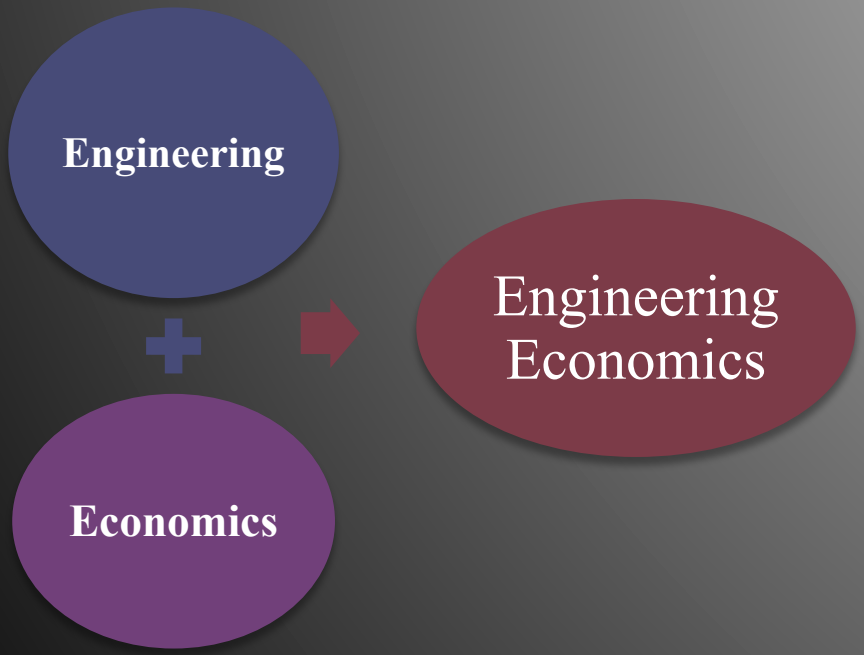
American University of Armenia
IE 340 – Engineering Economics
Spring, 2017

Introduction to Engineering Economics
Lecture 1, Chapter 1

ENGINEERING ECONOMICS



What is Economics ?

A social science of how limited resources are used to satisfy unlimited human wants

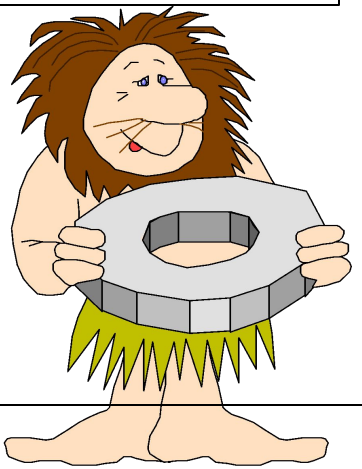
What is Engineering ?

Engineering is the application of scientific, economic, social, and practical knowledge, in order to design, build, and maintain structures, machines, devices, systems, and materials

Resources

LAND OR NATURAL RESOURCES

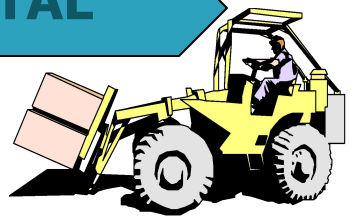
All gifts of nature, such as: water, air, minerals, sunshine, plant and tree growth, as well as the land itself which is applied to the production process.



LABOR

The efforts, skills, and knowledge of people which are applied to the production process.

CAPITAL



Real Capital (Physical Capital)

Tools, buildings, machinery -- things which have been produced which are used in further production

