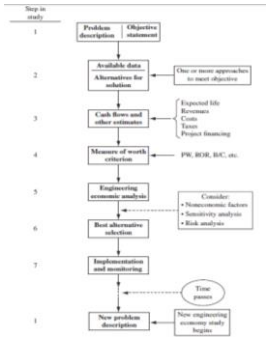
Engineering Economy

- Engineering Economy involves
  - Formulating
  - Estimating, and
  - 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

Decision Making & Engineering Economy

1. Understand the problem – define objectives
2. Collect relevant information
3. Define the set of feasible alternatives
4. Identify the criteria for decision making
5. Evaluate the alternatives and apply sensitivity analysis
6. Select the "best" alternative
7. Implement the alternative and monitor results

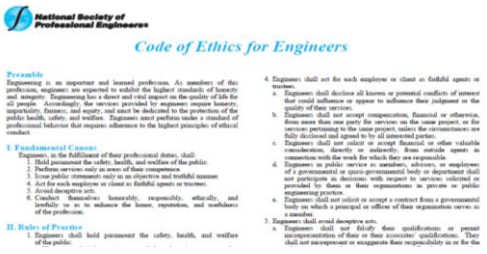


Ethics – Different Levels

- 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 ($) = amount owed now – original amount

A) $1000 placed in bank account one year ago is now worth $1025. Interest earned is _____.

B) $10,000 borrowed last year from Sharky's Easy Money, and you now owe $12,000. Interest owed is _____.

Interest paid over a specific time period is called an interest rate.

Interest rate, i (%) = $\frac{\text{interest accrued per time}}{\text{original amount}} \times 100\%$

What is the interest rate in example A? Example B?

Rate of Return

Rate of Return (ROR) – interest earned over a specific time period, expressed as a percentage of the original amount.

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

Borrower's perspective – interest rate paid

Investor's perspective – rate of return (ROR) or return on investment (ROI).

Engineering Economy

Other factors that act as interest:

- Inflation
- Appreciation
- Depreciation

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 are commonly used; however, range estimates with probabilities attached provide a better understanding of variability of economic parameters used to make decisions

Cash Flow Diagrams

Cash flow diagrams are a way to graphically represent the inflows and outflows of cash over time.

Estimates of cash flows typically follow the ***end-of-period*** convention (cash flows are assumed to occur simultaneously at the end of an interest period).

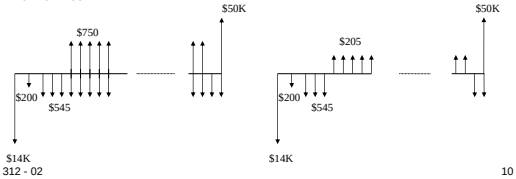
When several receipts and disbursements occur within an interest period, the ***net cash flow*** is depicted.

Net cash flow = receipts – disbursements
= cash inflows – cash outflows

Cash Flow Diagrams

Example: Rental property …

- $70K Purchase price with 20% down ($14K)
- Monthly expenses (utilities, maintenance, insurance, etc..) = $200
- Monthly P&I = $345 (starts in two months)
- Rental income = $750 (starting in 5 months)
- Expect to sell in a few years at a net profit of $50K
  (will need to spend two months prior to selling preparing the property)



Equivalence

Economic equivalence – different sums of money at different times can be equal in economic value because of the "time value of money" and interest rates.

Example: (assuming 5% interest rate)

$1000 today is equivalent to _____ a year from now.

$1000 a year from now is equivalent to _____ today.

What is the interest rate if an investment of $500 is equivalent to $545 a year from now?

Simple –vs- Compound Interest

Simple Interest – interest is calculated using the principal only.

interest = (principal)(number of periods)(interest rate)

Example: you invest $500 in an insurance policy that pays 8% simple interest. How much is the policy worth in 3 years?

	Principal	Interest
Year 0)	$500	
Year 1)	$500	$40
Year 2)	$500	$40
Year 3)	$500	$40
		$120

Simple –vs- Compound Interest

Compound Interest – interest is calculated using both the principal and interest earned.

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

Example: you invest $500 in an insurance policy that pays 8% compound interest. How much is the policy worth in 3 years?

	Principal	Interest	Total	
Year 0)	$500			
Year 1)	$500	_____	_____	$500(1.08)^1
Year 2)	$540	_____	_____	$500(1.08)^2
Year 3)	$583.2			$500(1.08)^3
		$129.85		

Power of Compound Interest

Historical Perspective – In 1626, Manhattan Island was purchased from a native tribe for $24. If that tribe had invested the $24 in an investment paying 8% annually, what would it be worth today?

$24(1.08)^{(2015-1626)}$ = $24(1.08)^{(389)}$ = $24(1.00424x10^{13})$

or $241.02 trillion

However, if the tribe invested in an investment that paid ***simple interest***:

$24 + $24(.08)(389) = $770.88

Symbols and Terminology

P – value or amount of money at time 0, also referred to as present worth (*PW*), present value (*PV*), net present value *(NPV*), or discounted cash flow *(DCF*).

F – value or amount of money at some future time, also referred to as future worth (*FW*) or future value *(FV*).

A – a series of consecutive, equal, end-of-period amount of money, also referred to as annual worth (*AW*) or equivalent uniform annual worth (*EUAW*). Does not have to be annual payouts, could be monthly, weekly, etc.

n – number of periods; years, months, days, …
i – interest rate or rate of return per time period
t – time, stated in periods

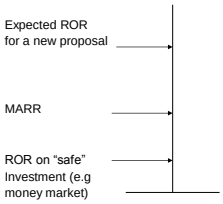
Symbols and Terminology

Example: To diligently plan for my retirement, I should invest $2K in an IRA each year. If I had started a few years ago and continued until I retire, I would be making that investment for about 20 years. I hope to obtain a rate of return of 6%.

A = $2000
i = 6% or .06 annually
n = 20
F = ? the value of the investment when I retire

Minimum Attractive Rate of Return (MARR)

The *Minimum Attractive Rate of Return* is a minimum level set by a Corporation when deciding on whether to pursue or not to pursue projects.



Is MARR constant from year to year?

Characteristics of the MARR

- 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

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

ROR ≥ MARR > 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 MARR = 10%. Project A, not funded due to lack of funds, is projected to have ROR_A = 13%. Project B has 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