Engineering Economics & Financial Management

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At the end of this session, the learner should be able to

L1:Explain the concept of ‘Time value of Money’

L2:Represent the cash flows in graphical form

“**Engineering** is a profession in which a knowledge of the mathematical and natural sciences is applied with **judgment** to develop ways to utilize **economically** the **materials and forces of nature** for the benefit of mankind“

-ABET

Engineering Economics?

Engineers seek solutions to problems, and the economic viability of each potential solution is normally considered along with the technical aspects.

Accounting Vs. Engineering Economics.

Evaluating past performance

Accounting

Evaluating and predicting future events

Engineering Economy

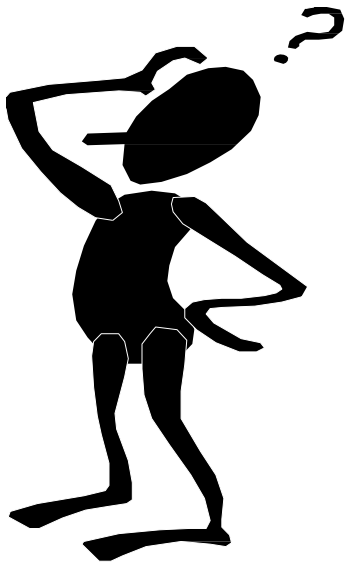
Past

Present

Future

Two Defining Factors in Engineering Economic Decisions

The factors of time and uncertainty are the defining aspects of any engineering economic decisions



Physical and Economic Efficiency

Efficiency (Physical) = Output / input

Efficiency (Economic) = Worth / Cost

Decision making process

1. Understand the Problem
2. Identify the decision criterion
3. Allocating Weights to the Criteria
4. Developing Alternatives
5. Analyzing alternatives
6. Select the “best” alternative
7. Implementing
8. Monitoring

Fundamental principles of Engg economics

- A nearby penny is worth a distant dollar – Time value of Money
- All that counts are the differences among the alternatives
- Marginal revenue must exceed marginal cost
- Additional risk is not taken without the additional expected return

Time value of Money

- The relationship between interest and time leads to the concept of “Time Value of Money”.

- The economic value of a sum depends on when it is received.

Time value of Money

- Money has a time value because it can earn more money over time (earning power).
- Money has a time value because its purchasing power changes over time (inflation).
- Time value of money is measured in terms of interest rate.
- Interest is the cost of money—a cost to the borrower and an earning to the lender.

Interest: It represents earning power of money. It is a rental amount charged by financial institutions for the use of money.

Eg: Interest on house loan, car loan, credit card etc.

Types: Simple interest and Compound interest

₹ 1000 can be made equivalent to ₹ 5000 at the end of one year. This statement refers to the concept of ----------

In order to retain purchasing power of money----------is included

The economic value of the money depends on ----------

₹ 1000 can be made equivalent to ₹ 5000 at the end of one year.
This statement refers to the concept of ----------
Time Value of Money

In order to retain purchasing power of money----------is included
Interest

The economic value of the money depends on ----------
Time (When it is received)

Some important terminologies….

Principal: an initial amount of money in transactions involving investment or debt.

Interest rate: measures the cost or price of money, expressed in percentage.

Interest period: a period of time, that determines how frequently the interest is calculated

Cash flow diagrams: graphical representation of cash transactions with reference to time.

- **Simple interest**: The practice of charging an interest rate only to an initial sum (principal amount).
  - In this case interest earned is directly proportional to capital involved in the loan.

If, I= interest earned through several time period.

P= Principal amount

i= rate of interest per period

N= number of interest periods (usually years)

Then, $I = P * i * N$

The total amount the borrower is supposed to pay the lender,

$F = P + I \Rightarrow P + PiN \Rightarrow$ $\boxed{F=P(1+iN)}$

- Compound interest: The practice of charging an interest rate to an initial sum and to any previously accumulated interest that has not been withdrawn.

