- **Course Title:** Engineering Cost Analysis & Economy (ENGR 222)
- **Session:** Fall 2024
- **Instructor:** Sudipta Chowdhury (chowdhurys@marshall.edu)
- **Class Time: TR 9.30 AM-10.45 AM**
- **Office hours: TR 11.00 AM-12.30 PM**

Foundation of Engineering Economy

What is Engineering Economy?

Engineering economy involves

- formulating,
- estimating, and
- evaluating the expected economic outcomes of alternatives designed to accomplish a defined purpose

Estimates of economic outcomes can be deterministic or stochastic in nature

Time Value of Money (TVM)

- TVM explains the change in the amount of money over time for funds owed by or owned by a corporation or individual
- More generally, the TVM is the relationship between the value of a payment at one point in time and its value at another point in time

The TVM is the most important concept in engineering economy

Interest Rate (IR)

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 (i) – Interest paid over a time period expressed as a percentage of principal

$$i(\%) = \frac{Interest\ accrued\ per\ unit\ time}{Principal} * 100\%$$

Interest rates can be applied over different periods, such as monthly, quarterly, or bi-annually. However, in most cases, interest rates are annualized.

Interest Rate (IR) vs Rate of Return (RoR)

- Rate of return (RoR) refers to a value that indicates how much return is generated based on the initial investment made.

$$RoR(\%) = \frac{Interest\ accrued\ per\ unit\ time}{Initial\ investment\ (capital)} * 100\%$$

- For an investment of $100 US Dollars (USD), and a return of $120 USD, the capital is first subtracted from the return to determine growth of $20 USD. This value is then divided by the capital, for a return rate of 0.20 or 20%, which indicates the RoR on that investment for one year.

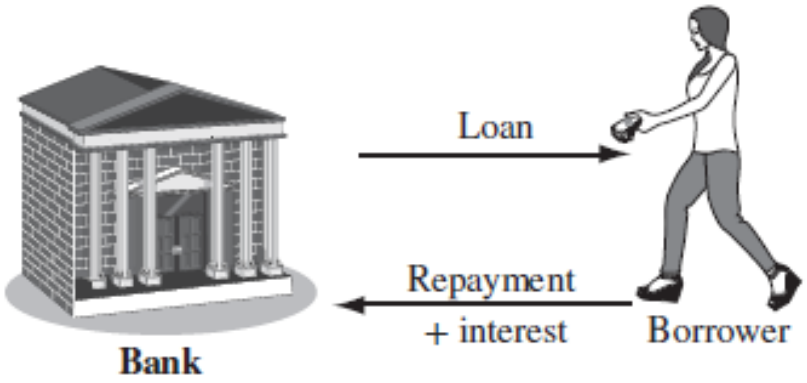
Interest Rate (IR) vs Rate of Return (RoR)

- An interest rate (IR) is indicative of the amount of interest that has to be paid on a loan. It has nothing to do with any gain or loss made on an investment.
- Someone taking out a loan of $100 USD, for example, and paying an additional $25 USD over the year in which it is paid back, would divide that 25 by 100. This would give an interest rate of 0.25 or 25%.

RoR is based on investments made while IR is paid on a loan

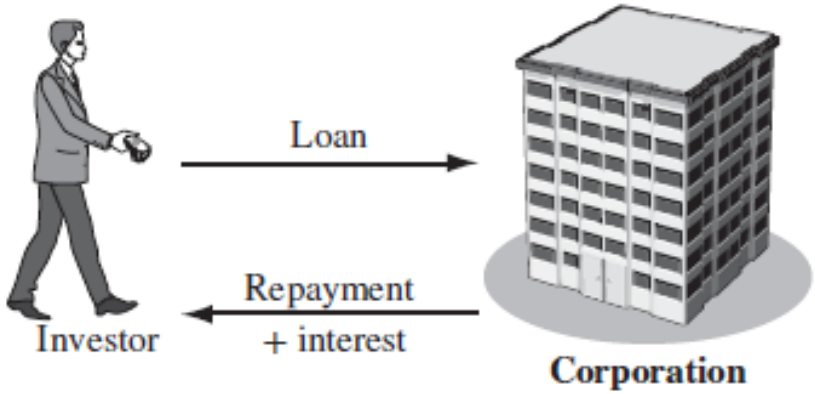
Interest Rate (IR) vs Rate of Return (RoR)

Interest paid



IR

Interest earned



RoR

Borrower's perspective – IR paid

Investor's perspective – RoR earned

Lets practice!

Example 1. An employee at company X borrows 10,000 USD and must repay a total of 10,700 USD exactly 1 year later. Determine the interest amount and interest rate paid.

