الجامعة الوطنية
National University
Science & Technology للعلوم والتكنولوجيا
كلية عمان البحرية الدولية
International Maritime College Oman

Final Exam
TPEE: PROCESS ENGINEERING ECONOMICS
Fall 2024

Points of attention:

- For each question, the maximum earned points are specified in the question.
- Write clearly! Answers that are not readable are not marked and don't earn marks!
- All answers should be written in English using **blue or black pens** only.
- Use the pencil only for diagrams and graphs.
- Show all the calculation steps in the given space.
- When finished, submit the question paper, together with the answer scripts and the signed cover page to the invigilator.
- Any cheating/copying may result in an instant failing of the examination.

Exam Duration:	3.0 hours
Instructor's Name:	Dr Jimoh K. Adewole
Exam Date:	08/01/2025
Program:	PE

	40
	10

Student Information

Name: ID:

Signature:

Invigilator

Initials: ☐ Student ID checked

Time received:

Part A [10 Marks] [10 marks]

Answer all the questions

Question 1

a) Explain the term “depreciation of a process equipment” and state three (3) requirements for a process equipment to be depreciated**.** (5 marks)

b) Explain the following terms as applied in Process Engineering Economics?
   i) Scrap value of a process plant (1 mark)
   ii) Service life of a process plant (1 mark)

c) Given that the current gross selling price of ammonia is $150/ ton. Estimate the fixed capital investment (FCI) for a 1,500ton/year ammonia plant whose Turnover ratio (TOR) is 0.65. The plant will operate at a 95% stream time. (2 marks)

d) If OMR 10 of simple interest is payable at the end of a year on a loan of OMR100, what is the interest rate? (1 marks)

Part B [30 Marks]

Answer any two questions

Question 2 **[15 marks]**

The delivered-equipment cost for a fluid processing plant is $100, 000. The plant is to be constructed as an addition to an existing plant. Using the ratio factors provided on the table in the appendix and taking the piping (installed) as 48% and building as 15% of the delivered equipment cost, determine:

i. the fixed capital investment

ii. the total capital investment

iii. the percentage of the fixed-capital investment that is due to cost of contractor’s fee

iv. the percentage of the total capital investment that is due to yard improvements?

v. the percentage of the total capital investment that is due to the working capital investment (Peters, Timmerhaus and West, 2011)

Question 3 **[15 marks]**

Sohar chemical company is 9 million kg of product. Estimate the manufacturing cost per annum under the following conditions:

Fixed-capital investment = $4, 000,000

Utilities:

MP steam = 50 kg/kg of product

Purchased electric power = 0.9 kWh/kg of product.

Filtered water = 0.083 m^3 /kg of product.

Operating labor = 12 persons per shift at $25.00 per employee-hour.

Number of shift = 3

Plant operates three hundred 24-h days per year.

Corrosive liquids are involved (which means there will be need for regular repair and maintenance). A large amount of direct supervision is required. There is no cost incurred on patent, royalty, interest, rent charges, insurance, local taxes, operating supplies, and laboratory charges.

Costs of power	$0.08/kWh
Cost of raw materials	$0.25/kg of product
Cost of filtered water	$2.26/$m^3$
Cost of MP steam	$1.5/kg
Plant overhead costs	50 percent of the cost for operating labor
Cost of direct supervision	15% of the operating labor
Cost of repair and maintenance	6% of fixed capital investment
Depreciation	10% of fixed capital investment

Question 4 **[15 marks]**

The total capital investment to build a plant is OMR 12,000,000 and the fixed capital investment of the process plant is OMR 9,523,810. Estimate the amount of working capital that will be needed for the project.

Given that the total sales (s) of the first year is OMR 1.5 million, the overall cost of operations is OMR 0.5 million, and the depreciation is half the value of the income taxes (take ∅ to be 0.35), develop an illustrative tree diagram of the cash flow of the company showing all the necessary components. The manufacturing (m) fixed capital investment is projected to be three times the nonmanufacturing (n) fixed capital investment (that is $m = 3n$).

Reference

Couper, J.R. (2003) *Process Engineering Economics*. New York: Marcel Dekker, Inc.