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

In 1626, Peter Minuit of the Dutch West India Company paid $24 to purchase Manhattan Island in New York from the Indians. In retrospect, if Minuit had invested the $24 in a savings account that earned 8% interest, how much would it be worth in 2007?

Note: Number of years =381 years

Simple Verses Compound interest- big deal?

Ans

SI	CI
F=$755	F= $130,215,319,909,015

Cash flow Diagrams

Representation of net cash inflow and outflow on a time line

- ✓ Receipts – Inflow- E.g. profit, commission etc
- ✓ Disbursements –Outflow- E.g. salary
- ✓ Point of view – Borrower or Lender

Cash flow Diagrams

E.g., $25,000 is the price of the Baxter, a new robot from Rethink Robotics in Boston that's designed to perform the repetitive tasks common on most assembly lines to help increase productivity. While the Baxter has no legs and no speech capacity, it has five cameras, two Olympic swimmer-length arms, a set of expressive digitally rendered eyes and eyebrows, and enough intelligence to learn tasks within an hour. A company wants to have this Baxter and borrows $20,000 from a bank. In addition, the company pays $200 as loan origination fee when the loan commences. The bank offers two repayment plans, one with equal payments made at the end of every year for five years, the other with one single payment made at the end of 5 years. The plans at 9% interest rate are summarized in the table:

Source: https://www.sfgate.com/business/article/Assembly-line-robot-Baxter-costs-22-000-3886109.php & Chan S Park

Cash flow Diagrams

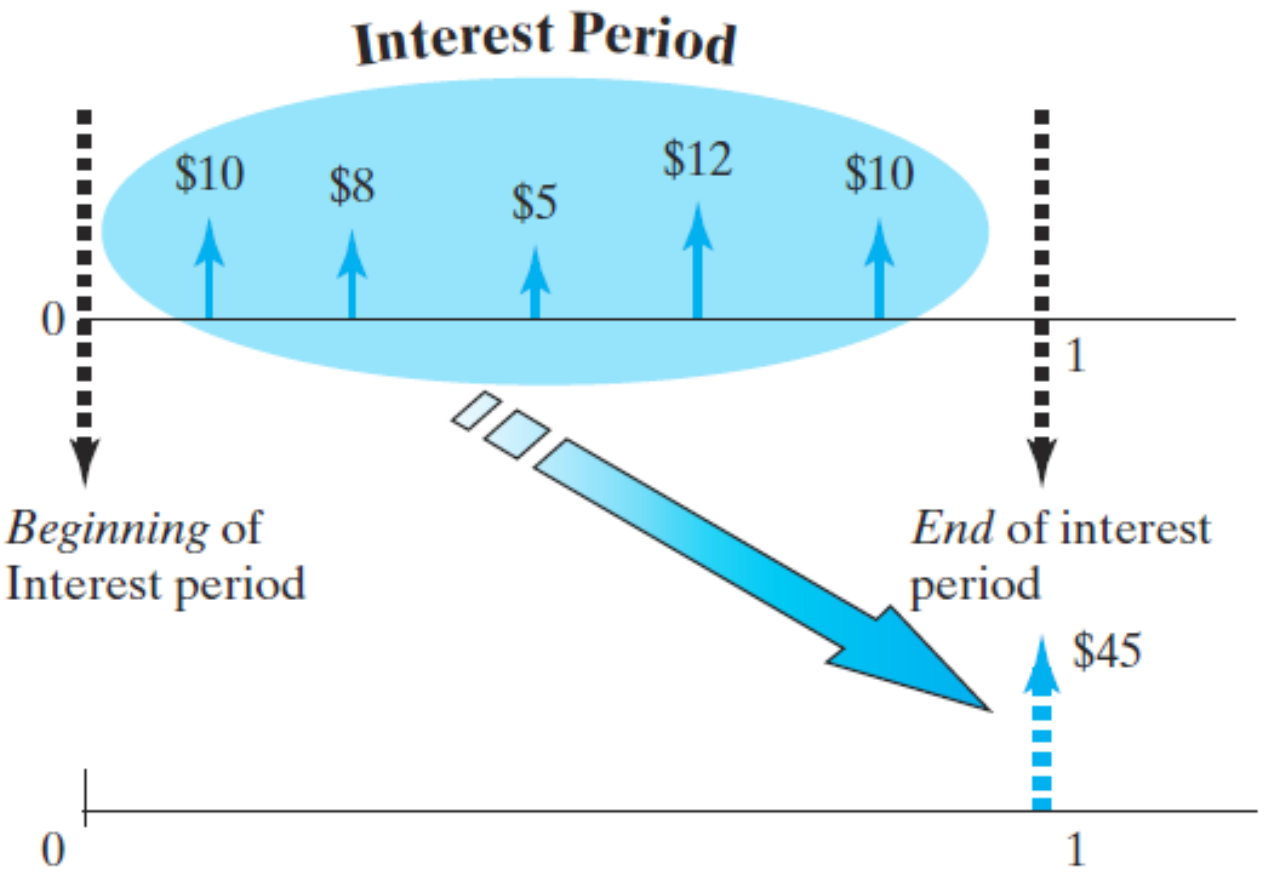
End of Year	Receipts	Payments	
		Plan 1	Plan 2
Year 0	$20,000.00	$ 200.00	$ 200.00
Year 1		5,141.85	0
Year 2		5,141.85	0
Year 3		5,141.85	0
Year 4		5,141.85	0
Year 5		5,141.85	30,772.48

