Chapter 1

Foundations Of Engineering Economy

LEARNING OUTCOMES

1. Economics role in decision making
2. Study approach
3. Ethics and economics
4. Interest rate
5. Terms and symbols
6. Cash flows
7. Economic equivalence
8. Simple and compound interest
9. Minimum attractive rate of return (MARR)
10. Spreadsheet functions

Why Engineering Economy is Important to Engineers

Engineers design and create

Designing involves economic decisions

Engineers must be able to incorporate economic analysis into their creative efforts

Understanding and applying time value of money, economic equivalence, and cost estimation are vital for engineers

Project decisions are made more on the return on investment or payback than on technology

You must communicate the basics of economy for your proposals to get funding

Time Value of Money (TVM)

Description: TVM explains the change in the amount of money over time for funds owed by or owned by a corporation or individual

- **Corporate investments are expected to earn a return**
- **Investment always involves money**
- **Money has a 'time value'**

The time value of money is the most important concept in engineering economy

Engineering Economy

Engineering Economy involves

- **Formulating**
- **Estimating**
- **Evaluating**
  - **Evaluating expected economic outcomes of alternatives designed to accomplish a defined purpose**

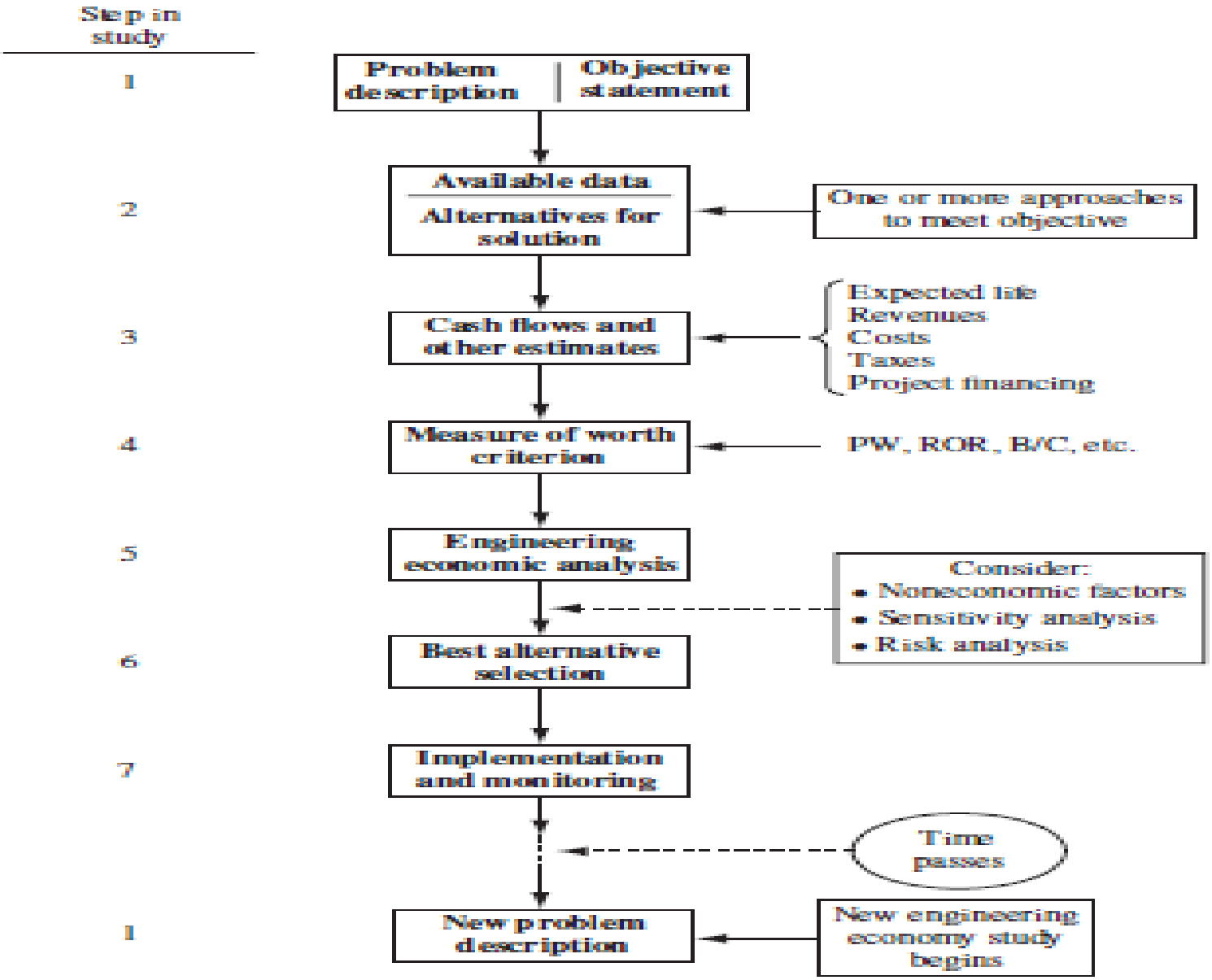
Easy-to-use math techniques simplify the evaluation