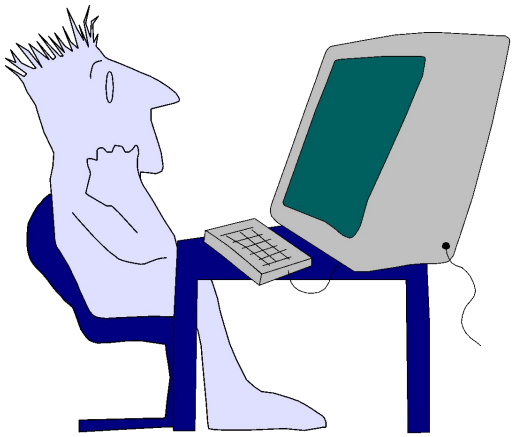
Financial Capital

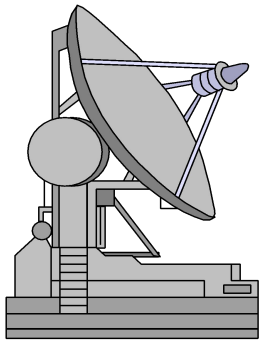
Assets and money which are used in the production process

Human Capital

Education and training applied to labor in the production process.

Engineering Economics, previously known as engineering economy, is a subset of economics for application to engineering projects





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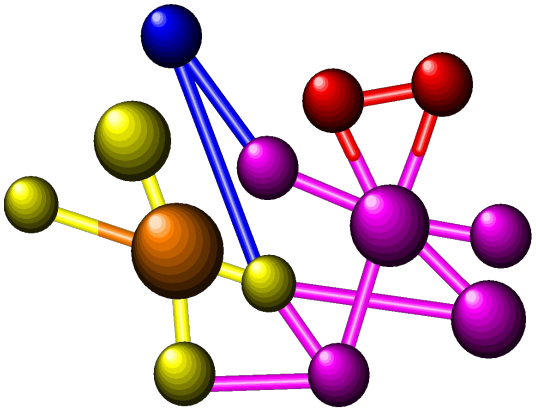

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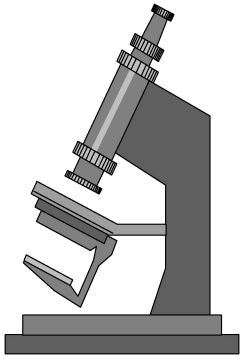

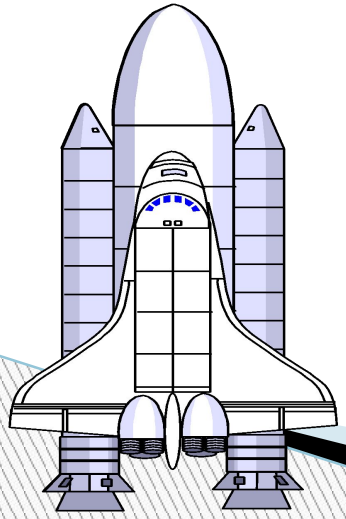

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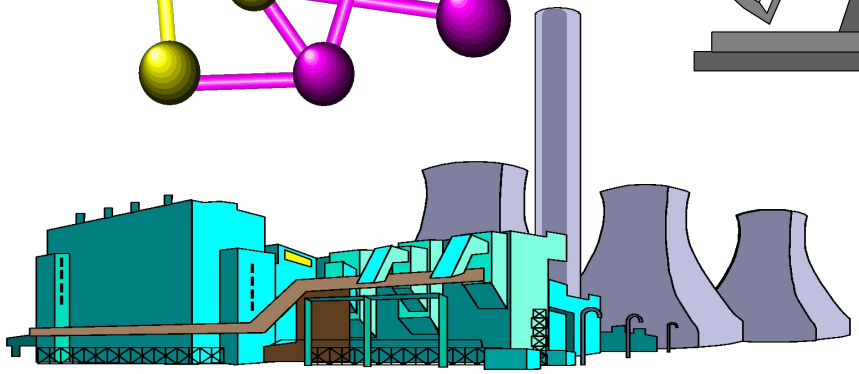


WHY DO ENGINEERS NEED TO LEARN ABOUT ECONOMICS?