$P = \$20{,}000,\ A = \$5{,}141.85,\ F = \$30{,}772.48$

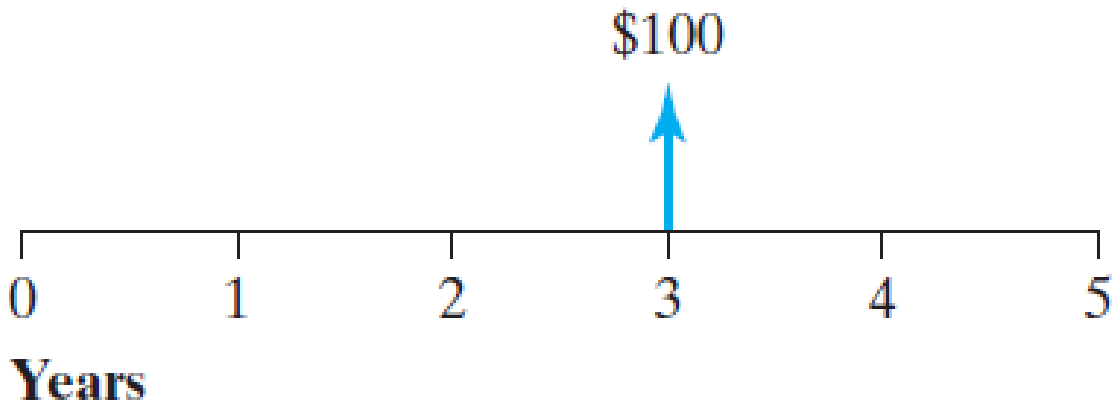
Source: https://www.sfgate.com/business/article/Assembly-line-robot-Baxter-costs-22-000-3886109.php & Chan S Park

