


Engineering Economy





Engineering economy deals with the evaluation of systems, products, and services in relationship to their costs.

Engineers should deal with two aspects of a System

- Physical feasibility
- Economic feasibility

- Economic efficiency = $\frac{\text{worth}}{\text{Cost}}$

$$= \frac{\text{output x value of each unit}}{\text{input x value of each unit}}$$

- Economic efficiency should be greater than one to justify a system. Therefore, the unit value of output should be greater than unit value of input.

Engineering Economic Concepts

- Value is the worth that a person attaches to a product or service. It is a relative concept.
- Utility is the power to satisfy needs
- Goods are objects with utility
- There are two types of goods:
 - consumer goods
 - producer goods

Exchange

- Is the process of exchange of utilities by two or more people.
- Exchange increases the overall utilities of goods and services.
- Persons sell an object of less utility to them and acquire an object of higher utility.

Cost Analysis

From an accounting point of view, costs are classified as

- Direct costs
 - direct labor cost
 - direct material cost
- Indirect costs
 - overhead costs

- Direct cost for a product/job can be easily calculated by considering items such as the cost of labor and materials used for that job.
- The cost of the steel bar and the wage of the machinist producing a shaft are direct costs of that shaft.

- Indirect cost cannot be conveniently assigned to a particular product, like managerial costs, administration costs, etc.
- Indirect costs include:
 - Utility
 - Administrative
 - Maintenance
 - Depreciation
 - Insurance
 - inventory, etc.

Opportunity Cost

- Is the cost incurred because using a resource eliminates the chance of using the resource to monetary advantage in some other alternative.

Costs of Projects

Costs can be classified as:

- First cost
- Operation and maintenance cost
- Life-cycle cost

- First cost is usually the cost of getting an activity started and occurs once only.

Example:

- For drilling, machine purchase, installation, and training costs are first cost.

- Operation and maintenance cost – is the cost that occurs during the operational periods and includes labor cost, repair cost, utility cost, insurance cost, etc.

Life-cycle Cost

- Each project or product has a life-cycle, which includes research, development, planning, design, testing, production, deployment, operation, maintenance, and phase out.
- All costs occurring during the life-cycle are considered life-cycle costs.

Costs also can be classified as fixed cost and variable costs. Fixed costs remain constant throughout the range of operational activities.

- Fixed costs include:
 - Land
 - Building
 - Lightening

- Variable costs are a function of activities level and include:
 - Labor
 - Material
 - Electricity – energy

Time Value of Money

- Since a dollar invested today is expected to be worth more than a dollar in the future, the money has earning power.
- Due to this fact the worth of a dollar at a future time is less than a dollar at the present time.
- That means the same dollar is worth different values at different time periods due to interest rate and inflation.

Sunk Cost

- Is a cost that has occurred in the past and should not be considered in the decision making for future actions.

Interest and Interest Rate

- Interest is the monetary cost of money, or the amount charged for borrowing money.
- The annual percentage of the capital charged for borrowing.
- Interest is charged to cover-risk of loss of capital, administrative expenses, and profit.
- A borrower is ready to pay the interest rate that he believes he will recover by investing the money.

