CH402 Chemical Engineering Process Design

Class Notes L15

Cost Components of Capital Investments

A template for today's lesson is found in Canvas Lesson 15

L15/16 Learning Objectives

L15:

1. Use cost components to estimate capital costs for chemical processing facilities.
2. Estimate capital costs using Lang factors.

L16:

1. Estimate capital costs using scaling factors.
2. Estimate capital costs based on turnover ratio.

Problem 6-3

The purchase and installation costs of some pieces of equipment are given as a function of weight rather than capacity. An example of this is the installed costs of large tanks. The 1990 cost for an installed aluminum tank weighing 45,000 kg was $640,000. For a size range from 10,000 to 450,000 kg, the installed cost weight exponent for aluminum tanks is 0.93. If an aluminum tank weighing 300,000 kg is required, what capital investment is needed in the year 2000?

Problem 6-4

The 1990 cost for an installed 304 stainless steel tank weighing 135,000 kg was $1,100,000. The installed cost weight exponent for stainless steel tanks is 0.88 for a size range from 100,000 to 300,000 kg. What weight of installed stainless steel tank could have been obtained for the same capital investment as in Problem 6-3?

Plant Costs - Methods A-G

- A - Detailed item estimate
- B - Unit cost estimate – based on records
- C - Percentage of delivered-equipment cost
- D - Lang factors
- E - Power factors with plant/capacity ratio
- F - Cost per unit capacity
- G - Turnover ratio

Percentage of Delivered-Equipment Cost

FE Ref. Manual pages 257

Method C

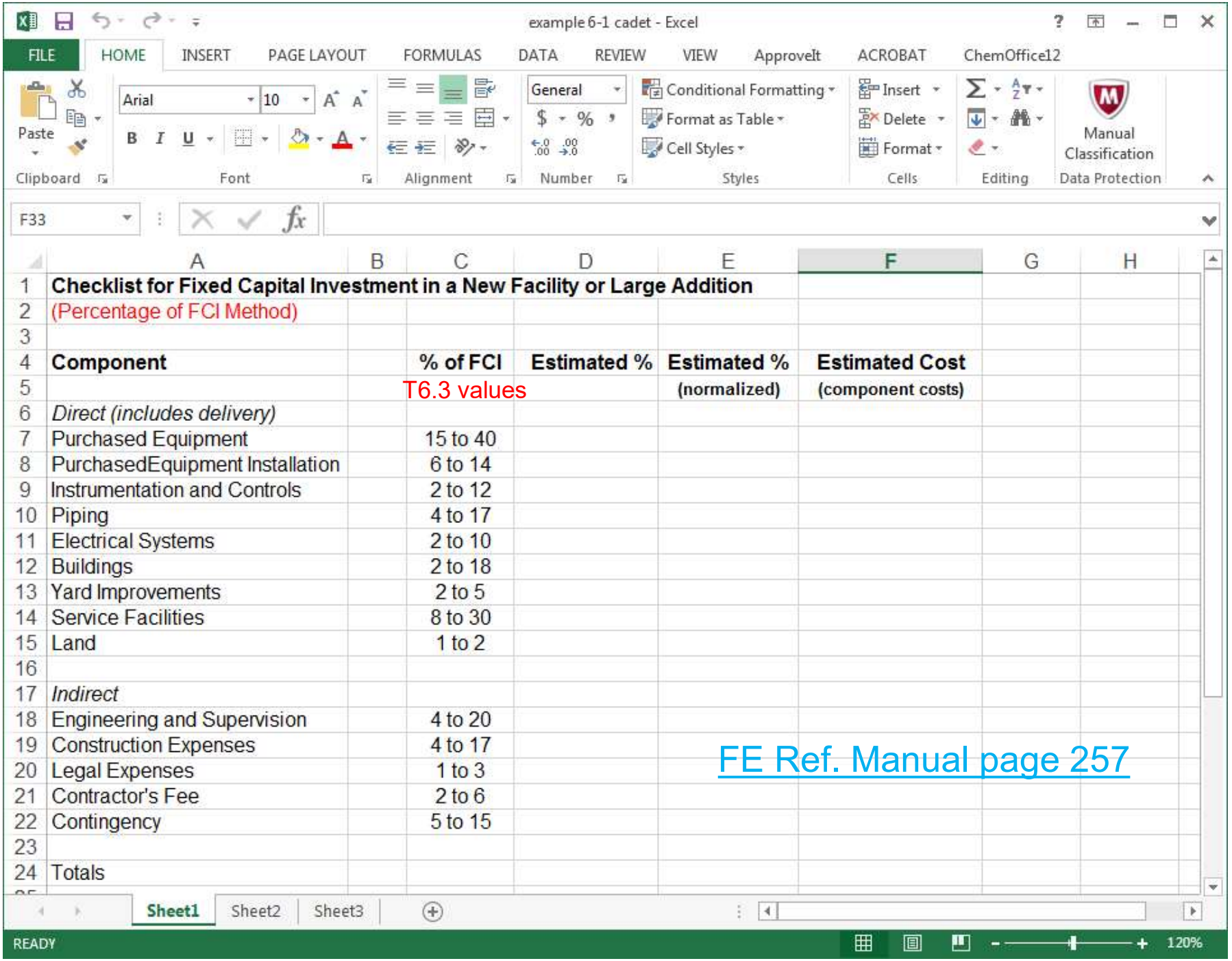
Component	Range
Direct costs	
Purchased equipment-delivered (including fabricated equipment and process machinery such as pumps and compressors)	100
Purchased-equipment installation	39–47
Instrumentation and controls (installed)	9–18
Piping (installed)	16–66
Electrical (installed)	10–11
Buildings (including services)	18–29
Yard improvements	10–13
Service facilities (installed)	40–70
Land (if purchase is required)	6
Total direct plant cost	264–346
Indirect costs	
Engineering and supervision	32–33
Construction expenses	34–41
Total direct and indirect plant costs	336–420
Contractor's fee (about 5% of direct and indirect plant costs)	17–21
Contingency (about 10% of direct and indirect plant costs)	36–42
Fixed-capital investment	387–483
Working capital (about 15% of total capital investment)	68–86
Total capital investment	455–569