Cash flow Diagrams – End-of-Period Convention

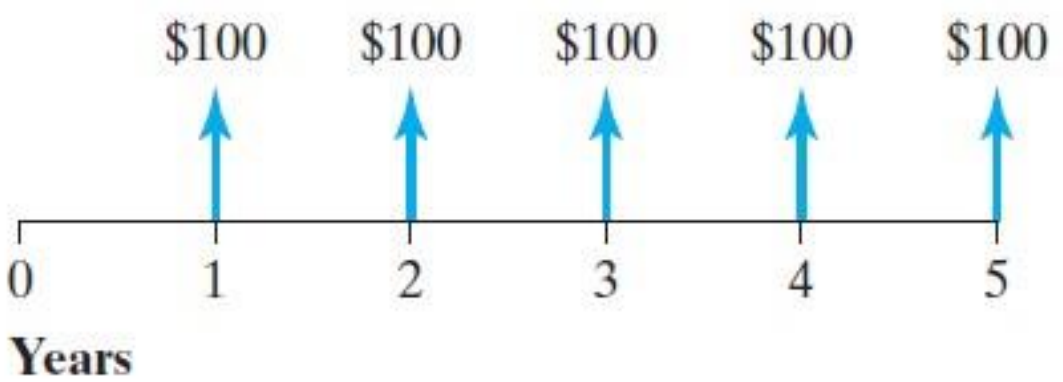
Unless otherwise mentioned, all cash flow transactions occur at the end of the interest time period