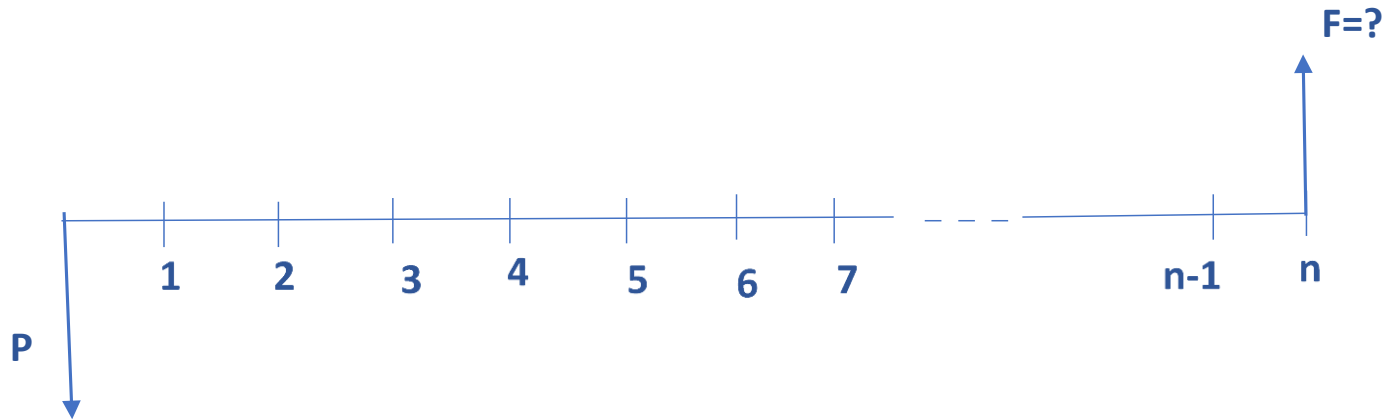
Interest rate formulas

Discrete payment / Discrete compounding

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	Factor	Find	Given	Formula
Single Payment	Compound Amount	F	P	$F = P \left(\frac{F}{P}, i, n \right)$ $F = P(1 + i)^n$

Cash flow:



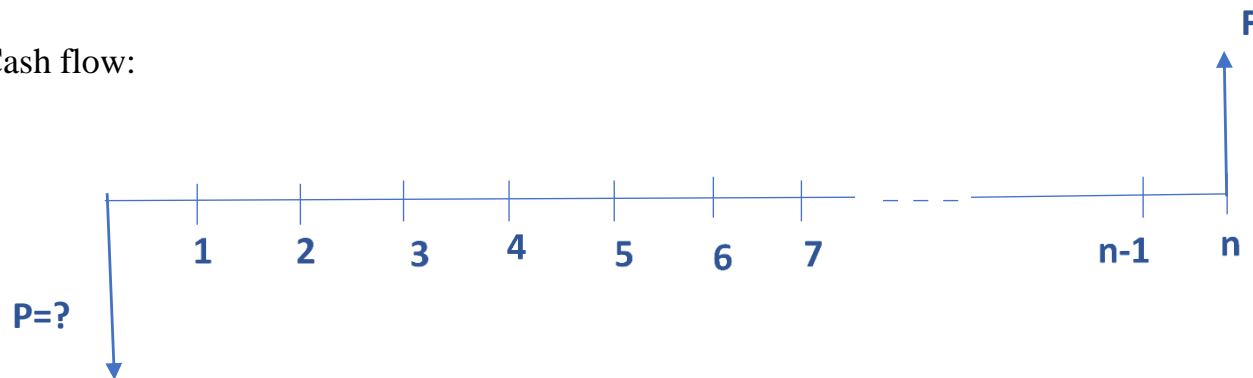
Example 1:

Suppose \$1,500 is deposited into an IRA with an interest rate of 4%, compounded annually. how much money will there be after 30 years?

$$F = 1,500(F/P, 4\%, 30) = 1,500 (3.2434) = 4,865.1$$

	Factor	Find	Given	Formula
Single Payment	Present Worth	P	F	$P = F(1 + i)^{-n}$ $P = F \left(\frac{P}{F}, i, n \right)$

Cash flow:



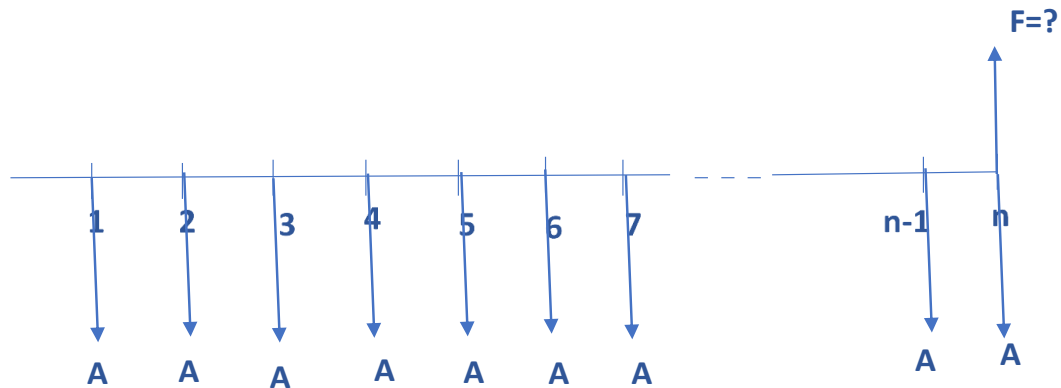
Example 2:

For an interest rate of 10% compounded annually find how much can be loaned now if \$2,000 will be repaid at the end of 3 years?

$$P = 2,000(P/F, 10\%, 3) = 2,000(0.7513) = 1,502.6$$

	Factor	Find	Given	Formula
Equal Payment Series	Compound Amount	F	A	$F = A \left[\frac{(1+i)^n - 1}{i} \right]$ $F = A \left(\frac{F}{A}, i, n \right)$

Cash flow:



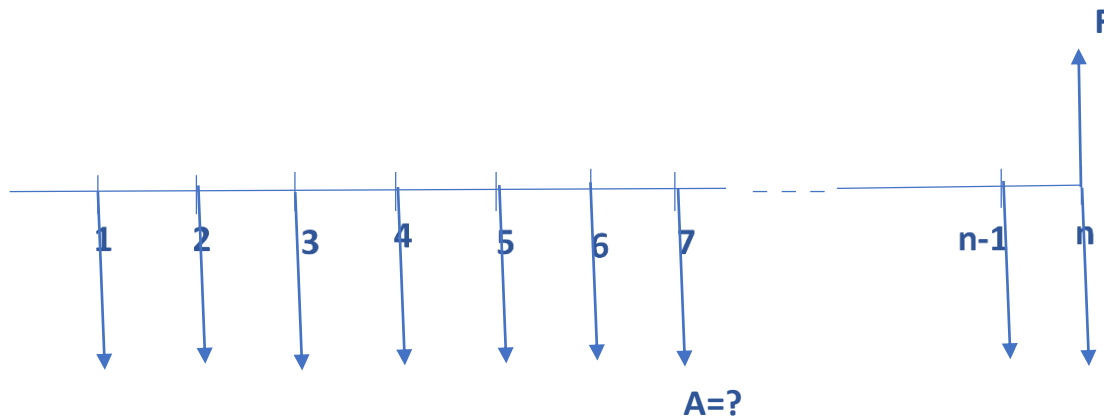
Example 3:

You are a financial planner. One of your clients is 40 years old and wants to begin saving for retirement. You advise her to put \$5,000 a year into the stock market. You estimate that the market's effective return will be, on average, 12 percent a year. Assume the investment will be made at the end of the year. What is the value of her savings after 20 years.

$$F = 5,000(F/A, 12\%, 20) = 5,000 (72.0524) = \$ 360,262$$

	Factor	Find	Given	Formula
Equal Payment Series	Sinking Fund	A	F	$A = F \left[\frac{i}{(1+i)^n - 1} \right]$ $A = F \left(\frac{A}{F}, i, n \right)$

Cash flow:

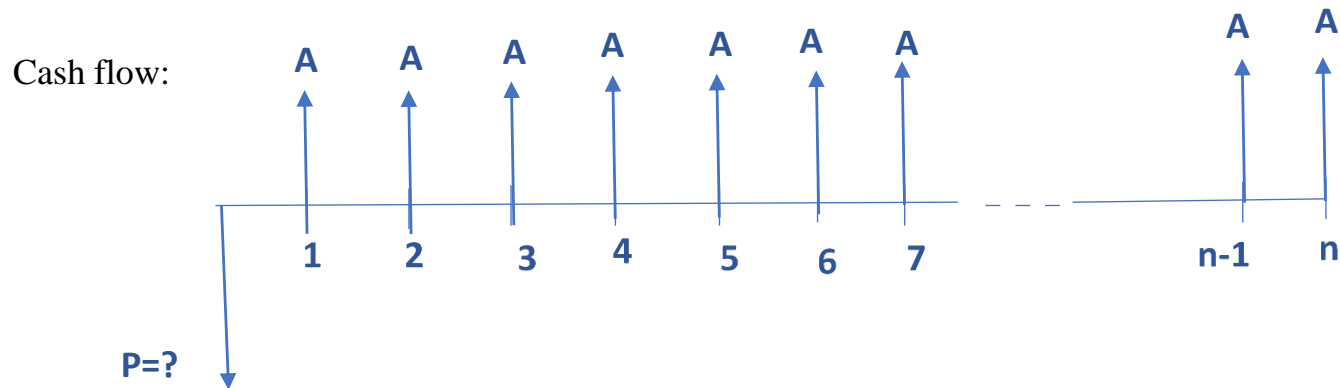


Example 4:

What equal series of payments must be put into a sinking fund to accumulate \$65,000 in 15 years at 15% compounded annually when payments are annual?