Peters, M.S., Timmerhaus, K.D. and West, R.E. (2011) *Plant design and economics for chemical engineers.* 5th edn. New York: McGraw-Hill.

MLO & Bloom's Level of Complexity

Q #	MLO Addressed	Complexity Level	Mark	Remark
1a	1	Understanding	5	
1b	1	Understanding	2	
1c&d	2,3	Understanding/Applying	3	
2	2	Applying/Analysing	15	
3	3	Analysing/Evaluating	15	
4	2,3	Analysing/Evaluating	15	

Appendix

ESTIMATION OF TOTAL PRODUCT COST (SHOWING INDIVIDUAL COMPONENTS)

Manufacturing cost = direct production costs + fixed charges + plant overhead costs

A. Direct production costs

1. Raw materials
2. Operating labor
3. Direct supervisory and clerical labor
4. Utilities
5. Maintenance and repairs
6. Operating supplies
7. Laboratory charges
8. Patents and royalties

B. Fixed charges

1. Depreciation
2. Local taxes
3. Insurance
4. Rent

C. Plant-overhead costs; includes costs for the following: general plant upkeep and overhead, payroll overhead, packaging, medical services, safety and protection, restaurants, recreation, salvage, laboratories, and storage facilities.

II. General expenses = administrative costs + distribution and selling costs + research and development costs

A. Administrative costs; includes costs for executive salaries, clerical wages, legal fees, office supplies, and communications

B. Distribution and selling costs; includes costs for sales offices, salesmen, shipping, and advertising

C. Research and development costs

D. Financing (interest)

III. Total product cost* = manufacturing cost + general expenses

IV. Gross Earnings: Gross Profit = Total Income - Total Product Cost;

Net Profit = (1- ∅) Gross Profit (Peters, Timmerhaus and West, 2011)

Linear (Straight Line) Depreciation Method

$$d = \frac{V_0 - V_S}{N} \qquad V_{b,n} = V_0 - n \times d$$

Declining Balance Depreciation Method

$d_n = (1- \alpha)^{n-1}\ \alpha\ V_0$ $\qquad V_{b,n} = (1-\alpha)^n V_0$

$$PBP = \frac{fixed\ capital\ investment}{annual\ cash\ flow}$$

Fixed capital investment = Manufacturing + Non Manufacturing

The annual cash flow can be calculated from the formula below:

$$A_j = (s_j - c_{oj})(1 - \varphi) + d_j\varphi$$

$$ROI = \frac{annual\ net\ profit}{total\ capital\ investment}$$

Gross Annual Sales (GAS) = Annual Production Rate × Selling Price

TOR = Gross Annual Sales ÷ Fixed Capital Investment

Table 1 Ratio factors for estimating capital investment items based on delivered-equipment cost

Values presented are applicable for major process plant additions to an existing site where the necessary land is available through purchase or present ownership.† The values are based on fixed-capital investments ranging from under $1 million to over $100 million.

	Percent of delivered-equipment cost for		
	Solid processing plant‡	**Solid-fluid processing plant‡**	**Fluid processing plant‡**
Direct costs			
Purchased equipment delivered (including fabricated equipment, process machinery, pumps, and compressors)	100	100	100
Purchased-equipment installation	45	39	47
Instrumentation and controls (installed)	18	26	36
Piping (installed)	16	31	68
Electrical systems (installed)	10	10	11
Buildings (including services)	25	29	18
Yard improvements	15	12	10
Service facilities (installed)	40	55	70
Total direct plant cost			
Indirect costs			
Engineering and supervision	33	32	33
Construction expenses	39	34	41
Legal expenses	4	4	4
Contractor's fee	17	19	22
Contingency	35	37	44
Total indirect plant cost			
Fixed-capital investment	397	428	504
Working capital (15% of total capital investment)	70	75	89
Total capital investment	467	503	593

†Because of the extra expense involved in supplying service facilities, storage facilities, loading terminals, transportation facilities, and other necessary utilities at a completely undeveloped site, the fixed-capital investment for a new plant located at an undeveloped site may be as much as 100 percent greater than that for an equivalent plant constructed as an addition to the existing plant.
‡See Table 6-6 for descriptions of types of process plants.