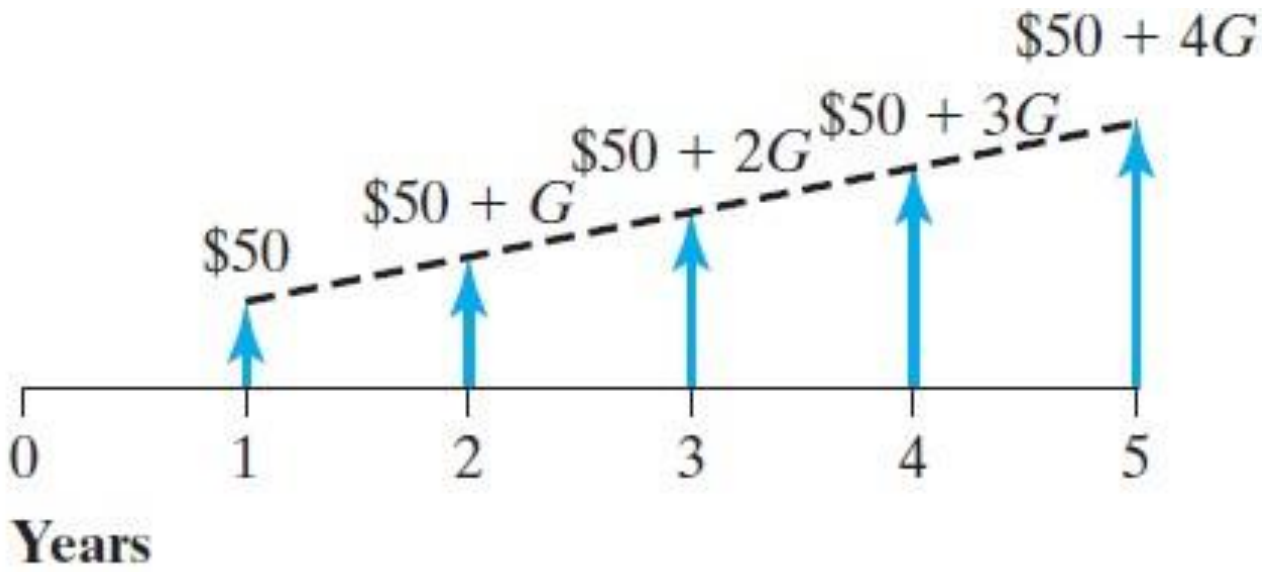
Types of cash flow



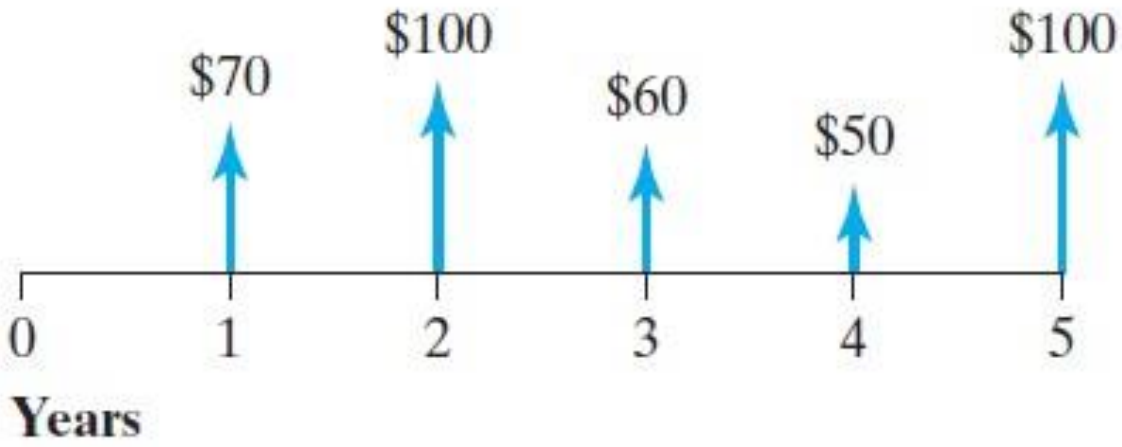
(a) Single cash flow



(b) Equal (uniform) payment series at regular intervals



(c) Linear gradient series, where each cash flow in the series increases or decreases by a fixed amount *G*



(e) Irregular payment series, which exhibits no regular overall pattern

Cash flow Diagrams

Draw Cash Flow Diagram for Plan-2. Part of the problem is reproduced below for your reference: -

$25,000 is the price of the Baxter, a new robot from Rethink Robotics in Boston that's designed to perform the repetitive tasks common on most assembly lines to help increase productivity. While the Baxter has no legs and no speech capacity, it has five cameras, two Olympic swimmer-length arms, a set of expressive digitally rendered eyes and eyebrows, and enough intelligence to learn tasks within an hour. A company wants to have this Baxter and borrows $20,000 from a bank. In addition, the company pays $200 as loan origination fee when the loan commences. The company has to repay the loan at the end of 5 years at an interest rate of 9%. The final amount is $30,772.48.

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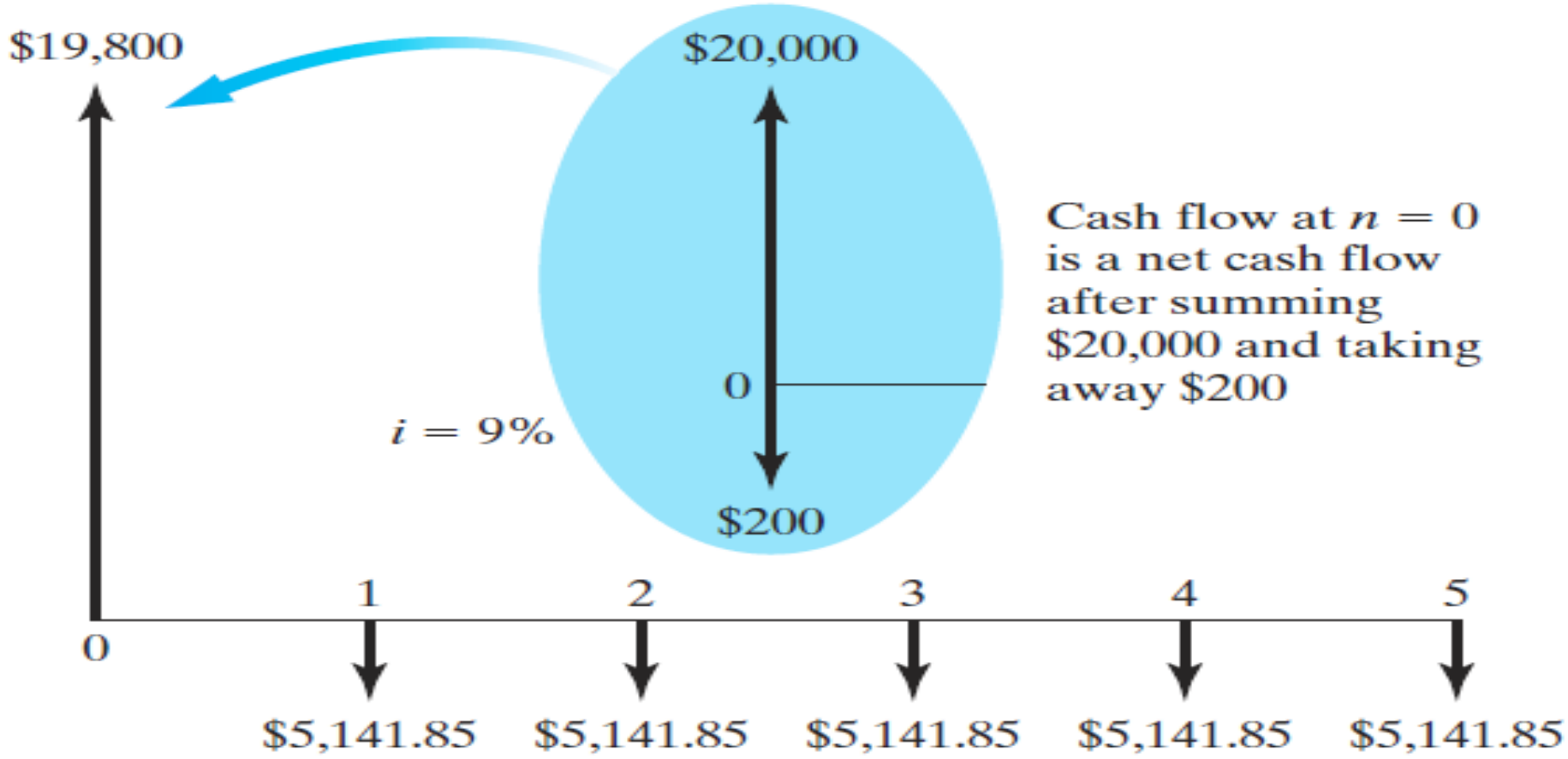
Cash flow Diagrams