- Ages ago, the most significant barriers to engineers were technological. The things that engineers wanted to do, they simply did not yet know how to do, or hadn't yet developed the tools to do. There are certainly many more challenges like this which face present-day engineers

  - *Natural resources (from which we must build things) are becoming more scarce and more expensive*
  - *Negative side-effects of engineering innovations (such as air pollution from automobiles)*

- Engineers must decide if the benefits of a project exceed its costs, and must make this comparison in a unified framework. The framework within which to make this comparison is the field of engineering economics, which strives to answer exactly these questions, and perhaps more.

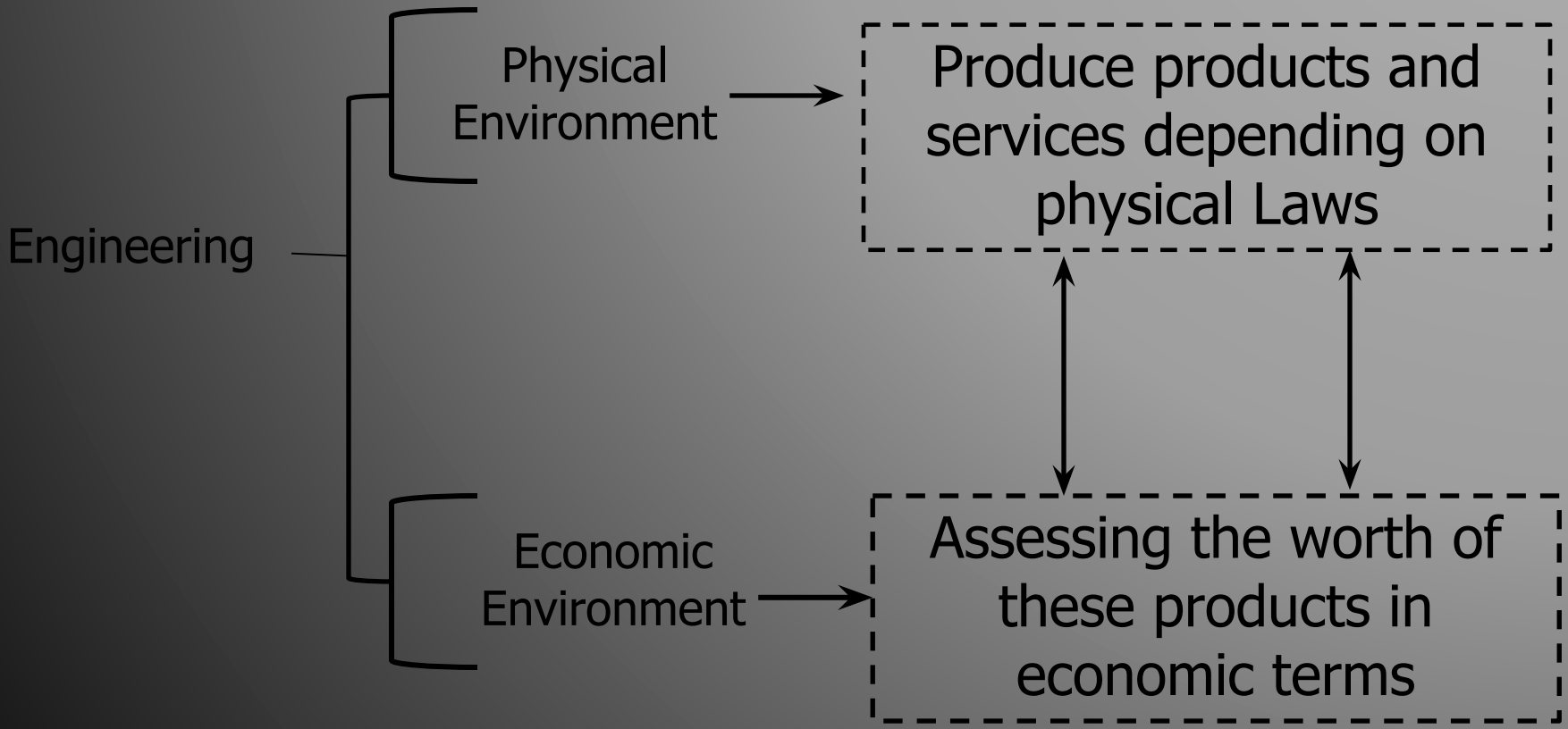
What is Engineering Economics?

