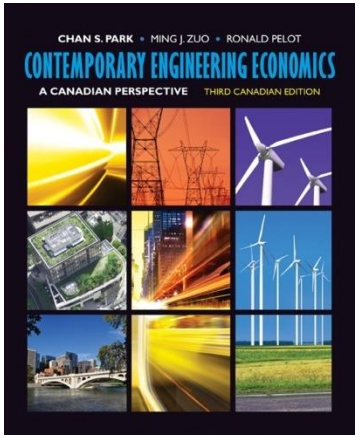
Cost Concepts Relevant to Decision Making



Lecture No. 20
Chapter 7
Contemporary Engineering Economics
Third Canadian Edition

Chapter Opening Story: High Hopes for Plastic Beer Bottles

High Hopes for Beer Bottles Three hundred billion beer bottles a year worldwide is a mighty tempting target for the plastics industry. Brewers generally say they need a bottle that provides shelf life of over 120 days with less than 15% loss of CO_2 and admittance of no more than 1 ppm of oxygen. Internal or external coatings, and three- or five-layer polyethylene terephthalate (PET) structures using barrier materials are being evaluated to reach that performance.

Summit International LLC, of Smyrna, Georgia, which specializes in preform and container development and market research, compared the manufacturing costs of five different barrier technologies against a standard monolayer PET bottle. Summit looked at three-layer and five-layer and at internally and externally coated containers, all of them reheat stretch blow moulded.

Chapter Opening Story: High Hopes for Plastic Beer Bottles (continued)

- What is the least expensive way to make a 0.5 L PET barrier beer bottle?

Types of Production Method	5-layer	3-layer	Internal coating	External coating
Capital investment (20,000 bottles/hr)	$10.8M	$9.9M	$9.2M	$7.5M
Direct Mfg Cost (per 1,000 units)	$59.35	$66.57	$46.90	$55.34
Comments	Need a bottle that provides shelf life of over 120 days with less than 15% loss of CO_2 and admittance of no more than 1 ppm of oxygen			

- Question: How were the cost data estimated?

Chapter 7 Objectives

- What are the various cost terminologies that are common in cost accounting and engineering economic studies?
- How does a cost item react or respond to changes in the level of production or business activities?
- What are the types of cost data that management needs in making choice between alternative courses of action?

Chapter 7 Objectives (continued)

- What are the types of present economic studies frequently performed by engineers in manufacturing and business environments?
- How does a firm develop a production budget related to operating activities?