Estimates of economic outcomes can be deterministic or stochastic in nature

General Steps for Decision Making Processes

1. Understand the problem – define objectives
2. Collect relevant information – e.g. cash flows, interest rate, estimated life
3. Define the set of feasible alternatives
4. Define the criteria for decision making
5. Evaluate the alternatives and explore sensitivity analysis
6. Select the “best” alternative (typically measured by dollars)
7. Implement the alternative and monitor results

Steps in an Engineering Economy Study



Ethics – Different Levels

Universal morals or ethics – Fundamental beliefs: stealing, lying, harming or murdering another are wrong

Personal morals or ethics – Beliefs that an individual has and maintains over time; how a universal moral is interpreted and used by each person

Professional or engineering ethics – Formal standard or code that guides a person in work activities and decision making

Code of Ethics for Engineers

All disciplines have a formal code of ethics. National Society of Professional Engineers (NSPE) maintains a code specifically for engineers; many engineering professional societies have their own code

National Society of Professional Engineers®

Code of Ethics for Engineers

Preamble

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct.

I. Fundamental Canons

Engineers, in the fulfillment of their professional duties, shall:

1. Hold paramount the safety, health, and welfare of the public.
2. Perform services only in areas of their competence.
3. Issue public statements only in an objective and truthful manner.
4. Act for each employer or client as faithful agents or trustees.
5. Avoid deceptive acts.
6. Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.

4. Engineers shall act for each employer or client as faithful agents or trustees.
   a. Engineers shall disclose all known or potential conflicts of interest that could influence or appear to influence their judgment or the quality of their services.
   b. Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.
   c. Engineers shall not solicit or accept financial or other valuable consideration, directly or indirectly, from outside agents in connection with the work for which they are responsible.
   d. Engineers in public service as members, advisors, or employees of a governmental or quasi-governmental body or department shall not participate in decisions with respect to services solicited or provided by them or their organizations in private or public engineering practice.
   e. Engineers shall not solicit or accept a contract from a governmental body on which a principal or officer of their organization serves as a member.
5. Engineers shall avoid deceptive acts.
   a. Engineers shall not falsify their qualifications or permit misrepresentation of their or their associates' qualifications. They shall not misrepresent or exaggerate their responsibility in or for the

Interest and Interest Rate

Interest – the manifestation of the time value of money

- Fee that one pays to use someone else's money
- Difference between an ending amount of money and a beginning amount of money

- $\text{Interest} = \text{amount owed now} - \text{principal}$

Interest rate – Interest paid over a time period expressed as a percentage of principal

- $$\text{Interest rate}(\%) = \frac{\text{interest accrued per time unit}}{\text{principal}} \times 100\%$$