Example 6-1

p. 240

Estimate the fixed capital investment for a process plant if the purchased-equipment cost is $100,000. Use the ranges of process-plant component cost outlined in Table 6-3, for a process plant handling both solids and fluids, with a high degree of automatic controls, and essentially outdoor operation. Do not include land.

Very Important Example – Needed for PS8 Problem 6-8


example 6-1 cadet - Excel
FILE
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ChemOffice12
Paste
Arial
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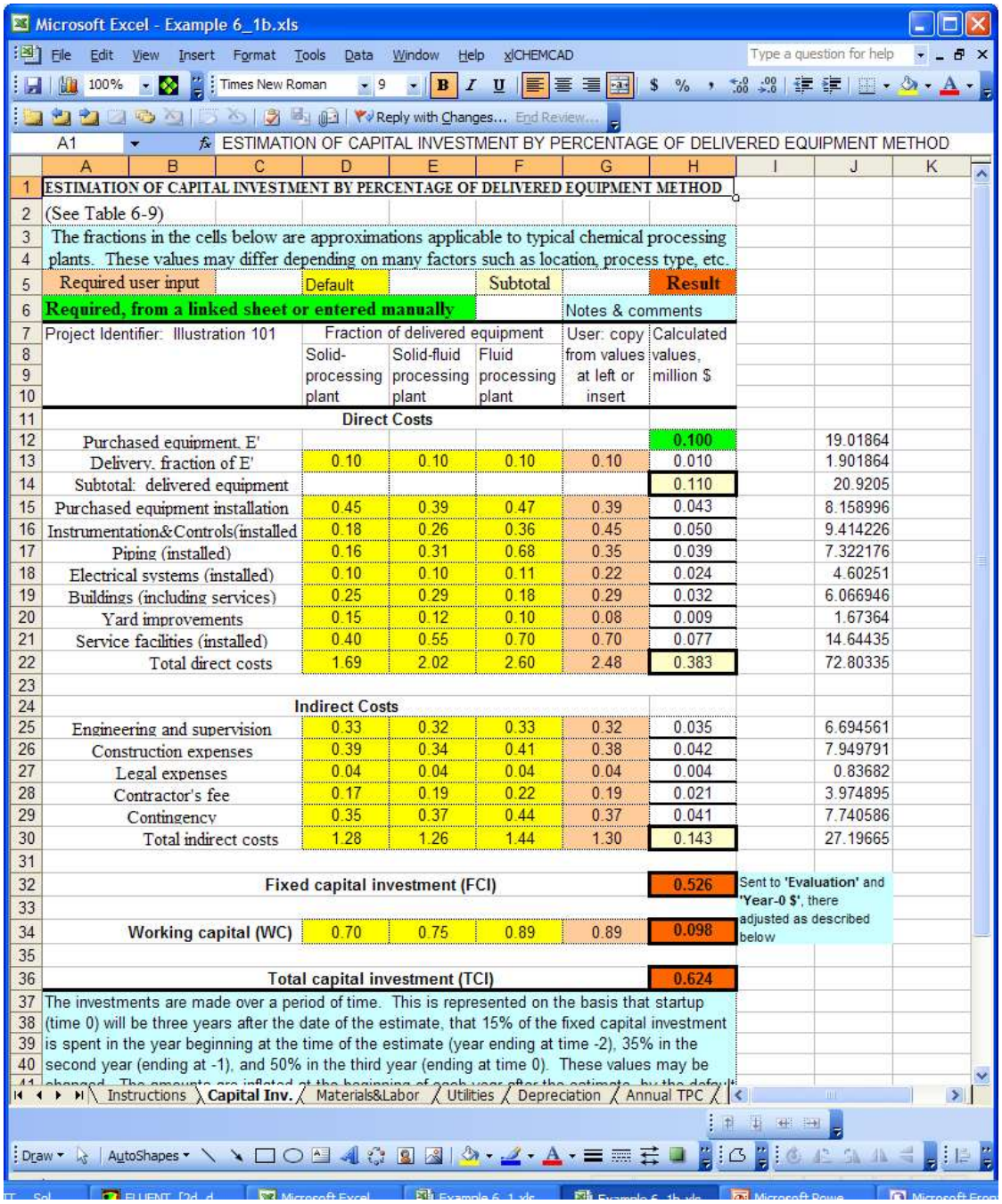
General
Conditional Formatting
Format as Table
Cell Styles
Insert
Delete
Format
Manual Classification
Clipboard
Font
Alignment
Number
Styles
Cells
Editing
Data Protection
F33
Checklist for Fixed Capital Investment in a New Facility or Large Addition
(Percentage of FCI Method)
Component
% of FCI
Estimated %
Estimated %
(normalized)
Estimated Cost
(component costs)
T6.3 values
Direct (includes delivery)
Purchased Equipment 15 to 40
PurchasedEquipment Installation 6 to 14
Instrumentation and Controls 2 to 12
Piping 4 to 17
Electrical Systems 2 to 10
Buildings 2 to 18
Yard Improvements 2 to 5
Service Facilities 8 to 30
Land 1 to 2
Indirect
Engineering and Supervision 4 to 20
Construction Expenses 4 to 17
Legal Expenses 1 to 3
Contractor's Fee 2 to 6
Contingency 5 to 15
Totals
FE Ref. Manual page 257
Sheet1
Sheet2
Sheet3
READY
120%

Use cost & evaluation spreadsheet from course webpage.



