Introduction to Selected Research Topics in Mechanical Engineering II

Engineering Economics

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22.02.2018

Basic Concepts-INTEREST

- **Interest** is a fee that is charged for the use of someone else's money.

- The size of the fee will depend upon the total amount of money borrowed and the length of time over which it is borrowed.

Basic Concepts-INTEREST

- **Example:** An engineer wishes to borrow \$20 000 in order to start his own business. A bank will lend him the money provided he agrees to repay \$920 per month for two years. How much interest is he being charged?
- The total amount of money that will be paid to the bank is

$$24 \times \$920 = \$22\ 080$$

Since the original loan is only \$20 000, the amount of interest is

$$\$22\ 080 - \$20\ 000 = \$2080$$

Basic Concepts-INTEREST RATE [i]

- If a given amount of money is borrowed for a specified period of time (typically, one year) a certain percentage of the money is charged as interest.
- This percentage is called the **interest rate**.

Basic Concepts-INTEREST RATE [i]

- **Example:** A student deposits $1000 in a savings account that pays interest at the rate of 6% per year. How much money will the student have after one year?
- The student will have his original $1000, plus an interest payment of 0.06 x $1000 = $60. Thus, the student will have accumulated a total of $1060 after one year.

Basic Concepts-INTEREST RATE [i]

- **Example:** An investor makes a loan of $5000, to be repaid in one lump sum at the end of one year. What annual interest rate corresponds to a lump-sum payment of $5425?

- The total amount of interest paid is $5425 - $5000 = $425. Hence the annual interest rate is

$$\frac{\$425}{\$5000} \times 100\% = 8.5\%$$

Basic Concepts-SIMPLE INTEREST

- **Simple interest** is defined as a fixed percentage of the **principal** (the amount of money borrowed), multiplied by the life of the loan.

$$I=niP$$

I =total amount of simple interest

n =life of the loan

i = interest rate (expressed as a decimal)

P = principal

Basic Concepts-SIMPLE INTEREST

- Normally, when a simple interest loan is made, nothing is repaid until the end of the loan period; then, both the principal and the accumulated interest are repaid. The total amount due can be expressed as

$$F=P+I=P(1+ni)$$

Basic Concepts-SIMPLE INTEREST

- **Example :** A student borrows $3000 from his uncle in order to finish school. His uncle agrees to charge him simple interest at the rate of ***5%*** per year. Suppose the student waits two years and then repays the entire loan. How much will he have to repay?

$$F = \$3000[1+ (2)(0.055)] = \$3330.$$

Basic Concepts-COMPOUND INTEREST

- When interest is compounded, the total time period is subdivided into several interest periods.
- Interest is credited at the end of each interest period, and is allowed to accumulate from one interest period to the next.
- During a given interest period, the current interest is determined as a percentage of the total amount owed.

Basic Concepts-COMPOUND INTEREST

- Thus, for the first interest period, the interest is determined as

$$I_1=iP$$

total amount accumulated is

$$F_1=P+I_1=P+iP=P(1+i)$$

Basic Concepts-COMPOUND INTEREST

- For the second interest period, the interest is determined as

$$I_2=iF_1=i(1+i)P$$

- total amount accumulated is

$$F_2=P+I_1+I_2=P+iP+i(1+i)P=(1+i)^2P$$

- For the third interest period

$$I_3 = i(1 + i)^2P \qquad F_3 = P(1+i)^3$$

Basic Concepts-COMPOUND INTEREST

- In general, if there are n interest periods, we have

$$F=P(1+i)^n$$

which is the so-called **law of compound interest**.

- Notice that F, the total amount of Money accumulated, increases exponentially with n, the time measured in interest periods.

Basic Concepts-COMPOUND INTEREST

- **Example :** A student deposits \$1000 in a savings account that pays interest at the rate of 6% per year, compounded annually. If all of the money is allowed to accumulate, how much will the student have after 12years? Compare this with the amount that would have accumulated if simple interest had been paid.

$$F = \$1000(1+0.06)^{12} = \$2012.20$$

- Thus, the student's original investment will have more than doubled over the 12-year period.
- If simple interest had been paid, the total amount that would have accumulated is determined as

$$F = \$1000[1+(12)(0.06)] = \$1720.00$$

Basic Concepts-THE TIME VALUE OF MONEY

- Since money has the ability to earn interest, its value increases with time.
- For instance, \$100 today is equivalent to

$$F = \$100(1 + 0.07)^5 = \$140.26$$

five years from now if the interest rate is ***7%*** per year, compounded annually.