Rate of Return

Interest earned over a period of time is expressed as a percentage of the original amount (principal)

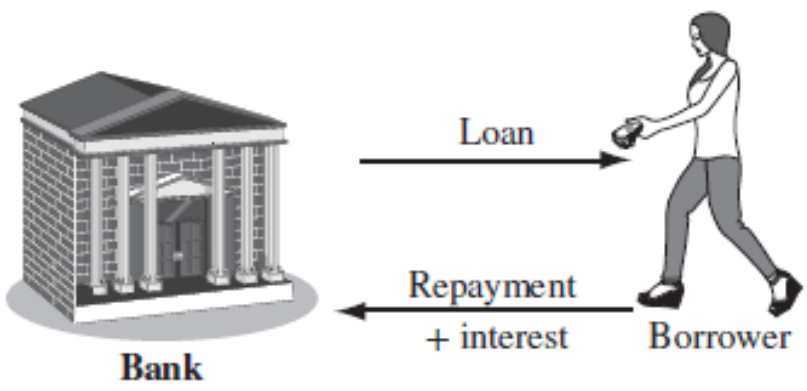
$$\text{Rate of return}\,(\%) = \frac{\text{interest accrued per time unit}}{\text{original amount}} \times 100\%$$

Borrower's perspective – interest rate paid

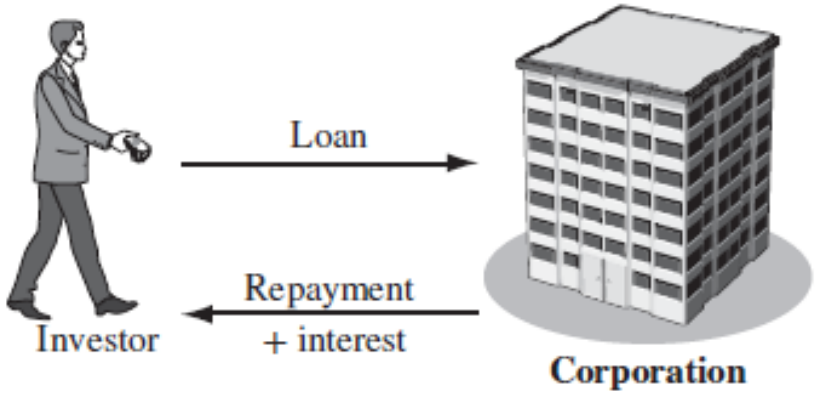
Lender's or investor's perspective – rate of return earned

Depends on your point of view

Interest paid



Interest earned



Interest rate

Rate of return

Commonly used Symbols

t = time, usually in periods such as years or months

P = value or amount of money at a time *t*

- designated as present or time 0

F = value or amount of money at some future time, such as at *t* = *n* periods in the future

A = series of consecutive, equal, end-of-period amounts of money

n = number of interest periods; years, months

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

Cash Flows: Terms

Cash Inflows – Revenues (R), receipts, incomes, savings generated by projects and activities that flow in. Plus sign used

Cash Outflows – Disbursements (D), costs, expenses, taxes caused by projects and activities that flow out. Minus sign used

Net Cash Flow (NCF) for each time period:

$$\text{NCF} = \text{cash inflows} - \text{cash outflows} = R - D$$

End-of-period assumption:

Funds flow at the end of a given interest period

Cash Flows: Estimating

Point estimate – A single-value estimate of a cash flow element of an alternative