(Adapted from Peters et al., 2011)

Used for estimating both the:

- Fixed capital investment (FCI)
- Total capital investment (TCI)

$$C_n = E\sum\left(1 + f_1 + f_2 + f_3 + f_4 + ...f_n\right)$$

Where C_n is the total or fixed capital investment;
$f_1, f_2, f_3, f_4, ...f_n$ are multiplying factors for the components (such as piping, building, direct costs, etc) which can be obtained from Table 6.1.
E is the delivered equipment cost

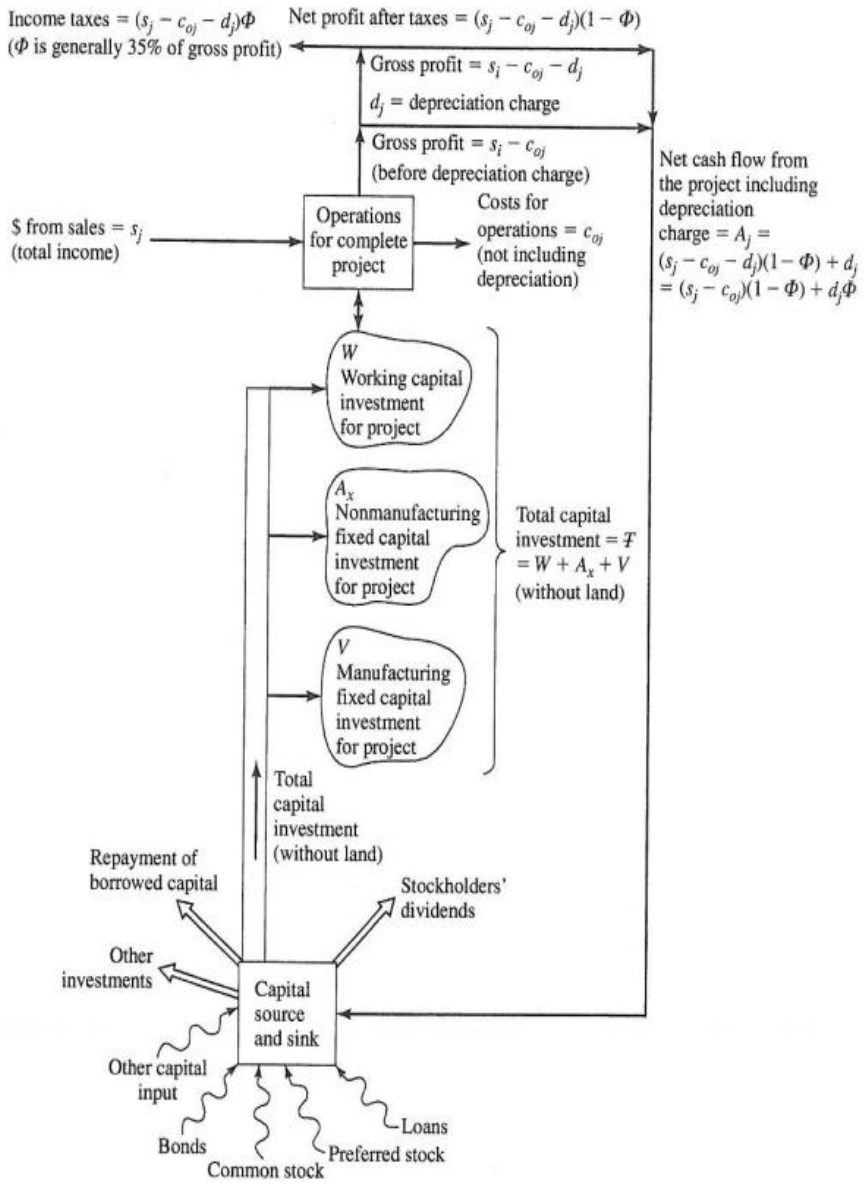

Figure 1 A representative tree diagram describing the cash flow of an Industry (Peters, Timmerhaus and West, 2011)