- Engineering Economics is about making decisions

- Engineering Economics assesses the appropriateness of a given project, estimates its value, and justifies it from an engineering standpoint

- Engineering Economics is the application of economic techniques to the evaluation of design and engineering alternatives

How Engineering is composed of physical and economic components



Physical Efficiency=System Output/System Input

Economic Efficiency=System Worth/System Cost

Engineering Economics: Origins

- The development of EI methodology is relatively recent

- A pioneer in the field was **Arthur Wellington**, a civil engineer, who at the end of 19th century addressed the role of economic analysis in engineering projects (his area of interest was railroad building in the USA)

- This early work was followed by other contributions in which the emphasis was put on techniques that depended on financial mathematics. In 1930, **Eugene Grant** published a textbook which was a milestone in the development of engineering economy as we know it today (economic point of view of engineering)

- In 1942 **Woods and DeGarmo** wrote a book, later titled Engineering Economy

Course Topics: IE 340

- Cost Concepts
- Time Value of Money
- Cash-Flow Concepts
- Comparing Alternatives
- Evaluating Projects
- Benefit-Cost Analysis
- Depreciation and Income Taxes
- Inflation and Price Changes
- Dealing with Uncertainty

Principles of Engineering Economy

1. Develop the Alternatives
   - **Creativity and innovation are essential to the process**
   - **The alternatives need to be identified and then defined for subsequent analysis**
   - **Consider the status quo, but do not focus on it(i.e., doing nothing)**
2. Focus on the Differences
   - **Only the differences among alternatives are relevant to comparison and decision**
3. Use a Consistent Viewpoint (perspective)
4. Use a Common Unit of Measure
   - **Use it for enumerating as many possible outcomes as possible, since it simplifies the analysis of alternatives**
5. Consider All Relevant Criteria
   - **Consider both those that can be measured in monetary terms and "non-monetary" criteria**
6. Make Uncertainty Explicit
7. Revisit Your Decisions: compare initial projected outcomes with actual results achieved

Engineering economic analysis procedure

1. Problem recognition, definition, and evaluation
2. Development of the feasible alternatives
   - **Searching for potential alternatives**
   - **Screening them to select a smaller group of feasible alternatives**
3. Development of the cash flows for each alternative (or of prospective outcomes)
4. Selection of a criterion (or criteria)
5. Analysis and comparison of the alternatives
6. Selection of the preferred alternative
7. Performance monitoring and post-evaluation results: helps to do better analysis and improves the operations in organization

Simpler procedure for formulating engineering economic decisions

Four essential steps in formulaing engineering economic decisions are:

- Creative step: find an opening through a barrier of economic and physical limitations
- Definition step: define all factors associated with each alternative originated in creative step
- Conversion step:
- Decision step

Creative step

- The *creative step* consists of finding an opening through a barrier of economic and physical limitations (ex. aluminum discovery or mining)
- We explore, investigate and research aiming at finding new opportunitites
- Many successful ideas are simply new combinations of known facts

Definition step

- In the *definition step*, we define the alternatives originated or selected for comparison
- Choice is always between alternatives, but we also need to choose which alternatives to consider
- Is it better to spend more time defining more possible alternatives or to take the decision fast considering only few?

Conversion step

- In order to be able to compare the alternatives we need to *convert* them to a common measure

- We express each alternative in terms of cash flows at specified date in the future, and state also those considerations that cannot be reduced to money terms

Decision step

- Having done all the abovementioned, we need to decide what to choose
- Consider multiple criteria
- Cancel out identical factors and stress the attention on differences
- When facts are missing use judgement
- Making the decision

What Kinds of Questions Can Engineering Economics Answer? An example

- Engineering economics is needed for many kinds of decision making
  - Example: Buying a car
    - Alternatives:
      - $18,000 now, or
      - $600 per month for 3 years
    - Which is better?