Cash inflow: Income = $150,000 per month

Range estimate – Min and max values that estimate the cash flow

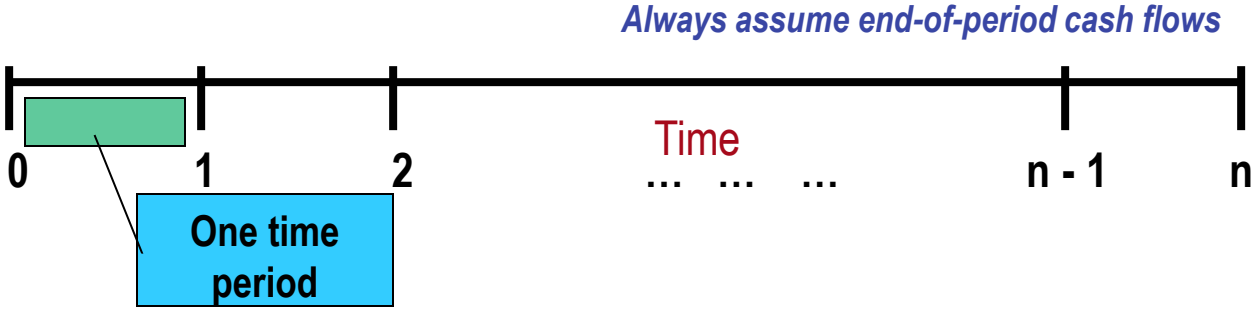
Cash outflow: Cost is between $2.5 M and $3.2 M

Point estimates (a constant) are commonly used; however, range estimates with probabilities assigned provide a better understanding of the variability and sensitivity of economic parameters used to make decisions.

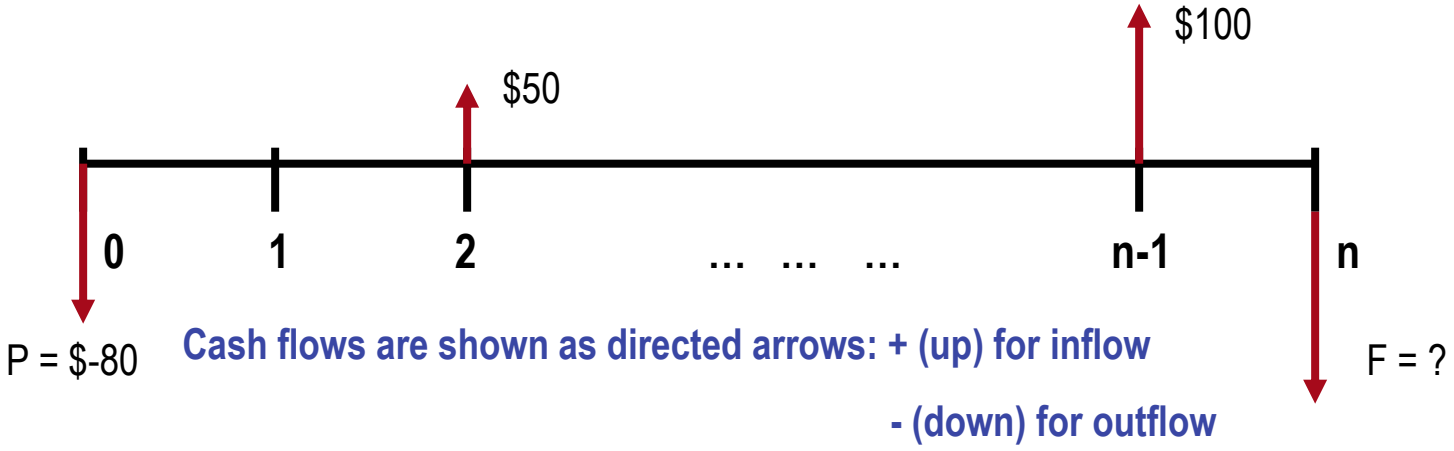
Cash Flow Diagrams

What a typical cash flow diagram might look like

Draw a time line



Show the cash flows (to approximate scale)

