

**BITS, PILANI, GOA CAMPUS, SECOND SEMESTER 2022 – 2023**  
**COMPREHENSIVE EXAM: PRODUCT AND PROCESS DESIGN PRINCIPLES – II (CLOSED BOOK)**  
**COURSE CODE: CHE F343 (PART A)**

**DATE: 16/05/23**

**TIME: 90 MINUTES**

**MAX. MARKS: 30**

**(ALL QUESTIONS ARE COMPULSORY. MAKE SUITABLE ASSUMPTIONS WHEREVER NECESSARY)**

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**Question**

**[30 marks]**

**A plant produces 5 million kg of ethylene annually.** The Total Capital Investment for a conventional chemical plant of this nature is Rs. 20 crores. The selling price of the product is Rs. 60/kg. Working capital amounts to 20 percent of the Total Capital Investment. **The investment is from company funds, and no interest is charged.** Raw-materials costs for this product are Rs.7/kg, operating labor Rs.6.0/kg, utilities Rs. 4/kg, and packaging Rs. 0.6/kg.

Distribution costs are 5 percent of the total product cost. The cost associated with patents and royalties is zero. Estimate the following:

- a. Manufacturing cost (See cost sheet provided) **per kilogram of product**
- b. Total Product Cost (TPC) **per kg and per year.** TPC is same as **Total Production Cost** in Seader
- c. Profit per kilogram of product and total profit in Rs. per year before taxes
- d. Net Profit per kilogram of product and total net profit using tax rate of 37% (after taxes)

Unless mentioned specifically, all data in the answer sheet should be in Variable/kg

**You are given the following data to solve this problem:**

**Total Capital Investment = Fixed Capital Investment + Working Capital**

**Unless specifically mentioned, take average and mention the average taken.**

**A Cost sheet is provided below to help in your calculations Read this cost sheet carefully and data/info provided in the cost sheet before solving this problem. Note what data is given and in what units. The cost sheet must be used in conjunction with the information provided after the cost sheet and data provided in the problem. Do not use the cost sheet as is.**

**You can tabulate your calculations and present your answer**

**Note: This section is important and must be used in conjunction to the Cost sheet provided**

- All percentages in the Cost sheet need not apply as is.
- Take operating supplies (Item 6, Part A) as a percentage of Fixed Capital Investment (FCI)
- Laboratory charges is 10 – 20% (Item 7, Part A) of operating labor
- Costs associated with patents and royalties can be ignored. Packing cost is part of Direct Production costs.
- Depreciation can be computed based on Fixed Capital Investment
- Rent can be ignored.
- Plant overhead costs is 50 – 70% of cost for operating labor, supervision and Maintenance
- Administrative cost is 15% of cost for operating labor, supervision and Maintenance

- Take the cost associated with Research and Development as 5% of Total Product cost (TPC).
- There is no interest charged
- Based on data given, you will end up with an equation in Total Product Cost (TPC) which needs to be solved to obtain TPC.

## COST SHEET

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

- A. Direct production costs (about 60% of total product cost)
1. Raw materials (**10–50%** of total product cost)
  2. Operating labor (**10–20%** of total product cost)
  3. Direct supervisory and clerical labor (**10–25%** of operating labor)
  4. *Utilities* (**10–20%** of total product cost)
  5. *Maintenance and repairs* (**2–10%** of **fixed-capital** investment)
  6. Operating supplies (**10–20%** of cost for maintenance and repairs, or **0.5–1%** of **fixed-capital** investment)
  7. Laboratory charges (10–20% of operating labor)
  8. Patents and royalties (**0–6%** of total product cost)
- B. Fixed charges (**10–20%** of total product cost)
1. Depreciation (depends on **life** period, salvage **value**, and method of calculation-about 10% of **fixed-capital** investment for machinery and equipment and **2–3%** of building value for buildings)
  2. Local taxes (**1–4%** of fixed-capital investment)
  3. Insurance (**0.4–1%** of **fixed-capital** investment)
  4. Rent (**8–12%** of value of rented **land** and buildings)

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Plant-overhead costs (50–70% of cost for operating labor, supervision, and maintenance, or **5–15%** of total product cost); 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.