$$A = 65,000(A/F, 15\%, 15) = 65,000(0.0210) = \$1,365$$

	Factor	Find	Given	Formula
Equal Payment Series	Present Worth	P	A	$P = A \left[\frac{(1+i)^n - 1}{i(1+i)^n} \right]$ $P = A \left(\frac{P}{A}, i, n \right)$



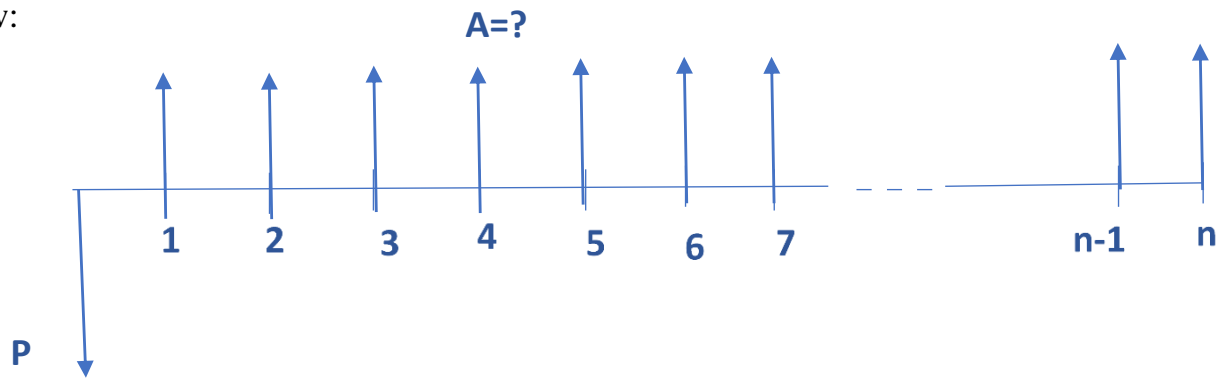
Example 5:

A business generates annual incomes of \$20,000 for the next 10 years with a salvage value of \$200,000. At $i=10\%$ per year how much cash one should pay for it?

$$P_w = 20,000(P/A, 10\%, 10) + 200,000 (P/F, 10\%, 10) = \$200,000$$

	Factor	Find	Given	Formula
Equal Payment Series	Capital Recovery	A	P	$A = P \left[\frac{i(1+i)^n}{(1+i)^n - 1} \right]$ $A = P \left(\frac{A}{P}, i, n \right)$

Cash flow:



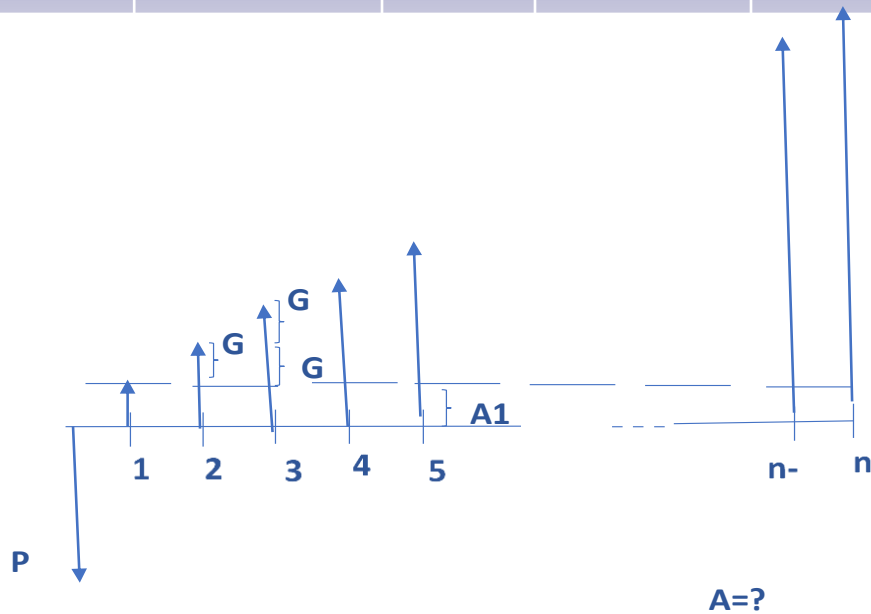
Example 6:

A Bank offers you a \$50,000, five-year term loan at 5 percent annual interest. What will your annual loan payment be?

$$A = 50,000(A/P, 5\%, 5) = 50,000 (0.2310) = \$11,550$$

	Factor	Find	Given	Formula
Gradient Series	Uniform Gradient Series	A	G	$A = G \left[\frac{1}{i} - \frac{n}{(1+i)^n - 1} \right]$ $A = G \left(\frac{A}{G}, i, n \right)$

Cash flow:



Example 7:

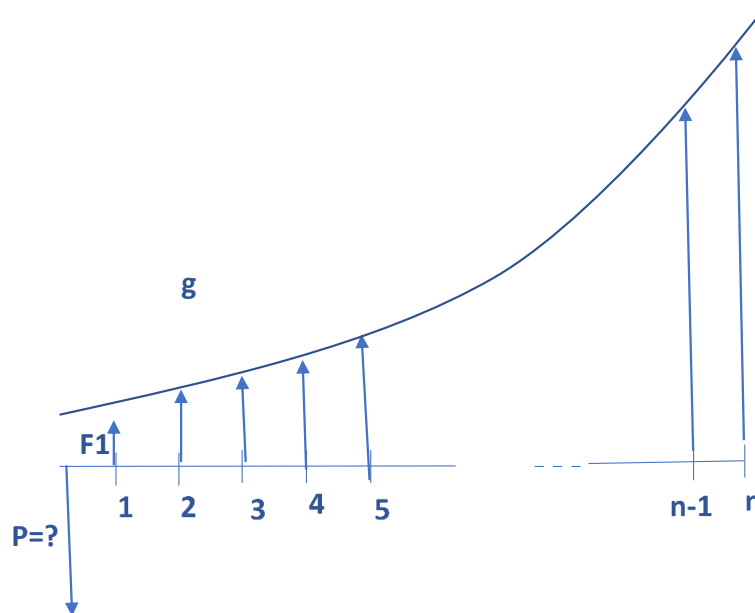
A manufacturer is going to modify a material handling system in a small job shop. This modification will result in first year saving of \$2,000, a second year saving of \$4000, third year savings of \$6,000 and so on. The system last for 20 years at 20% return on investment. The system is tailor made for this job hop and has no market (salvage) value at any time. How much could be justified now for system modification.

$$A=2,000(A/G, 20\%, 20) + 2,000 = 2,000(4.4643) + 2,000 = \$10,928.6$$

$$P = 10,928.6 (P/A, 20\%, 20) = 10,928.6(4.8696) = \$53,218$$

	Factor	Find	Given	Formula
Gradient Series	Geometric Gradient	P	F1	$P = \frac{F_1}{1+g} \left[\frac{(1+g')^n - 1}{g'(1+g')^n} \right]$ $P = \frac{F_1 \left(\frac{P}{A}, i, n \right)}{1+g}$ <p>Where $g' = \left[\frac{(1+i)}{(1+g)} \right] - 1$</p>

Cash flow:



Example 8:

An automobile owner is concerned about the increasing cost of gasoline. He feels that the cost of gasoline will be increasing at the rate of 3% per year over this year's price of \$1.4 per gallon. Experience with his car indicates that he averages 19 miles per gallon of gasoline. Since he expects to drive an average of 19,000 miles each year, what is the present worth of the cost of fuel for this individual for the next 4 years?

Gallons consumed = 1000 gallons per year

First year cost = $1000 * \$1.4 = \$1,400$

$g' = 8.74\%$

$P = [1400 / (1 + 0.03)] * (P/A, 8.74\%, 4) = \$14,290$

Effective interest rate

Nominal interest rate: when the interest rate is expressed per year without the impact of compounding.

r : nominal interest rate

i : interest rate per period

c = number of compounding period per year

$$r = i * c$$

Effective interest rate :

$$i_e = (1 + r/c)^c - 1$$

Example 9:

What is the monthly payment for a loan of \$100,000 to be paid back in 5 years with a nominal interest rate of %12 compounded monthly?

What are the yearly payment?

$i_e = 12\%/12 = 1\%$ compounded monthly per month

$A = 100,000(A/P, 1\%, 60) = 100,000(.0222) = \2220 per month

$i_e = (1 + r/c)^c - 1 = (1 + .01)^{12} - 1 = .01268$ compounded annually

$A = 100,000(A/P, 12.68\%, 5) = \28209.79 per year