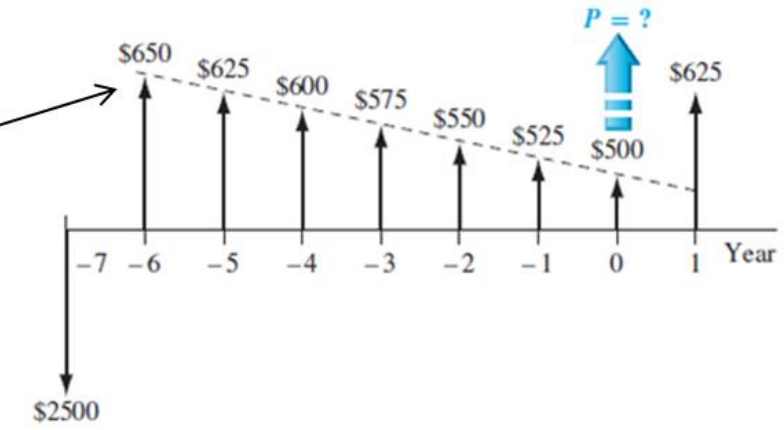


Cash Flow Diagram Example

Plot observed cash flows over last 8 years and estimated sale next year for $150. Show present worth (P) arrow at present time, $t = 0$

End of Year	Income	Cost	Net Cash Flow
−7	$ 0	$2500	$−2500
−6	750	100	650
−5	750	125	625
−4	750	150	600
−3	750	175	575
−2	750	200	550
−1	750	225	525
0	750	250	500
1	750 + 150	275	625

This is called a 'gradient' – a constant change over each period.



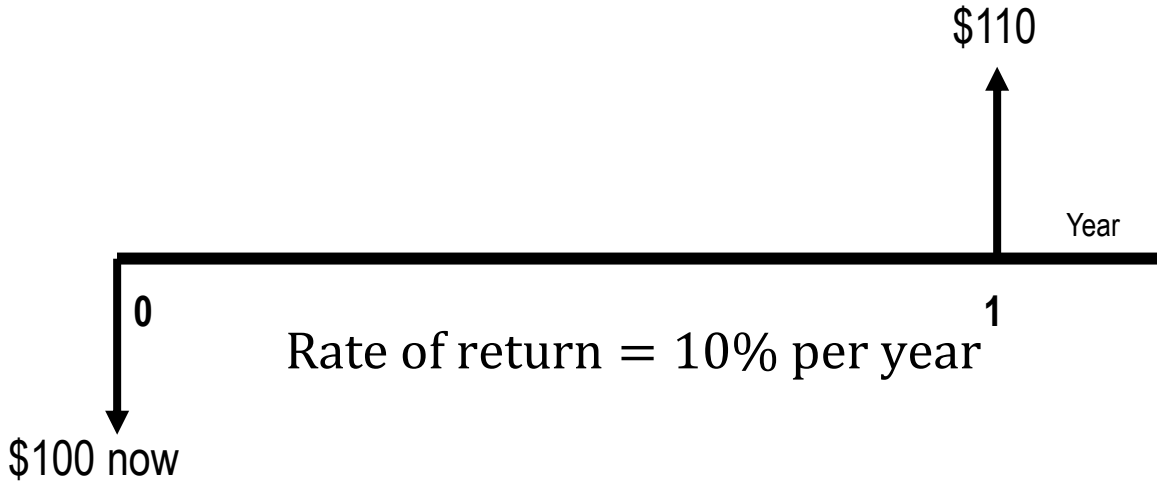
Economic Equivalence

Definition: Combination of **interest rate** (rate of return) and **time value of money** to determine different amounts of money at different points in time that are economically equivalent

How it works: Use interest rate *i* and time *t* in upcoming relations to move money (values of P, F and A) between time points $t = 0, 1, \ldots, n$ to make them equivalent (not equal) at the rate *i*

Example of Equivalence

Different sums of money at different times may be equal in economic value at a given rate



$100 now is economically equivalent to $110 one year from now, if the $100 is invested at a rate of 10% per year.