Engineering Economics Helps Make **Cash Flow Comparisons!**

- Example: Buying a car
  - Alternatives:
    - $18,000 now, or
    - $600 per month for 3 years
      (= $21,600 total)
  - Which is better?
    - It depends!
      - Issue: how much is *money now* worth compared to *money in the future*?
    - Leads to idea of *time value of money!*

Key Concept: *Time Value of Money*

- Would you rather have:
  - $100 today, or
  - $100 a year from now?

Time Value of Money

- Would you rather have:
  - $100 today, or
  - $100 a year from now?
- Basic assumption:
  - Given a fixed amount of money, and
  - A choice of having it now or in the future,
- Most people would prefer to have it sooner rather than later

Time Value of Money

Most people would prefer to have it sooner. Why???

- Reasons:
  - Security ?
  - Interests ?
  - Inflation?
  - Currency strength ?
  - Uncertainty ?

Time Value of Money

- One consequence of the time value of money:
  - Suppose you are willing to exchange a certain amount now for some other amount later
  - Then the later amount has to be ___larger or smaller___?

Time Value of Money

- The time value of money centers around the idea of an *interest rate* (if projecting into the future):
  - Or, equivalently, a *discount rate* (if rolling back to the present)

Time value of money deals with changes in the value of money over some period of time (due to investment opportunities, uncertainty, etc.)

This is a key concept in engineering economics!

What Does This Mean for Us?

- In this course, we will learn methods to:
  - *Compare different cash flows over time*
- Using the *interest rate* or *discount rate*:
  - How much more a dollar today is worth compared to a dollar in one year
- For example, if the interest rate is 5%:
  - $1 today is worth as much as $1.05 next year

Interest rates

- Interest factor: The ratio between an amount one period in the future and an equivalent amount now.
  - Example: If you are indifferent between $5 now and $6 one period in the future, the interest factor is 6/5 = 1.20 (per period)
- *Interest rate* = interest factor – 1
  - In above example, it's 0.20 = 20%

Nominal and Real interest rates

Fisher Equation

$$1 + i_t = (1 + r_{t+1})(1 + \pi_{t+1})$$
$$= 1 + r_{t+1} + \pi_{t+1} + r_{t+1}\pi_{t+1}$$

$$i_t = r_{t+1} + \pi_{t+1} + r_{t+1}\pi_{t+1}$$
$$\approx r_{t+1} + \pi_{t+1}$$

i_t - nominal interest rate
r_{t+1} - real interest rate expected inflation
π_{t+1} - expected inflation

An Example

- A bank offers to pay $1,027.50 one year from now if you buy (now) a certificate of deposit with $1,000. What is the interest rate?
- Interest factor is 1,027.50/1,000 = 1.0275
- Interest rate is 1.0275 - 1 = 2.75%

What Kinds of Questions Can Engineering Economics Answer?

- **It will help you make good decisions:**
  - **In your professional life**
    - **(Regardless of whether you go into the private or public sector)**
  - ***And in your personal life!***
- **Knowledge of engineering economics will have a significant impact on you personally!**

What Kinds of Questions Can Engineering Economics Answer?

ENGINEERING ECONOMICS INVOLVES:

FORMULATING, ESTIMATING, AND EVALUATING ECONOMIC OUTCOMES

WHEN CHOICES OR ALTERNATIVES ARE AVAILABLE

How Does It Do This?

BY USING SPECIFIC

MATHEMATICAL RELATIONSHIPS

TO COMPARE THE CASH FLOWS OF THE DIFFERENT ALTERNATIVES

(typically using spreadsheets)

Where Do I Get the Data?