Lecture 20 Objectives

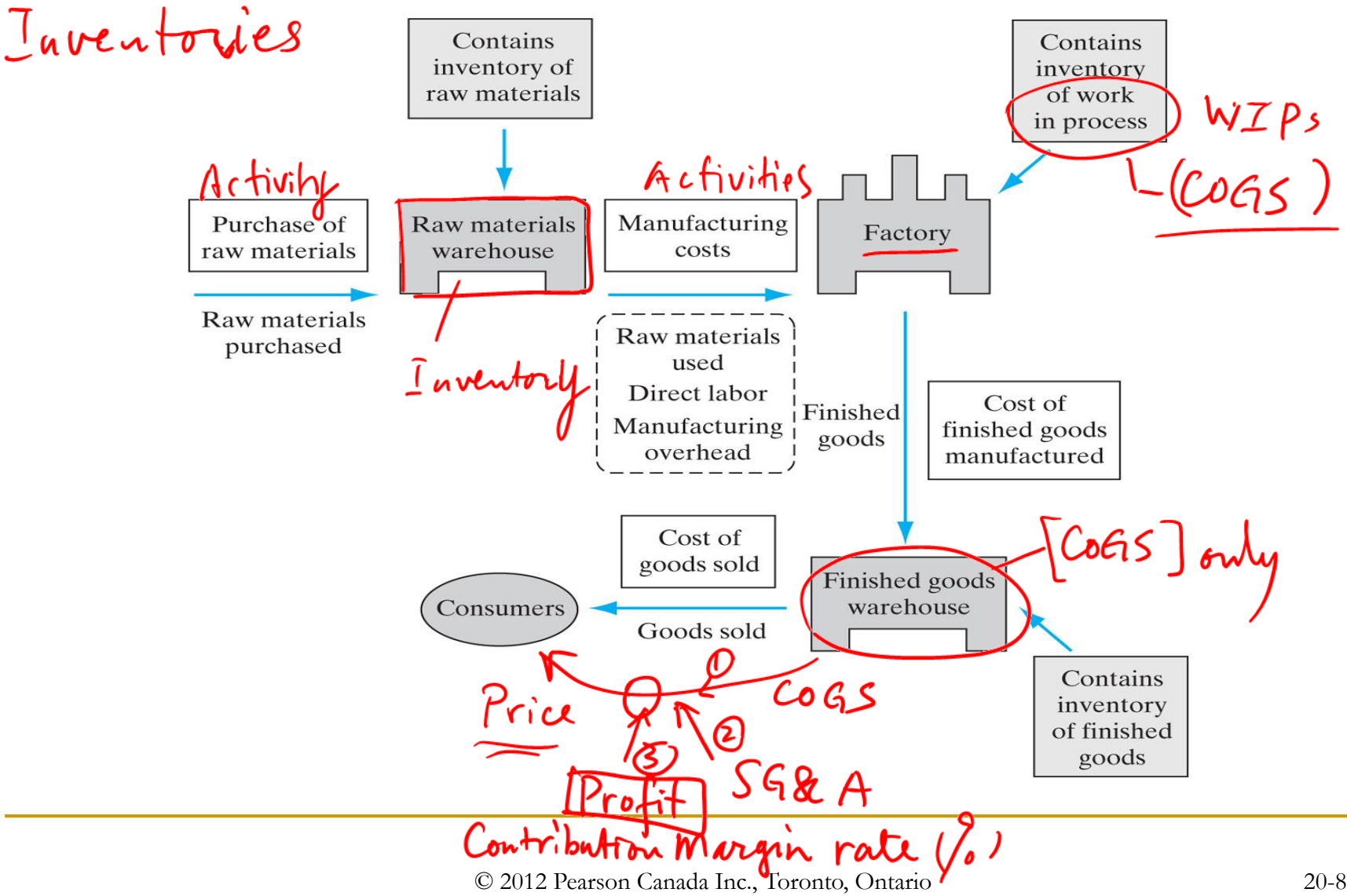
- What are the various cost terminologies that are common in cost accounting and engineering economic studies?
- How does a cost item react or respond to changes in the level of production or business activities?

fixed cost / variable cost ?

General Cost Terms

- Manufacturing Costs
  - **Direct Cost**: a cost that can be directly traced to producing specific goods or services; examples include direct raw materials and direct labour
  - **Overhead**: a reference in accounting to all costs not related to direct labour and direct materials. Examples include indirect materials, indirect labor, maintenance and repair costs, heat and lighting, equipment depreciation,etc.
- Nonmanufacturing Costs
  - additional costs incurred in supporting any manufacturing operation, such as overhead associated with the company's selling and administration functions, marketing associated with sales activities, and administrative functions