Microsoft Excel - Example 6_1b.xls

A1: ESTIMATION OF CAPITAL INVESTMENT BY PERCENTAGE OF DELIVERED EQUIPMENT METHOD

	A	B	C	D	E	F	G	H	I	J	K
1	ESTIMATION OF CAPITAL INVESTMENT BY PERCENTAGE OF DELIVERED EQUIPMENT METHOD										
2	(See Table 6-9)										
3	The fractions in the cells below are approximations applicable to typical chemical processing										
4	plants. These values may differ depending on many factors such as location, process type, etc.										
5	Required user input			Default		Subtotal		Result			
6	Required, from a linked sheet or entered manually						Notes & comments				
7	Project Identifier: Illustration 101			Fraction of delivered equipment			User: copy	Calculated			
8				Solid-processing plant	Solid-fluid processing plant	Fluid processing plant	from values at left or insert	values, million $			
9											
10											
11	Direct Costs										
12	Purchased equipment, E'							0.100		19.01864	
13	Delivery, fraction of E'			0.10	0.10	0.10	0.10	0.010		1.901864	
14	Subtotal: delivered equipment							0.110		20.9205	
15	Purchased equipment installation			0.45	0.39	0.47	0.39	0.043		8.158996	
16	Instrumentation&Controls(installed			0.18	0.26	0.36	0.45	0.050		9.414226	
17	Piping (installed)			0.16	0.31	0.68	0.35	0.039		7.322176	
18	Electrical systems (installed)			0.10	0.10	0.11	0.22	0.024		4.60251	
19	Buildings (including services)			0.25	0.29	0.18	0.29	0.032		6.066946	
20	Yard improvements			0.15	0.12	0.10	0.08	0.009		1.67364	
21	Service facilities (installed)			0.40	0.55	0.70	0.70	0.077		14.64435	
22	Total direct costs			1.69	2.02	2.60	2.48	0.383		72.80335	
23											
24	Indirect Costs										
25	Engineering and supervision			0.33	0.32	0.33	0.32	0.035		6.694561	
26	Construction expenses			0.39	0.34	0.41	0.38	0.042		7.949791	
27	Legal expenses			0.04	0.04	0.04	0.04	0.004		0.83682	
28	Contractor's fee			0.17	0.19	0.22	0.19	0.021		3.974895	
29	Contingency			0.35	0.37	0.44	0.37	0.041		7.740586	
30	Total indirect costs			1.28	1.26	1.44	1.30	0.143		27.19665	
31											
32	Fixed capital investment (FCI)							0.526	Sent to 'Evaluation' and 'Year-0 $', there adjusted as described below		
33											
34	Working capital (WC)			0.70	0.75	0.89	0.89	0.098			
35											
36	Total capital investment (TCI)							0.624			
37	The investments are made over a period of time. This is represented on the basis that startup										
38	(time 0) will be three years after the date of the estimate, that 15% of the fixed capital investment										
39	is spent in the year beginning at the time of the estimate (year ending at time -2), 35% in the										
40	second year (ending at -1), and 50% in the third year (ending at time 0). These values may be										

Sheet tabs: Instructions | Capital Inv. | Materials&Labor | Utilities | Depreciation | Annual TPC

FE Ref. Manual pages 257

Lang Factors

Method D

PTW, Page 254

Table 6-10. Revised Lang factors for estimation of fixed-capital investment (FCI) or total capital investment (TCI)

Factor × delivered-equipment cost = FCI or TCI		
	Lang factors	
Type of Plant	FCI	TCI
Solid	4.0	4.7
Solid-fluid	4.3	5.0
Fluid	5.0	6.0

H.J. Lang, Chem. Eng., 54 (10) 1947, page 117; H.J. Lang, Chem. Eng., 55 (6) 1948, page 112

Example 1: Delivered equipment cost (DEC) for a fluid processing plant is $100,000

FCI = 5.0 × $100,000 = $500,000 and TCI = 6.0 × $100,000 = $600,000

Example 2: Purchased equipment cost for a fluid processing plant is $100,000

DEC = $100,000 + .1 × $100,000 = $110,000 (delivery = 10% of PEC, slide 10)

FCI = 5.0 × $110,000 = $550,000 and TCI = 6.0 × $110,000 = $660,000

Problem 6-8.

The purchased-equipment cost for a plant which produces pentaerythritol (solid-fluid processing plant) is $300,000. The plant is to be an addition to an existing formaldehyde plant. The major part of the building cost will be for indoor construction. The contractor's fee will be 7% of the direct plant cost. All other costs are close to the average values found for typical chemical plants. On the basis of this information, estimate the total direct plant cost, the fixed capital investment, and the total capital investment.