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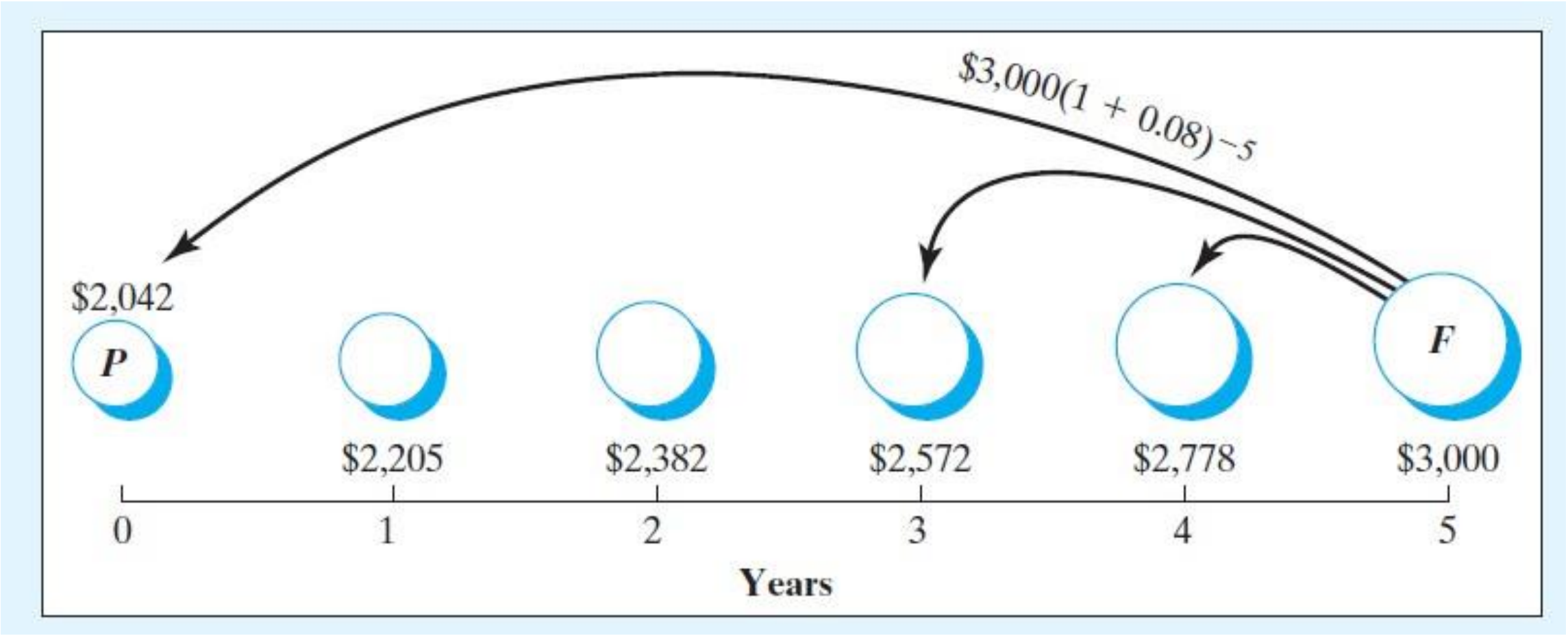
At the end of this session, the learner should be able to