Simple and Compound Interest (1)

Simple Interest

- **Interest is calculated using principal only**

$$\text{Interest} = (\text{principal})(\text{number of periods})(\text{interest rate})$$

$$I = Pni$$

Example: $100,000 lent for 3 years at simple *i* = 10% per year. What is repayment after 3 years?

$$\text{Interest} = 100{,}000(3)(0.10) = \$30{,}000$$

$$\text{Total due} = 100{,}000 + 30{,}000 = \$130{,}000$$

Simple and Compound Interest (2)

Compound Interest

- Interest is based on principal plus all accrued interest
- That means interest *earns* interest and compounds over time

Interest = (principal + all accrued interest) (interest rate)

Interest for time period *t* is

$$I_t = \left(P + \sum_{j=1}^{j=t-1} I_J \right) (i)$$

Compound Interest Example

Example: $100,000 lent for 3 years at *i* = 10% per year compounded. What is repayment after 3 years?

Interest, year 1: $I_1 = 100{,}000(0.10) = \$10{,}000$

Total due, year 1: $T_1 = 100{,}000 + 10{,}000 = \$110{,}000$

Interest, year 2: $I_2 = 110{,}000(0.10) = \$11{,}000$

Total due, year 2: $T_2 = 110{,}000 + 11{,}000 = \$121{,}000$

Interest, year 3: $I_3 = 121{,}000(0.10 = \$12{,}100$

Total due, year 3: $T_3 = 121{,}000 + 12{,}100 = \$\mathbf{133{,}100}$

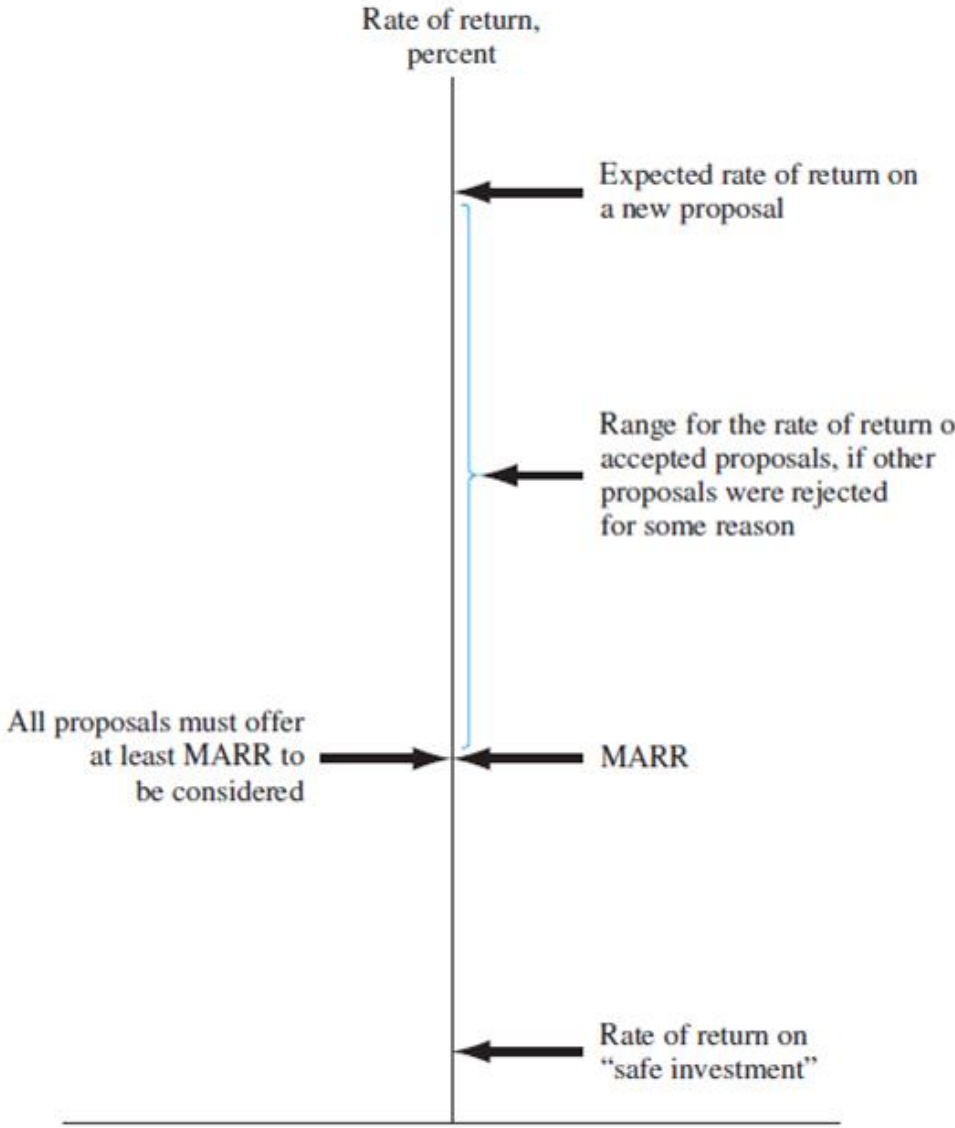
Compounded: $133,100 Simple: $130,000

Minimum Attracti

MARR is a reasonable rate of return (percent) established for evaluating and selecting alternatives

An investment is justified economically if it is expected to return at least the MARR

Also termed *hurdle rate, benchmark rate* and *cutoff rate*



MARR Characteristics

MARR is established by the financial managers of the firm

MARR is fundamentally connected to the cost of capital

Both types of capital financing are used to determine the weighted average cost of capital (WACC) and the MARR

MARR usually considers the risk inherent to a project (the higher the risk means the higher the MARR)

Types of Financing

Equity Financing – Funds either from retained earnings, new stock issues, or owner's infusion of money.