- **Engineering economics is based mainly on estimates of *future* costs and benefits:**
  - **So it has to deal with risk and uncertainty**
- **The costs, benefits, and other parameters are typically unknown, and can vary over time:**
  - **The values of these parameters will dictate a particular numerical outcome**
  - **And therefore a particular decision!**
- ***Sensitivity analysis* can be used to explore how the decision changes as our estimates change**

SOME BASIC ECONOMIC CONCEPTS

Value and Utility

- **Value** is the worth that a person attaches to a good or service
- Value is inherent in a regard a person has for it, not in the item itself
- Value is not the cost of the item

- **Utility** is a power to satisfy human wants and is determined subjectively
- Utility is the satisfaction that a person derives from an item

Exchange

- Without the subjectivity of the concepts “value” and “utility” there would hardly be any room for exchange between people. Why?
- Through exchange we can increase the total utility of the goods and services. How?
- Exchange is possible when it is mutually benefitial

What If I Don't Like the Answers?

- **Remember:**
  - **"Tools" don't make decisions**
  - **People make decisions, based on *values***
- **Engineering economics is just a set of tools:**
  - **It can help in decision making**
  - **But *it won't make the decision for you***
- **Which alternative is "best" is up to you!**

Application of 2E analysis procedure Example

- Your friend bought a small apartment building for $100,000. He spent $10,000 of his own money for the building and obtained a mortgage from a local bank for the remaining $90,000. The annual mortgage payment is $10,500.
- Your friend also expects that annual maintenance on the building and grounds will be $15,000.
- There are four apartments (two bedrooms each) in the building that can each be rented for $360 per month.
- Refer to the seven-step procedure and answer to the following questions:

Application of 2E analysis procedure Example

- Does your friend have a problem? If so, what is it?
- What are his alternatives? (Identify at least three).
- Estimate the economic consequences and other required data for the alternatives.
- Select a criterion for discriminating among alternatives, and use it to advise your friend on which course of action to pursue.
- Attempt to analyze and compare the alternatives in view of at least one criterion in addition to cost.
- What should your friend do based on the information you and he have generated?

Application of 2E analysis procedure Example

- Your friend spends each year $10,500 + $15,000 = $25,500, but receives 4 X $360 X 12 = $ 17,280, i.e.
- He is losing $8,220 each year – this is the problem!
- Options
  - Raise the rent (Will the market bear an increase?)
  - Lower maintenance expenses (but not so far as to cause safety problems)
  - Sell the apartment building (What about a loss?)
  - Abandon the building (bad for your friends reputation)
- Option 1
  - Raise the total rent by $360 X 4 + $ R, to cover monthly expenses $ 2.125 and the interest that could be earned on $ 10,000.
  - This would imply the minimum increase of the rent per apartment per month by ($2,125 - $1,440)/4 = $171.25, i.e. more that by 50%

Application of 2E analysis procedure Example

- Option 2
  - Lower monthly expenses to $2,125-$ΔC, so that this expenses and the interest that could be earned on $ 10,000 are covered by the revenue of $1,440 per month.
  - Also, suppose he could earn 0.25 % interest on $ 10,000 (i.e. $25 per month)
  - C (maintenance expenses)+25 + 10500/12 = 1440
  - Monthly expenses should be reduced to (C= $1,440 - $25 - $10,500/12) = $540, i.e. more than 50% decrease in maintenance expenses. Monthly expenses will be reduced to $2,125-$540 = $1585
- Option 3
  - Try to sell the building for $ X, which recovers the original $10,000 and (ideally) recovers the $8,220/12 = $685 per month loss. It would also be perfect to recover the interest that could be earned on $10,000.
- Option 4
  - Walk away from the venture. The bank would likely assume possession and may try to collect fees from your friend.
  - This option would be very bad for his credit rating.

Application of 2E analysis procedure Example

- Criteria
  - One criterion could be to minimize the expected loss of money. In this case you might advise to pursue option 1 to 3.
  - Another, additional criterion could be “credit-worthiness”. Then the option 4 is ruled out. Option 3 could also harm friend’s credit rating. So options 1 and 2 would remain as realistic and acceptable
- Decision or advise
  - Do a market analysis to see if the rent could be raised – option 1.
  - Maybe a fresh paint and carpets would make apartments more appealing.
  - If so, the rent can probably be raised while keeping 100% occupancy of the four apartments.