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

- A. Administrative costs (about 15% of costs for operating labor, supervision, and maintenance, or **2–6%** of total product cost); includes costs for executive salaries, clerical wages, legal fees, office supplies, and communications
- B. Distribution and selling costs (**2–20%** of total product cost); includes costs for sales offices, salesmen, shipping, and advertising
- C. Research and development costs (**2–5%** of every sales **dollar** or about 5% of total product cost)
- D. Financing (interest)? (**0–10%** of total capital investment)

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**COMPREHENSIVE EXAM: PRODUCT AND PROCESS DESIGN PRINCIPLES – II (CLOSED BOOK)**

**COURSE CODE: CHE F343 (PART B)**

**DATE: 16/05/23**

**TIME: 75 MINUTES**

**MAX. MARKS: 50**

**(ALL QUESTIONS ARE COMPULSORY. MAKE SUITABLE ASSUMPTIONS WHEREVER NECESSARY)**

**Question 1**

**[8 + 6 = 14 marks]**

- A project can produce 12,000 units per year at 100% capacity. The variable cost per unit is Rs 3 up to 100% capacity. Fixed costs are Rs 10,000 per year. Find the breakeven point (capacity) if the selling price is Rs. 5 per year. Now the manufacturer finds that he can sell only 80% at Rs 5 per unit. How much should he charge for additional unit if he brings production up to 100% capacity and increase profits after taxes by an additional Rs. 1000. The tax rate is 52%.
- A chemical plant produces methanol. The plant capacity  $X$  (ton/day) is related to the variable cost of methanol in (Rs/ton), the relationship being given as  $50000 + 5X$ . The fixed cost or charges are Rs. 2,00,000 per day. Methanol sells at Rs. 60,000/- per ton. What would be the optimal plant capacity (in ton/day) for minimum total cost per ton of methanol? What would be the breakeven capacity in ton/day? Careful of units while working on this problem. **Note: Total Product Cost (Rs/ton) = Fixed Cost + Variable Cost (Rs/ton).**

**Question 2**

**[4 + 8 + 4 = 16 marks]**

- The original cost for a distillation tower is \$50,000, and the useful life of the tower is estimated to be 10 years. How much must be placed annually in an annuity at an interest rate of 6 percent to obtain sufficient funds to replace the tower at the end of 10 years? If the scrap value of the distillation tower is \$5000, determine the asset value (i.e., the total book value of the tower) at the end of 5 years based on straight line depreciation.
- With total yearly payments of \$10,000 for 10 years, compare the compound amount accumulated at the end of the 10 years if the payments are (1) at the end of the year, (2) weekly, and (3) continuous. The effective (annual) interest rate is 8 percent, and the payments are uniform. Also determine the present worth at time zero for each of the three types of payments.
- A new storage tank can be purchased and installed for \$10,000. The estimated service life of this tank is 10 years. It has been proposed that an available tank with the capacity equivalent to the new tank be used instead of buying the new tank. If the latter tank were repaired, it would have a service life of 3 years before similar repairs would be needed again. Neither tank has any scrap value. Money is worth 6 percent compounded annually. On the basis of equal capitalized costs for the two tanks, how much can be spent for repairing the existing tank?

**Question 3**

**[6 + 8 + 6 = 20 marks]**

- The original value of a piece of equipment is \$22,000, completely installed and ready for use. Its salvage value is estimated to be \$2000 at the end of a service life estimated to be 10 years. Determine the asset (or book) value of the equipment at the end of 5 years using:
  - Straight-line method.
  - Textbook declining-balance method using a suitable value of  $d$
  - Double declining-balance (200 percent) method

Do not draw a Table. Just give the asset value with the working shown at the end of 5 years.

- A power plant for generating electricity is part of a plant design proposal. Two alternative power plants with the necessary capacity have been suggested. One uses a boiler and steam turbine while the other uses a gas turbine. The following information applies to the two proposals:

	Boiler and Steam Turbine	Gas Turbine
Initial Investment	\$600000	\$400000

Fuel costs per year	\$160000	\$230000
Maintenance and Repairs per year	\$12000	\$15000
Insurance and Taxes per year	\$18000	\$12000
Depreciation recovery period	20	10
Salvage value at end of service	0	0

Use present worth analysis

c. In the design of a chemical plant, the following expenditures and revenues are estimated after the plant has achieved its desired production rate:

Total Capital Investment: \$1,00,00,000

Working Capital: \$10,00,000

Annual Sales: \$ 80,00,000 per year

Annual expenditures: \$20,00,000 per year

Assuming straight line depreciation over a 10 year project analysis period, find the ROI after taxes, the payback period and Venture Profit at an  $i_{\min}$  of 20%

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