Use Cost and Evaluation Worksheet (colorful worksheet).

New Definitions - Important

Grass-Roots Plant

- A complete plant including infrastructure erected on a new area or site.
- Investment includes all costs of land, site development, battery-limit facilities, and auxiliary facilities.

Battery Limit

- The design of most process units includes a pipe rack on one side of the unit that contains all the piping entering and exiting the unit. The battery limit is where the piping crosses the defined boundary between the unit and the area outside of the unit.
- Battery limits typically exclude storage facilities, administrative buildings, utilities, or auxiliary facilities unless otherwise specified.
- The operational principle is primarily safety but is commonly applied in process design as well. In preparing for major maintenance of a unit, it is cleared of hazardous materials and isolated from the rest of the refinery. A chief operator can go to the battery limits and determine whether all the necessary blinds have been properly installed. He or she signs off on a blind list confirming full unit isolation before work begins.

Plant Costs - Methods A-G

- A - Detailed item estimate
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- G - Turnover ratio

Method G: Turnover Ratio

- Use existing data to calculate turnover ratio.
- Assume turnover ratio is constant.

$$\text{Turnover Ratio} = \frac{\text{gross annual sales}}{\text{fixed capital investment}}$$

Eq. 6-11, p. 258

0.2 to 4 y^{-1}

± 30 % accuracy.

Use in PS8, problem 6-9

Problem 6-9.

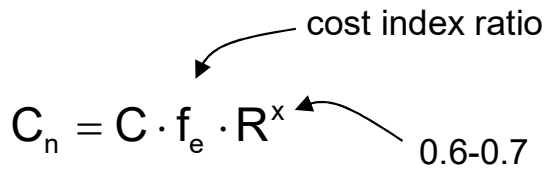
Estimate by the turnover ratio method the fixed-capital investment required in 2000 for a proposed sulfuric acid plant (battery-limit) which has an annual capacity of 1.3×10^8 kg/yr of 100% sulfuric acid (contact catalytic process), using the data from Table 6-11, when the selling price of sulfuric acid is $86 per metric ton. The plant will operate 325 days/year. Repeat the calculation, using the cost capacity exponent (scaling) method with data from Table 6-11

Problem 6-9.

Estimate by the turnover ratio method the fixed-capital investment required in 2000 for a proposed sulfuric acid plant (battery-limit) which has an annual capacity of 1.3×10^8 kg/yr of 100% sulfuric acid (contact catalytic process), using the data from Table 6-11, when the selling price of sulfuric acid is $86 per metric ton. The plant will operate 325 days/year. Repeat the calculation, using the cost capacity exponent (scaling) method with data from Table 6-11

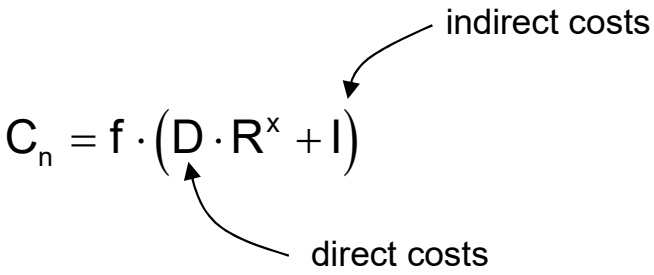
Method E: Power Factors and Plant Capacity Ratio

Similar to what we have been doing for single pieces of equipment.



Eq. 6-9, p. 254

Table 6-11, p. 255



Eq. 6-10

± 20 % accuracy.

$$\text{Cost of Plant A} = \text{Cost of Plant B} \cdot \left(\frac{\text{Capacity of Plant A}}{\text{Capacity of Plant B}} \right)^n$$

FEE p. 150

Problem 6-10.

The total capital investment for a chemical plant is $1 million, and the working capital is $100,000. If the plant can produce an average of 8000 kg of final product per day during a 365-day year, what selling price in dollars per kilogram of product would be necessary to give a turnover ratio of 1.0?

Questions?