L3: Find worth of Cash transactions at different point in time.

Economic equivalence



Equivalence principles

1. Common time basis
2. Equivalence depends on interest rate
3. Equivalence calculations may require conversion of multiple cash flows into single cash flow
4. equivalence is maintained regardless of point of view

- Compound interest: The practice of charging an interest rate to an initial sum and to any previously accumulated interest that has not been withdrawn.

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

Economic Equivalence

Suppose you have the alternative of receiving either $12,000 at the end of five years or P dollars today. Currently you have no need for money, so you would deposit the P dollars in a bank that pays 5% interest. What value of P would make you indifferent in your choice between P dollars today and the promise of $12,000 at the end of five years?

Ans: $9402

Suppose that you are obtaining a personal loan from your uncle in the amount of $20,000 (now) to be repaid in two years to cover some of your college expenses. If your uncle usually earns 8% interest (annually) on his money, which is invested in various sources, what minimum lump-sum payment two years from now would make your uncle happy?

Ans: 23328

Interest factor table

10.0%

N	Single Payment: Compound Amount Factor (F/P,i,N)	Single Payment: Present Worth Factor (P/F,i,N)	Equal Payment Series: Compound Amount Factor (F/A,i,N)	Equal Payment Series: Sinking Fund Factor (A/F,i,N)	Equal Payment Series: Present Worth Factor (P/A,i,N)	Equal Payment Series: Capital Recovery Factor (A/P,i,N)	Gradient Series: Gradient Uniform Series (A/G,i,N)	Gradient Series: Gradient Present Worth (P/G,i,N)	N
1	1.1000	0.9091	1.0000	1.0000	0.9091	1.1000	0.0000	0.0000	1
2	1.2100	0.8264	2.1000	0.4762	1.7355	0.5762	0.4762	0.8264	2
3	1.3310	0.7513	3.3100	0.3021	2.4869	0.4021	0.9366	2.3291	3
4	1.4641	0.6830	4.6410	0.2155	3.1699	0.3155	1.3812	4.3781	4
5	1.6105	0.6209	6.1051	0.1638	3.7908	0.2638	1.8101	6.8618	5
6	1.7716	0.5645	7.7156	0.1296	4.3553	0.2296	2.2236	9.6842	6
7	1.9487	0.5132	9.4872	0.1054	4.8684	0.2054	2.6216	12.7631	7
8	2.1436	0.4665	11.4359	0.0874	5.3349	0.1874	3.0045	16.0287	8
9	2.3579	0.4241	13.5795	0.0736	5.7590	0.1736	3.3724	19.4215	9
10	2.5937	0.3855	15.9374	0.0627	6.1446	0.1627	3.7255	22.8913	10
11	2.8531	0.3505	18.5312	0.0540	6.4951	0.1540	4.0641	26.3963	11
12	3.1384	0.3186	21.3843	0.0468	6.8137	0.1468	4.3884	29.9012	12
13	3.4523	0.2897	24.5227	0.0408	7.1034	0.1408	4.6988	33.3772	13
14	3.7975	0.2633	27.9750	0.0357	7.3667	0.1357	4.9955	36.8005	14
15	4.1772	0.2394	31.7725	0.0315	7.6061	0.1315	5.2789	40.1520	15
16	4.5950	0.2176	35.9497	0.0278	7.8237	0.1278	5.5493	43.4164	16
17	5.0545	0.1978	40.5447	0.0247	8.0216	0.1247	5.8071	46.5819	17
18	5.5599	0.1799	45.5992	0.0219	8.2014	0.1219	6.0526	49.6395	18

