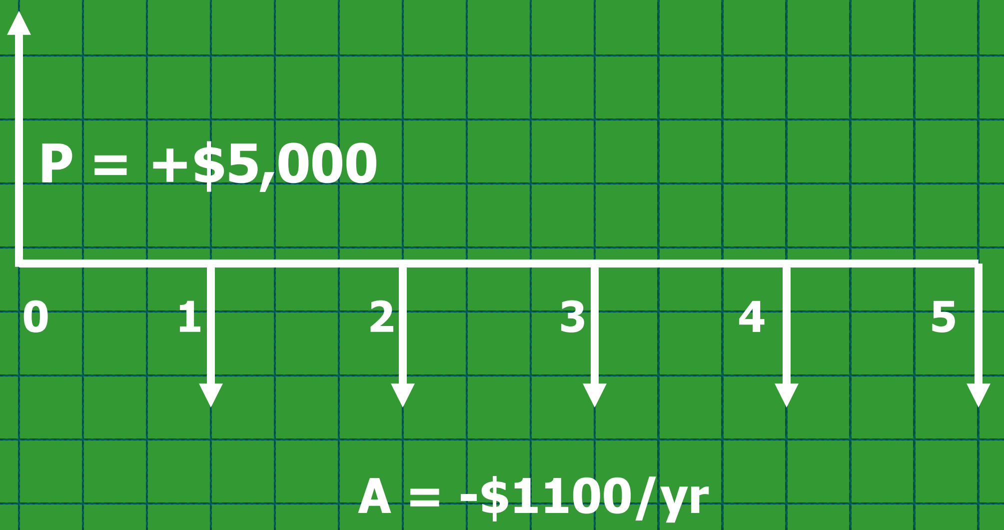
1.10 Lending - Borrowing

- **From the Lender's Perspective**



1.10 Lending - Borrowing

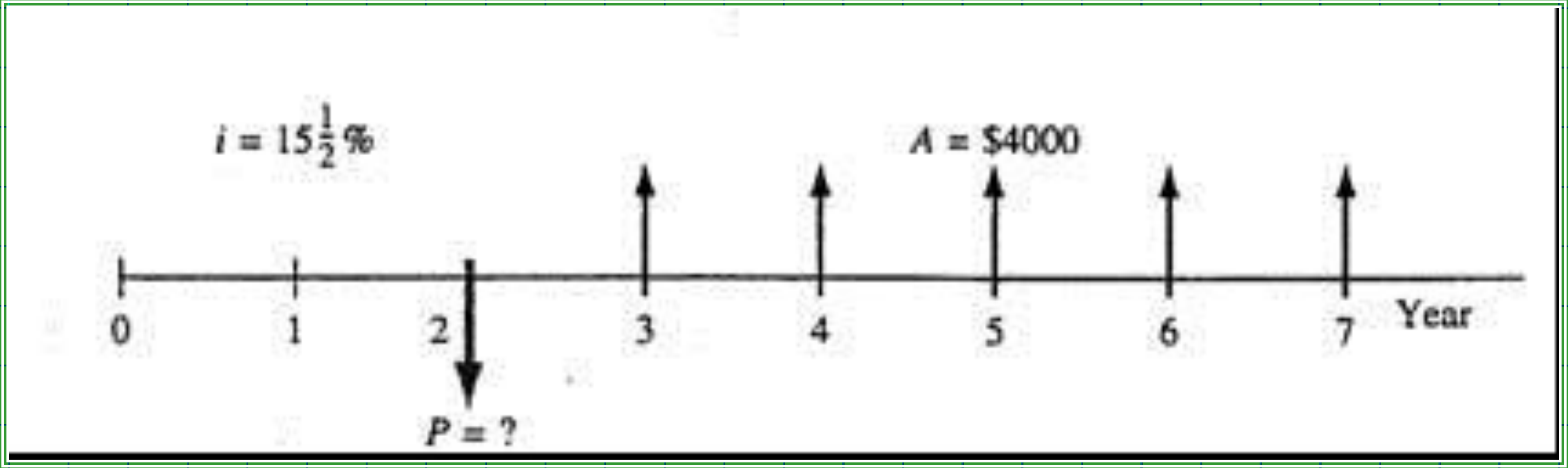
- From the Lender's Perspective



1.10 Example 1.17

- A father wants to deposit an unknown lump-sum amount into an investment opportunity 2 years from now that is large enough to withdraw $4000 per year for state university tuition for 5 years starting 3 years from now.
- If the rate of return is estimated to be 15.5% per year, construct the cash flow diagram.

1.10 Example 1.17 CF Diagram



CHAPTER I Section 1.11

Rule of 72: Estimating doubling Time and Interest Rate

Section 1.11
Rule of 72: Estimating Doubling Time and Interest Rate

- A common question most often asked by investors is:
  - How long will it take for my investment to double in value?
  - Must have a known or assumed compound interest rate in advance
  - Assume a rate of 13%/year to illustrate….

1.11 Rule of 72's for Interest

- **The Rule of 72 states:**
  - **The approximate time for an investment to double in value given the compound interest rate is:**
  - **Estimated time (n) = 72/i**
  - **For i = 13%: 72/13 = 5.54 years**

1.11 Rule of 72's for Interest

- **Likewise one can estimate the required interest rate for an investment to double in value over time as:**
  - $i_{approximate} = 72/n$
  - **Assume we want an investment to double in say 3 years.**
  - **Estimate i –rate would be: 72/3 = 24%**

Section 1.12
Spreadsheet Applications

- Section 1.12 introduces the concepts associated with using a spreadsheet program like Microsoft Excel.
- To build and improve your knowledge of modeling by using Excel you must build your own models and experiment with the various functions
- You instructor will determine the extent and depth of use of Excel for this course

Chapter 1 Summary

- **Engineering Economy**:
  - **Application of economic factors and criteria to evaluate alternatives considering the time value of money (interest and time)**

- **Engineering Economy Study**:
  - **Involves modeling the cash flows**
  - **Computing specific measures of economic worth**
  - **Using an interest rate(s)**
  - **Over a specified period of time**

- **The concept of *equivalence* helps in understanding how different sums of money at different times are equal in economic terms**

- **Simple** and **Compound** Interest
  - The differences between simple interest (based on principal only) and compound interest (based on principal and interest upon interest) have been described in formulas, tables, and graphs

- **Compounding of Interest**
  - **The power of compounding is very noticeable, especially over long periods of time.**
  - **Notion of computing interest on interest**

- **The MARR**
  - **The MARR is a reasonable rate of return established as a hurdle rate to determine if an alternative is economically viable.**
  - **The MARR is always higher than a return from a safe investment.**

- **Attributes of Cash Flows**
  - **Difficulties with their estimation.**
  - **Difference between estimated and actual value.**
  - **End-of-year convention for cash flow location.**

- **Attributes of Cash Flows**
  - **Net cash flow computation.**
  - **Different perspectives in determining the cash flow sign convention.**
  - **Construction *of a cash flow diagram.***
- **Introduction to spreadsheet analysis**

End of Slide Set

McGraw Hill