Professional Engineering

Project Economics

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Lecture Outline

- **Introductory Overview**
  - Terminology
  - Where engineers encounter economics in their work
- **Fundamental Concepts**
  - Time value of money
    - Types of money
    - Present value of cash-flows
  - Engineering economics in the overall project management process

Why do Engineers Need to Learn about Economics ?

- **No longer possible simply to design and build things for the sake of designing and building**
  - Natural resources becoming more scarce and expensive
  - Negative side-effects of engineering innovations
  - Place project ideas within larger framework of the environment
- **Project must offer net benefit to people affected**
  - Inherent benefits
  - Negative side-effects
  - Cost of consuming natural resources
  - Unified framework
- **Unified framework is field of engineering economics**

The Two Basic Components of Engineering

- **Physical Environment**
- **Economic Environment**

‘Efficiency’ of Components of Engineering (1)

- **Examples where engineering efficiency crucial**
  - Choosing best design for high-efficiency electric furnace
  - Selecting most suitable robot for welding on auto assembly line
  - Making a recommendation whether aeroplanes for a particular service should be purchased or leased
  - Considering choice between reusable and disposable bottles for high-demand beverages

‘Efficiency’ of Components of Engineering (2)

- **Physical efficiency**
  - –system outputs divided by system inputs
- **Economic Efficiency**
  - –system cost divided by system worth
- **Economic Efficiency takes precedence over Physical Efficiency**

Risk and Uncertainty in Engineering

- **In virtually all situations there is doubt as to the ultimate values of quantities**
- **Risk and uncertainty in decision-making is caused by lack of precise knowledge**
- **Decisions under risk …**
  - problems modeled in terms of possible outcomes where occurrence probabilities can be estimated
- **Decisions under uncertainty …**
  - characterized by several unknown futures for which probabilities of occurrence cannot be estimated

Engineering Economic Studies

Four key steps …

- **Create**
  - research, exploration, investigation of opportunities
- **Define**
  - synthesize economic and physical requirements, and enumerate inputs/outputs
- **Convert**
  - alternatives converted to common measure
- **Decide**
  - decisions on system alternatives made on basis of differences
  - small number of real world systems there will be complete knowledge but most systems areas of uncertainty likely to remain
  - areas of uncertainty bridged by consideration non-quantitative data/information, such as common sense, judgment, etc

Fundamental Economic Concepts

- **Value**
  - Designates worth attached to an object or service
  - Measures/appraises utility in some medium of exchange
  - Not the same as cost or price
- **Cost (relates to money outflow)**
  - First (or Initial)
  - Operation and Maintenance
  - Fixed
  - Variable
  - Incremental (or Marginal)
  - Sunk
  - Life-cycle
- **Price (relates to money income)**

Lecture Midpoint

- **Introductory Overview**
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  - Where engineers encounter economics in their work
- **Fundamental Concepts**
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    - Types of money
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Time Value of Money (Background)

- Types of Money
  - Lump Sum
  - Uniform Series
- Equivalent Value
  - Depending on point in time
    - present, or
    - some past or future date
  - Two items of money at different points in time are equivalent if equal to each other as same money type at a specified date
- Analysis on complete project requires
  - Cash-flows for different money types at their applicable points in time be converted to one money type at single point in time
  - Then added together to obtain total equivalent value of project

Time Value of Money (Components)

- **Investment - or Capital**
  - Lump sums of money (current or future) which a company has available to use
- **Interest - or Return (noun)**
  - Uniform series of money (nearly always future) received from customers as payments - due use of the capital

Time Value of Money (Components)

- **Interest**
  - For simple interest the payment is calculated/due/made at the end of each time period in the uniform series

Suppose that $50,000 is borrowed at a simple interest rate of 8% pa

At the end of each year the interest owed and paid would be:

I = $50,000 x 0.08 = $4,000

If the loan is repaid after three years total interest charge would be:

I = $4,000 x 3 = $12,000

… and total repayment … $50,000 + $12,000 = $62,000

- Mathematically …

Repayment = Investment x (1 + Interest Rate x No of years)

Time Value of Money (Components)

- **Interest**
  - For compound interest payment is calculated at each time period in the uniform series but is due/made only once, at end of overall time period

    Suppose $50,000 is borrowed at a compound interest rate of 8% pa
    At the end of the first year the interest owed would be:
    I = $50,000 x 0.08 = $4,000
    At the end of the second year the interest owed would be:
    I = $50,000 x 0.08 + $4,000 x .08 = $4,320
    At the end of the third year the interest owed would be:
    I = $50,000 x 0.08 + $4,000 x .08 + $4,320 x .08 = $4,666
    If the loan is repaid after three years total interest charge would be:
    I = $4,000 + $4,320 + $4,666 = $12,986