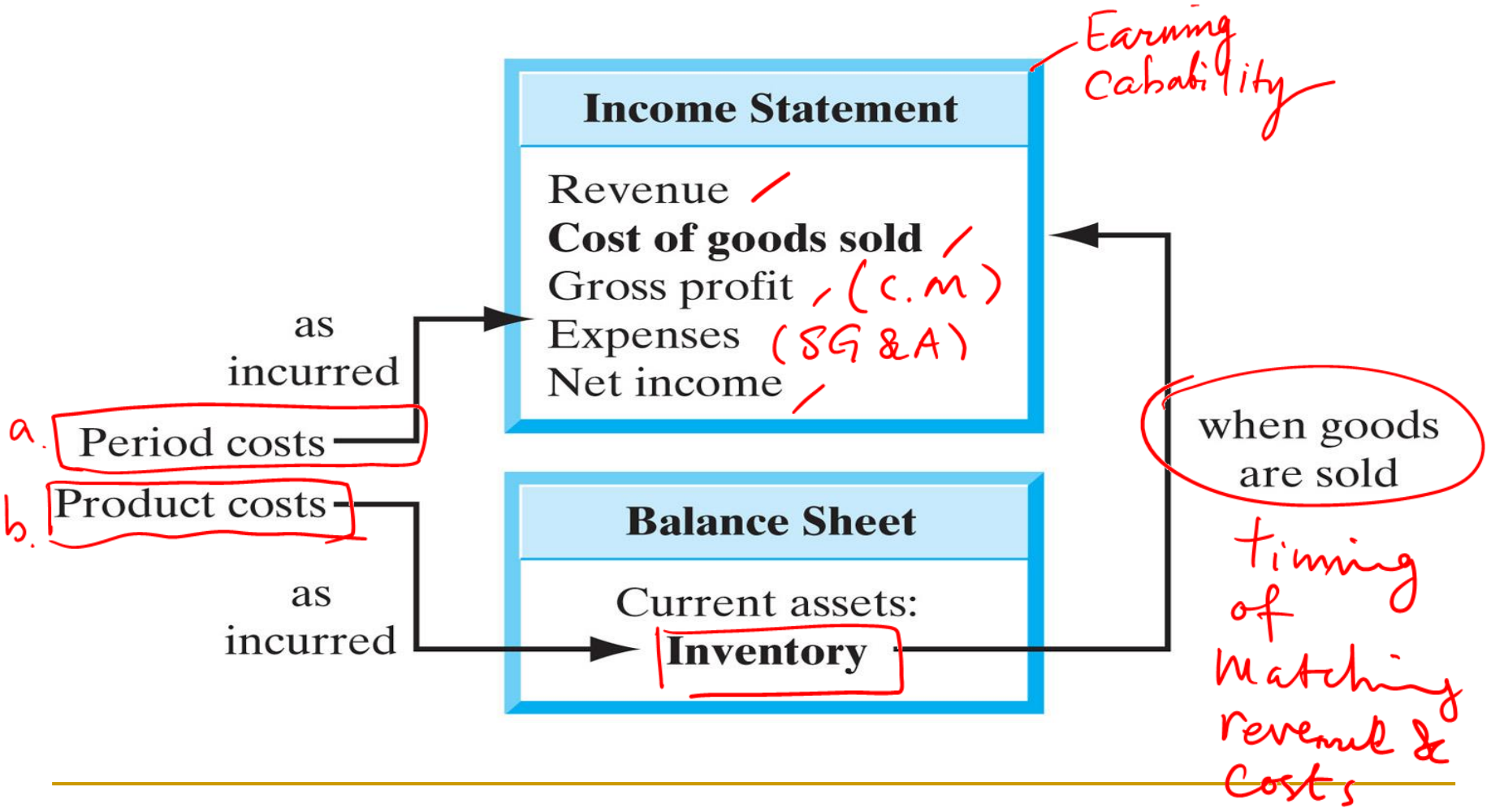
Various Types of Manufacturing Costs



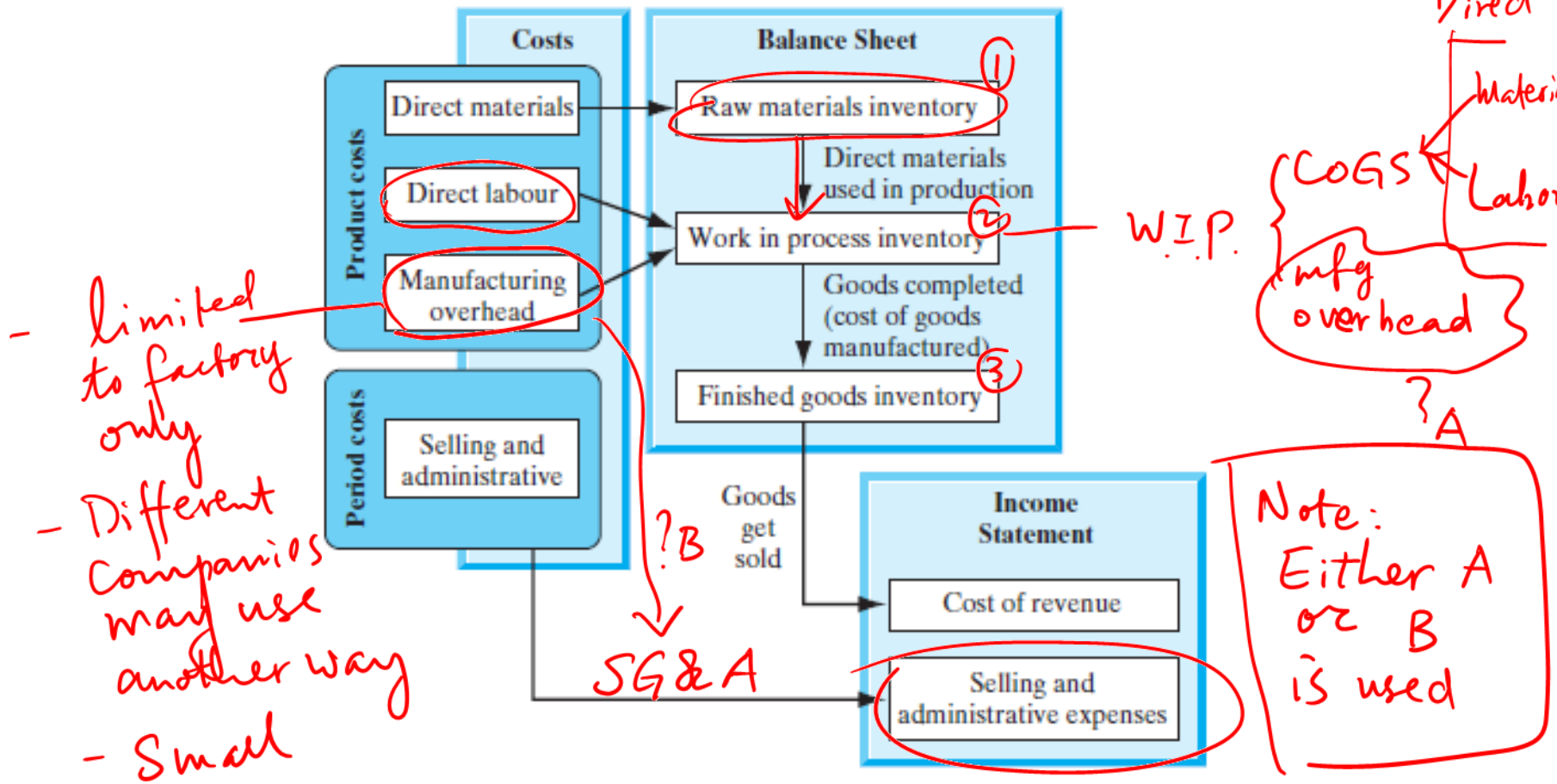
Classifying Costs for Financial Statements

- **Matching Concept:** The costs incurred to generate particular revenue should be recognized as expenses in the same period that the revenue is recognized.
- **Period Costs:** Associated revenues are received in the same period the cost is incurred. Some examples include: general and administrative expenses, selling expenses, insurance and income tax expenses.
- **Product Costs:** Those costs that are matched against revenues on a product basis. They are costs involved in the purchase or manufacture of goods. Some examples include direct material cost, direct labour cost, and manufacturing overhead.

How the Period Costs and Product Costs Flow Through the Financial Statement



Cost Flows and Classifications in a Manufacturing Company



Example 7.1: Classifying Costs for Uptown Ice Cream Shop

Product Cost

Period Cost

Items	Total Cost	Unit Cost*	% of Price
Ice cream (cream, sugar, milk, and milk solids)	$120,250	$0.65	26%
Cone	9,250	0.05	2
Rent	132,275	0.71	29
Wages	46,250	0.25	10
Benefit	9,250	0.05	2
GST	23,125	0.13	5
Income taxes	14,800	0.08	3
Debt service	42,550	0.23	9
Supplies	16,650	0.09	4
Utilities	14,800	0.08	3
Other expenses (insurance, advertising, fees, and heating and lighting for shop)	9,250	0.05	2
Profit	24,050	0.13	5
Total	**$462,500**	**$2.50**	**100**

Example 7.1: Classifying Costs for Uptown Ice Cream Shop (continued)

- Product Costs

Raw materials:	
Ice cream @ $0.65	$120,250
Cone @ $0.05	9,250
Labour:	
Wages @ $0.25	46,250
Benefits @ $0.05	9,250
Overhead:	
Supplies @ $0.09	16,650
Utilities @ $0.08	14,800
Total product cost	$216,450