- We say that the ***future worth*** of **\$100** is **\$140.26** if ***i*** = ***7%*** (per year) and ***n*** = 5 (years).

Basic Concepts-THE TIME VALUE OF MONEY

- Since money increases in value as we move from the present to the future, it must decrease in value as we move from the future to the present. Thus, the **present worth** of \$140.26 is \$100 if $i = 7\%$ (per year) and $n = 5$ (years).

Basic Concepts-THE TIME VALUE OF MONEY

- **Example :** A student who will inherit *$5000* in three years has a savings account that pays *5.5%* per year, compounded annually. What is the present worth of the student's inheritance?

$$P=\frac{F}{(1+i)^n}=\frac{\$5000}{(1+0.05)^3}=\$4258.07$$

- The present worth of *$5000* is *$4258.07* if i = *5.5%,* compounded annually, and n = *3.*

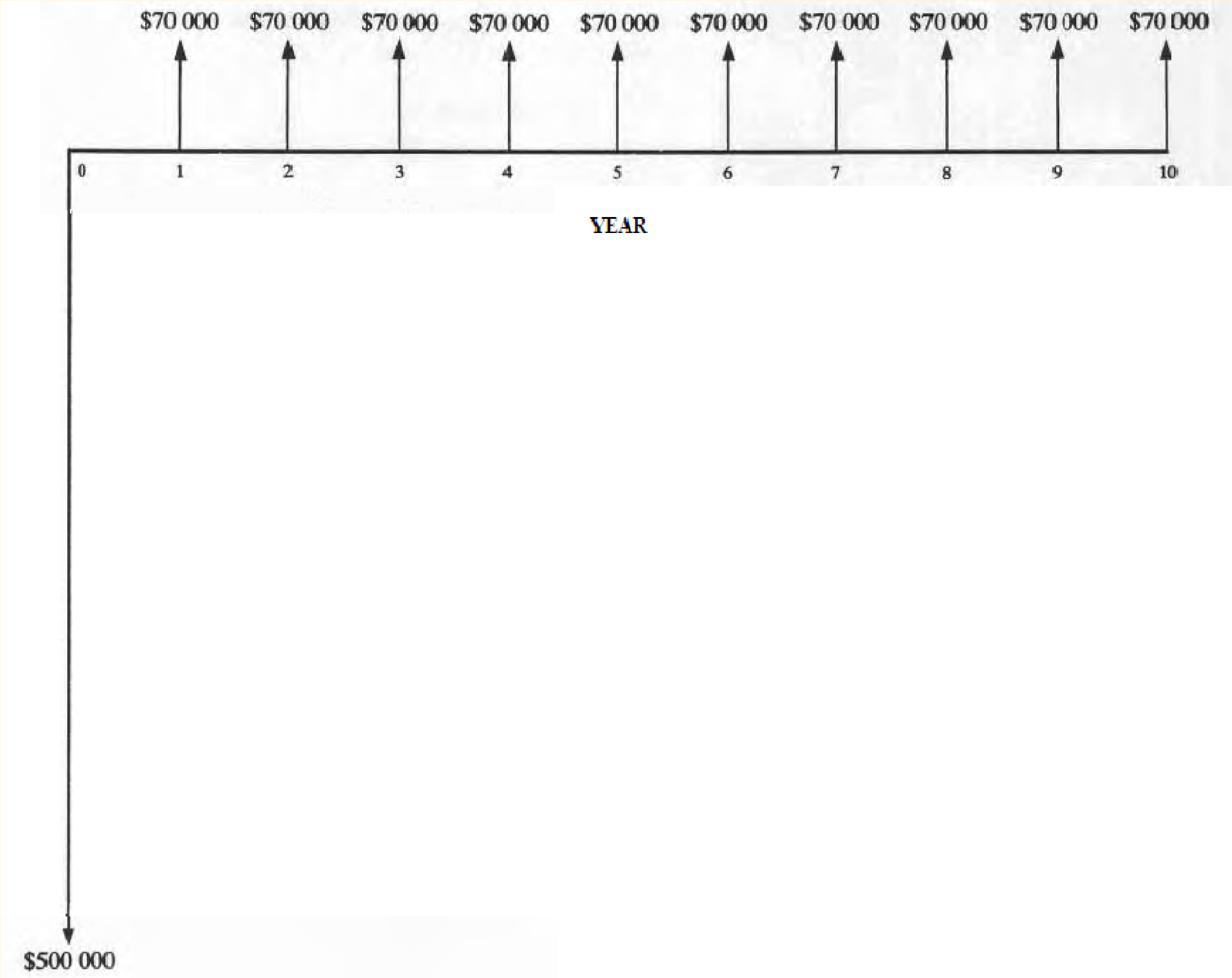
Basic Concepts-CASH FLOWS

- A **cash flow** is the difference between total cash receipts (inflows) and total cash disbursements (outflows) for a given period of time (typically, one year).
- The easiest way to visualize a cash flow is through a cash flow diagram, in which the individual cash flows are represented as vertical arrows along a horizontal time scale.
- Positive cash flows (net inflows) are represented by upward-pointing arrows, and negative cash flows (net outflows) by downward-pointing arrows; the length of an arrow is proportional to the magnitude of the corresponding cash flow.

Basic Concepts-CASH FLOWS

- A company plans to invest $500 000 to manufacture a new product. The sale of this product is expected to provide a net income of $70 000 a year for 10 years, beginning at the end of the first year. Notice that the initial $500 000 investment is represented by a downward-pointing arrow located at the end of year 0 (i.e., at the beginning of year 1). Each annual net income ($70 000) is indicated by an upward-pointing arrow located at the end of the corresponding year.

Basic Concepts-CASH FLOWS



Annual Compounding -SINGLE-PAYMENT, COMPOUND-AMOUNT FACTOR

- The ratio

$$\frac{F}{P} = (1+i)^n$$

is called the single-payment, compound-amount factor.