    … and total repayment … $50,000 + $12,966 = $62,986

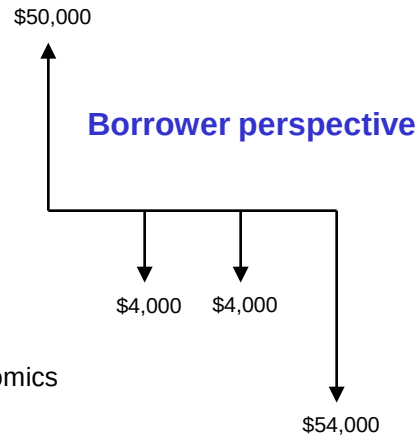
  - Mathematically …
    Repayment = Investment x $(1+ \text{Interest Rate})^{\text{No of years}}$

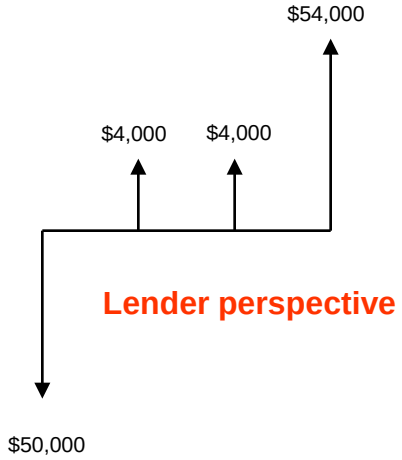
Time Value of Money (Components)

- Investment - or Capital
- Interest - or Return
- Interest Rate - or Rate of Return
  - needs to take account of time value of money of alternative opportunities, particularly the relative risk of the opportunities
  - always in the compound interest form (ie: interest accumulates on interest; $P=[1+i]^n$)
- Time Period or Project Lifetime
  - reflects how long the tangible assets of the project (buildings, equipment, etc) will last
  - often divided into periods that are consistent with the timing of the cash-flows

Cash Flow Diagrams

- Diagram Convention
  - Horizontal Axis is marked off in equal increments, one per period
  - Receipts are represented by upward pointing arrows
  - Payments are represented by downward pointing arrows
  - All cash flows are assumed to take place at the end of the year in which they occur (shorter periods are used in appropriate circumstances)
  - Arrow lengths are approximately proportional to magnitude of cash flow
  - Expenses incurred before time = 0 are sunk costs (and therefore irrelevant)
  - Since there are two parties to every transaction, it is important to note that cash flow directions in cash flow diagrams depend upon point of view taken
- Example of Typical Cash Flow Diagrams





Time Value of Money (Conversion)

- **Calculate total present value of project by …**
  - Listing all the cash flow items (payments: –ve and receipts: +ve) against the dates at which they will occur
  - Discounting current and future cash flow items back to their equivalent value at the current date using the interest rate, and
  - Adding all the discounted values together

Time Value of Money (Conversion)

- Example …

  See how much better off you are investing $50,000 over 3 yrs at 8% pa simple interest rather than investing at 5% pa

A	B	C	D	E
Time Period	Actual Cash Flow	Expected Return Rate	Cumulative Multiplier $(1 + I)^n$	Discounted Cash Flow Column B ÷ Column D
End year "n" ...	$	I		$
Present (year 0)	-50,000		1.000	-50,000
1	+4000	5.0%	1.050	+3,810
2	+4,000	5.0%	1.103	+3,628
3	+54,000	5.0%	1.158	+46,647
Total	+12,000			+4,085

Project Economics (Summary)

- Purpose
  - establish economic analysis required to support decisions on project viability
  - provide project management team with an economic model for project decisions involving schedule, capital and operating cost changes
  - develop economic model details so that project design contractors can evaluate alternatives during design process

Project Economics (Summary)

- Key Elements
  - assumptions used for initial project economics evaluations (and for updates)
  - capital and operating expenditure estimates for each evaluation update
  - cash flow analyses testing project basis (and any alternatives reviewed), for changes in present value, discounted cash flow return, earnings profiles
  - additional economic indicators deemed to be useful for project evaluation, such as payout, maximum cash impairment, book returns, return on investment
  - identification of financial vulnerabilities through economic sensitivities on raw materials and utilities availability and price, capital expenditure, schedule, overruns/underruns, operating factors, foreign exchange, taxation issues