Lets practice!

Example 2. Stereophonics, Inc., plans to borrow $20,000 from a bank for 1 year at 9% interest for new recording equipment. (a) Compute the interest and the total amount due after 1 year. (b) Construct a column graph that shows the original loan amount and total amount due after 1 year used to compute the loan interest rate of 9% per year.

Cash Flows

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:

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

Cash Flows

Cash Inflow	Cash Outflow
Cash inflow is the net cash amount coming into your business that you have available for a period of time.	Cash outflow is the net cash amount that is going out of your business because you are paying someone else or another entity.
Examples of cash inflow include customer payments, return on investments, and interest you receive on loans you have given to another entity.	Examples of cash outflow include money spent on fixed assets, salaries, payment made to suppliers, loans taken and interest paid on them, wages, transport costs, and insurance dividends that require you to pay.

Cash Flows

- Company A has earned $350,000 from operating activities, $50,000 from financial activities, and $5,000 from investment activities
- The net cash flow would be as follows:

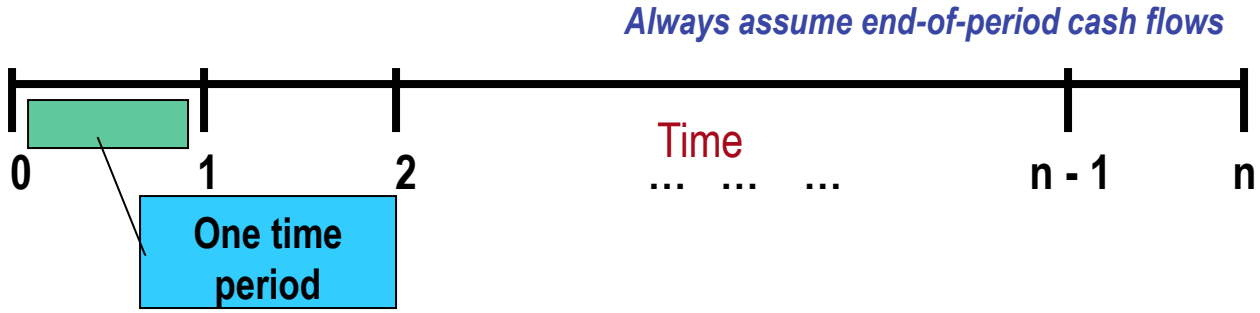
$$\text{Net cash flow} = \$350{,}000 + \$50{,}000 + \$5{,}000$$

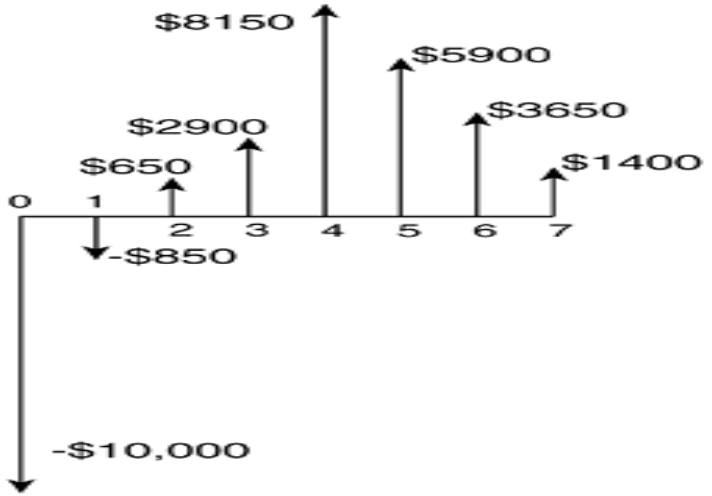
$$\text{Net cash flow} = \$405{,}000$$

- If A lost money due to an investment, then the investment amount will be written as a negative
- For instance, if in the above example, if A lost $5,000 then the net cash flow would be $405,000 - $5000 which would equate to a net cash flow value of $400,000

Cash Flows

What a typical cash flow diagram might look like





Lets practice!

Example 3: An electrical engineer wants to deposit an amount P now (assume $ 10,000) such that she can withdraw an equal annual amount of A1 = $2000 per year for the first 5 years, starting 1 year after the deposit, and a different annual withdrawal of A2 = $3000 per year for the following 3 years. How would the cash flow diagram appear if i = 8.5% per year?