Factor notation

Single payment compound amount factor

$$F = P(1 + i)^N = P(F/P, i, N).$$

	Single Payment	
N	Compound Amount Factor (F/P,i,N)	Present Worth Factor (P/F,i,N)
1	1.1000	0.9091
2	1.2100	0.8264
3	1.3310	0.7513
4	1.4641	0.6830
5	1.6105	0.6209

Eg. If you invest 50,000 today at an interest rate of 10% how much will be there in your account at the end of 5years?

Factor notation

Single payment Present worth factor (discounting factor)

$$P = F\left[\frac{1}{(1+i)^N}\right] = F(P/F, i, N).$$

Eg. Suppose you want to get 1,00,000 rupees at the end of 6 years at an interest rate of 10%, how much should you invest now??

Single Cash – Present Worth / Future Worth/ time/interest

For an interest rate of 13% compounded annually, find
(a) How much can be lent now if $10,000 will be repaid at the end of five years?
(b) How much will be required in four years to repay a $25,000 loan received now?

a. 5427; b. 40761

How many years will it take an investment to triple itself if the interest rate is 12% compounded annually?

Ans: 9.69 years

Single Cash – Present Worth / Future Worth/ time/interest

You bought 300 shares of Microsoft (MSFT) stock at $2,600 on December 31, 2005. Your intention is to keep the stock until it doubles in value. If you expect 15% annual growth for MSFT stock, how many years do you anticipate holding onto the stock? Compare your answer with the solution obtained by the Rule of 72

Ans: 4.96 years

Suppose you buy a share for $10 and sell it for $20. Then your profit is $10. If that happens within a year, your rate of return is an impressive 100% ($10/$10 = 1). If it takes five years, what would be the average annual rate of return on your investment?

Ans: 15% approx

Factor notation

Uneven payment series

Wilson Technology, a growing machine shop, wishes to set aside money now to invest over the next four years in automating its customer service department. The company can earn 10% on a lump sum deposited now, and it wishes to withdraw the money in the following increments:

- **Year 1:** $25,000, to purchase a computer and database software designed for customer service use;
- **Year 2:** $3,000, to purchase additional hardware to accommodate anticipated growth in use of the system;
- **Year 3:** No expenses; and
- **Year 4:** $5,000, to purchase software upgrades.

How much money must be deposited now to cover the anticipated payments over the next 4 years?

Evaluation:

Q3.

How much invested now at 6% would be just sufficient to provide three payments, with the first payment in the amount of $7,000 occurring two years hence, then $6,000 five years hence, and finally $5,000 seven years hence?

Q4.

A local newspaper headline blared, "Bo Smith Signed for $30 Million." A reading of the article revealed that on April 1, 2005, Bo Smith, the former record-breaking running back from Football University, signed a $30 million package with the Dallas Rangers. The terms of the contract were $3 million immediately, $2.4 million per year for the first five years (with the first payment after 1 year) and $3 million per year for the next five years (with the first payment at year 6). If Bo's interest rate is 8% per year, what would his contract be worth at the time he signs it?