Volume based

- Period Costs

Business taxes:	
GST @ $0.13	$ 23,125
Income taxes @ $0.08	14,800
Operating expenses:	
Rent @ $0.71	132,275
Debt service @ $0.23	42,550
Other @ $0.05	9,250
Total period cost	$222,000

Time

Cost Classification for Predicting Cost Behaviour

- Volume Index
  - The unit of measure used to define operating volume or activity. May be based on production inputs or production outputs.
- Cost Behaviours
  - Fixed Costs: costs of providing a company's basic operating capacity; independent of the level of volume of a business
  - Variable Costs: close relationship to level of volume of a business; includes direct labour and material costs
  - Mixed Costs: contain elements of both fixed costs and variable costs; examples include depreciation and electricity costs

Cost Classification for Predicting Cost Behaviour (continued)

- Average Unit Costs: expresses activity on a per unit basis
  - Fixed cost per unit varies with changes in volume.
  - Variable cost per unit of volume is a constant.
  - Mixed cost per unit of volume contains both the constant and variable elements.

Assumptions Used in Calculating the Average Cost of Owning and Operating a New Vehicle

What's Covered	Costs Base
Fuel	National average self-service price 81.2 ¢ per litre for regular-grade gasolines.
Maintenance	Costs of retail parts and labour for routine maintenance, as specified by the vehicle manufacturer.
Tires	Costs are based on the price of one set of replacement tires of the same quality, size, and ratings as those that came with the vehicle.
Insurance	A full-coverage policy for a mature driver with a good driving record and commuting fewer than 16 kilometres per day to and from work.
Licence, Registration, and Taxes	All government taxes and fees payable at time of purchase, as well as fees due each year to keep the vehicle licensed and registered.
Depreciation	Based on the difference between the new-vehicle purchase price and the estimated trade-in value at the end of four years.
Finance	Based on a four-year loan at 7.25% interest with a 10% down payment.

Example 7.2: Calculating Average Cost per Kilometre as a Function of Mileage (continued)

Cost Classification of Owning and Operating a Passenger Car

Cost Classification	Reference	Cost
Variable costs:		
Fuel per kilometre		$0.068
Maintenance per kilometre		$0.024
Tires per kilometre		$0.016
Annual fixed costs:		
Insurance (comprehensive)		$1780
Licence, registration, taxes		$111
Finance charge		$768
Mixed costs: Depreciation		
Fixed portion per year (18,000 kilometres)		$3857
Variable portion per kilometre (above 18,000 kilometres)		$0.024

Example 7.2: Calculating Average Cost per Kilometre as a Function of Mileage

Given the data in the previous slide, develop a cost-volume chart and calculate the average cost per kilometre as a function of the annual mileage

DISCUSSION: First we may examine the effect of driving an additional 1000 kilometres over the allotted 18,000 kilometres. Since the loss in the car's value due to driving an additional 1000 kilometres over 18,000 kilometres is estimated to be $24, the total cost per year and the average cost per kilometre, based on 19,000 kilometres, can be recalculated as follows:

- Added depreciation cost: $24.
- Added operating cost: 1000 kilometres × 10.70 cents = $107.
- Total cost per year: $8442 + $24 + $107 = $8573.
- Average cost per kilometre ($8573/19,000 kilometres): 45.12 cents per kilometre.

Note that the average cost comes down as you drive more, as the ownership cost per kilometre is further reduced.

SOLUTION

Given: Financial data.

Find: The average cost per kilometre at an annual operating volume between 18,000 and 24,000 kilometres.