- (F/P, i%, n) notation is helpful when setting up the solution to a compound interest problem.

Annual Compounding -SINGLE-PAYMENT, COMPOUND-AMOUNT FACTOR

COMPOUND INTEREST FACTORS - ANNUAL COMPOUNDING

INTEREST RATE = 6.00 PERCENT

N	SINGLE-PAYMENT COMPOUND-AMOUNT FACTOR (F/P)	UNIFORM-SERIES COMPOUND-AMOUNT FACTOR (F/A)	UNIFORM-SERIES CAPITAL-RECOVERY FACTOR (A/P)	GRADIENT SERIES FACTOR (A/G)
1	1.0600	1.0000	1.06000	.0000
2	1.1236	2.0600	.54544	.4854
3	1.1910	3.1836	.37411	.9612
4	1.2625	4.3746	.28859	1.4272
5	1.3382	5.6371	.23740	1.8836
6	1.4185	6.9753	.20336	2.3304
7	1.5036	8.3938	.17914	2.7676
8	1.5938	9.8975	.16104	3.1952
9	1.6895	11.4913	.14702	3.6133
10	1.7908	13.1808	.13587	4.0220
11	1.8983	14.9716	.12679	4.4213
12	2.0122	16.8699	.11928	4.8113

Annual Compounding -SINGLE-PAYMENT, COMPOUND-AMOUNT FACTOR

- **Example 2.1 A** student deposits *$1000* in a savings account that pays interest at the rate of 6% per year, compounded annually. If all of the money is allowed to accumulate, how much money will the student have after *12* years?
- We wish to solve for ***F,*** given *P,* i, and *n.* Thus, where the factor

(F/P, 6%, *12)* was evaluated from table.

$$F = P \times (F/P, i\%, n) = \$1000(F/P, 6\%, 12) = \$1000(2.0122) = \$2012.2$$

Annual Compounding -SINGLE-PAYMENT, PRESENT-WORTH FACTOR

- The single-payment, present-worth factor is the reciprocal of the single-payment, compound amount factor.

$$\frac{P}{F} = \left(\frac{F}{P}\right)^{-1} = (1+i)^{-n}$$

- The expanded notation for this quantity is (P/F, i%, n).

Annual Compounding -SINGLE-PAYMENT, PRESENT-WORTH FACTOR

- **Example 2.2 A** certain sum of money will be deposited in a savings account that pays interest at the rate of 6% per year, compounded annually. If all of the money is allowed to accumulate, how much must be deposited initially so that *$5000* will have accumulated after *10* years?

- We wish to solve for ***P,*** given F, i, and n.

$(F/P, 6\%, 10)^{-1} = (1.7908)^{-1} = 0.5584.$

P=F x (P/F, i%, n)=$5000 (P/F, 6%, 10)=$5000 0.5584=$2792

REFERENCES

- Jose Sepulveda, William Souder, Byron Gottfried, Schaum's Outline of Engineering Economics,McGraw-Hill (1984)