Debt Financing – Borrowed funds from outside sources – loans, bonds, mortgages, venture capital pools, etc. Interest is paid to the lender on these funds

For an economically justified project

$$\mathbf{ROR} \geq \mathbf{MARR} > \mathbf{WACC}$$

Opportunity Cost

Definition: Largest rate of return of all projects not accepted (forgone) due to a lack of capital funds

If no MARR is set, the ROR of the first project not undertaken establishes the opportunity cost

Example: Assume $\mathbf{MARR} = 10\%$. Project A, not funded due to lack of sufficient funds, is projected to have $\mathbf{ROR_A} = 13\%$. Project B has $\mathbf{ROR_B} = 15\%$ and is funded because it costs less than A

Opportunity cost is 13%, i.e., the opportunity to make an additional 13% is forgone by not funding project A

Introduction to Spreadsheet Functions

Excel financial functions

Present Value, P:	= PV(i%,n,A,F)
Future Value, F:	= FV(i%,n,A,P)
Equal, periodic value, A:	= PMT(i%,n,P,F)
Number of periods, n:	= NPER((i%,A,P,F)
Compound interest rate, i:	= RATE(n,A,P,F)
Compound interest rate, i:	= IRR(first_cell:last_cell)
Present value, any series, P:	= NPV(i%,second_cell:last_cell) + first_cell

Example: Estimates are P = $5000 n = 5 years i = 5% per year

Find A in $ per year

Function and display: = PMT(5%, 5, 5000) displays A = $1154.87

Chapter Summary (1)

Engineering Economy fundamentals

- Time value of money
- Economic equivalence
- Introduction to capital funding and MARR
- Spreadsheet functions

Interest rate and rate of return

- Simple and compound interest

Cash flow estimation

- Cash flow diagrams
- End-of-period assumption
- Net cash flow
- Perspectives taken for cash flow estimation

Chapter Summary (2)

Ethics

- Universal morals and personal morals
- Professional and engineering ethics (Code of Ethics)

Economic Equivalence

- Combination of interest rate and time value of money

Simple and Compound Interest

- Simple interest is Pni (Principal, #periods, and interest rate)
- Compound interest is where interest is earned/paid on interest

MARR and Opportunity Cost

- Debt or equity capital financing
- Impact of not selecting an project opportunity