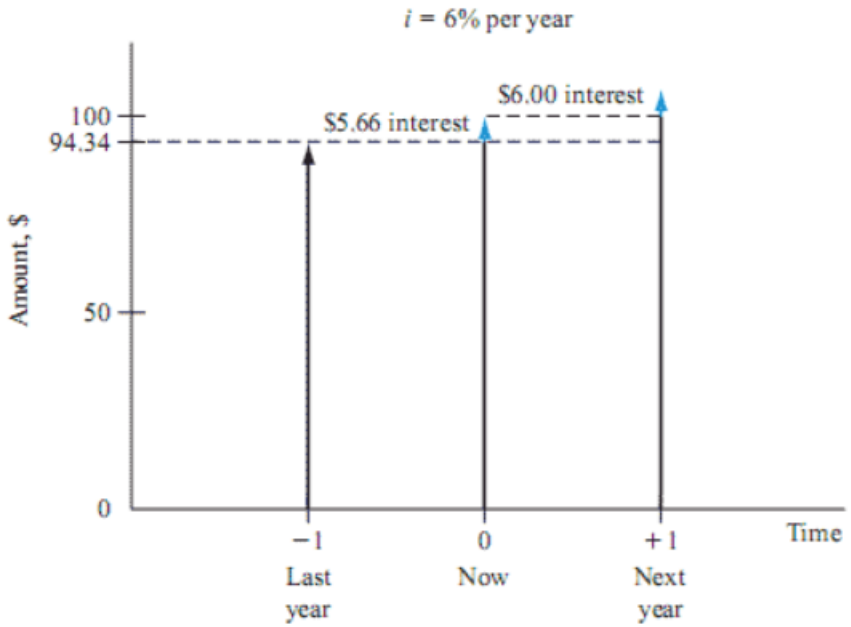
Economic Equivalence

- Economic equivalence is a concept that refers to the combination of interest rate and time value of money to determine the different amounts of money at different points in time that are equal in economic value.
- If the interest rate is 6% per year, $100 today (present time) is equivalent to $106 one year from today.
  Amount accrued = 100 + 100(0.06) = 100(1 + 0.06) = $106
- If someone offered you a gift of $100 today or $106 one year from today, it would make no difference which offer you accepted from an economic perspective. However, the two sums of money are equivalent to each other only when the interest rate is 6% per year.

Economic Equivalence

- A total of $100 now is equivalent to $100/1.06 = $94.34 one year ago at an interest rate of 6% per year.
  - We can state the following: $94.34 last year, $100 now, and $106 one year from now are equivalent at an interest rate of 6% per year.

Equivalence of money at 6% per year interest



Simple Interest

- **Simple interest** is calculated using only the principal amount of the loan.
- To calculate simple interest, use the following formula:

$$Simple\ Interest\ =\ P\ x\ i\ x\ n$$

- In this case, the variable P is your principal amount, i is your annual interest rate, and n is the term of the loan, expressed in years.

Simple Interest

- Example. You are borrowing $10,000 from Bank A to finance an automobile purchase. You were quoted a simple interest rate of 5 percent, with a loan term of 5 years. The amount of simple interest you will pay, in addition to the principal of $10,000, will be $2,500:

$$\$10{,}000 \; x \; .05 \; x \; 5 \; = \; \$2{,}500$$

- Example. In this next example, let us say you take out a personal loan toward your first home purchase from your family. They graciously lend you $40,000 at a 2 percent interest rate. They say you can pay it back slowly over the next 10 years. You will end up paying $8,000 in interest in this deal.

$$\$40{,}000 \; x \; .02 \; x \; 10 \; = \; \$8{,}000$$

Compound Interest

- **Compound interest** is calculated using the principal amount of the loan, plus the interest that has accumulated over previous periods
- The formula for compound interest looks like this:

$$Compound\ Interest\ = P[(1+i)^n - 1]$$

Compound Interest

- Let's use the same example used for simple interest calculation (slide 22). This time, you are taking out a $10,000 loan from Bank A, but the 5% interest rate is compounded. The loan term is still 5 years. In this case, you'll end up paying back $2,762.82 in compounded interest.

$$\$10{,}000[(1 + .05)\text{^}5 - 1] = \$10{,}000\ (0.27628)$$

- In the prior example, the simple interest was $2,500. The compounded rate increases your interest repayment by $2762.82

Lets practice!

Example 4: Assume an engineering company borrows $100,000 at 10% per year compound interest and will pay the principal and all the interest after 3 years. Compute the annual interest and total amount due after 3 years.

Minimum Attractive/Acceptable Rate of Return (MARR)

- MARR is the lowest internal rate of return the organization would consider to be a good investment
- An investment is justified economically if it is expected to return at least the MARR
- MARR usually considers the risk inherent to a project (the higher the risk means the higher the MARR)

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

QUESTIONS?