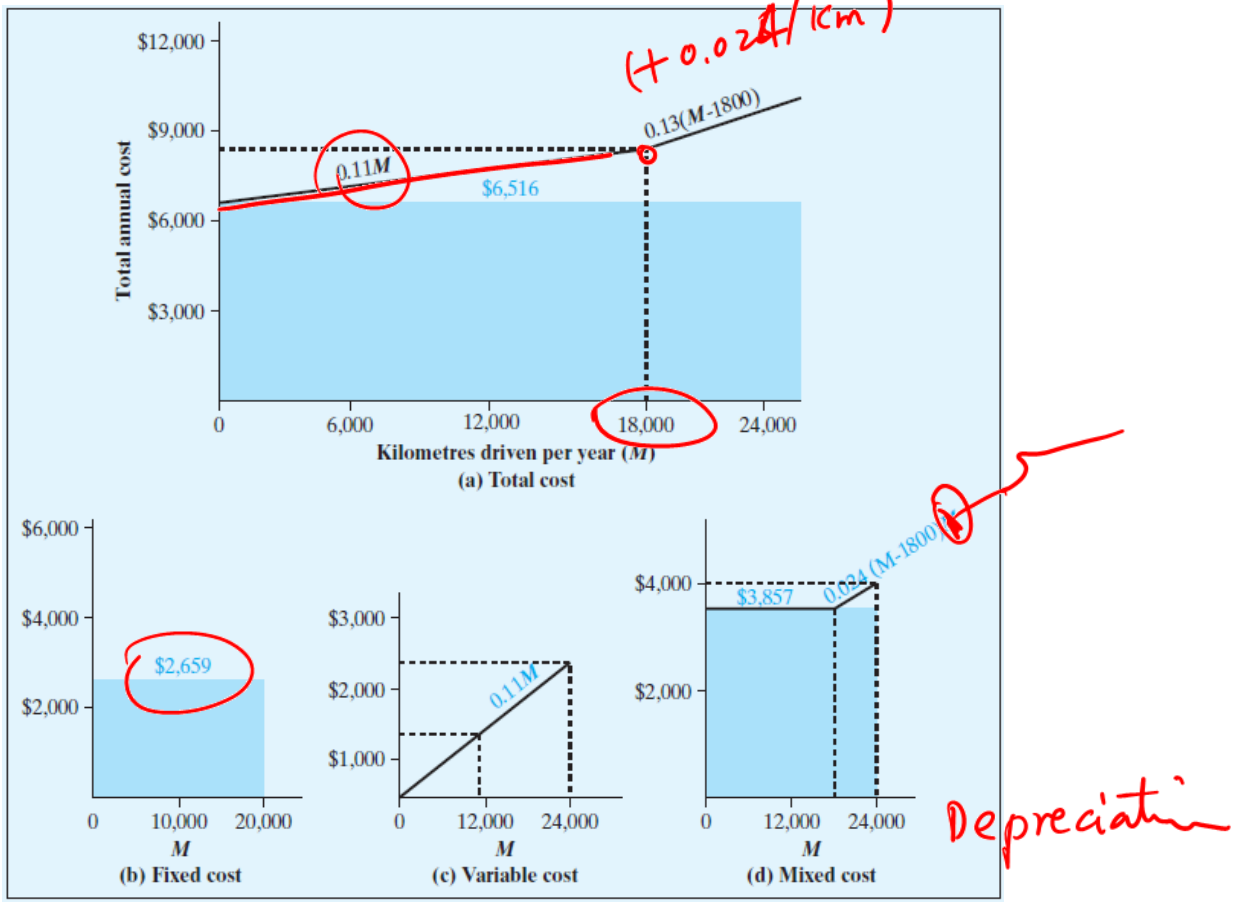
Example 7.2: Calculating Average Cost per Kilometre as a Function of Mileage (continued)

Operating Costs as a Function of Mileage Driven

Volume Index (km)	18,000	19,000	20,000	21,000	22,000	23,000	24,000
Variable costs ($0.107 per km)	$1926	$2033	$2140	$2247	$2354	$2461	$2568
Fixed costs:	2659	2659	2659	2659	2659	2659	2659
Mixed costs (depreciation):							
Fixed portion:	3857	3857	3857	3857	3857	3857	3857
Variable portion ($0.024/km):	–	24	48	72	96	120	144
Total variable cost	1926	2057	2188	2319	2450	2581	2712
Total fixed cost	6516	6516	6516	6516	6516	6516	6516
Total costs	$8442	$8573	$8704	$8835	$8966	$9097	$9228
Cost per km	$0.4690	$0.4512	$0.4352	$0.4207	$0.4075	$0.3955	$0.3845

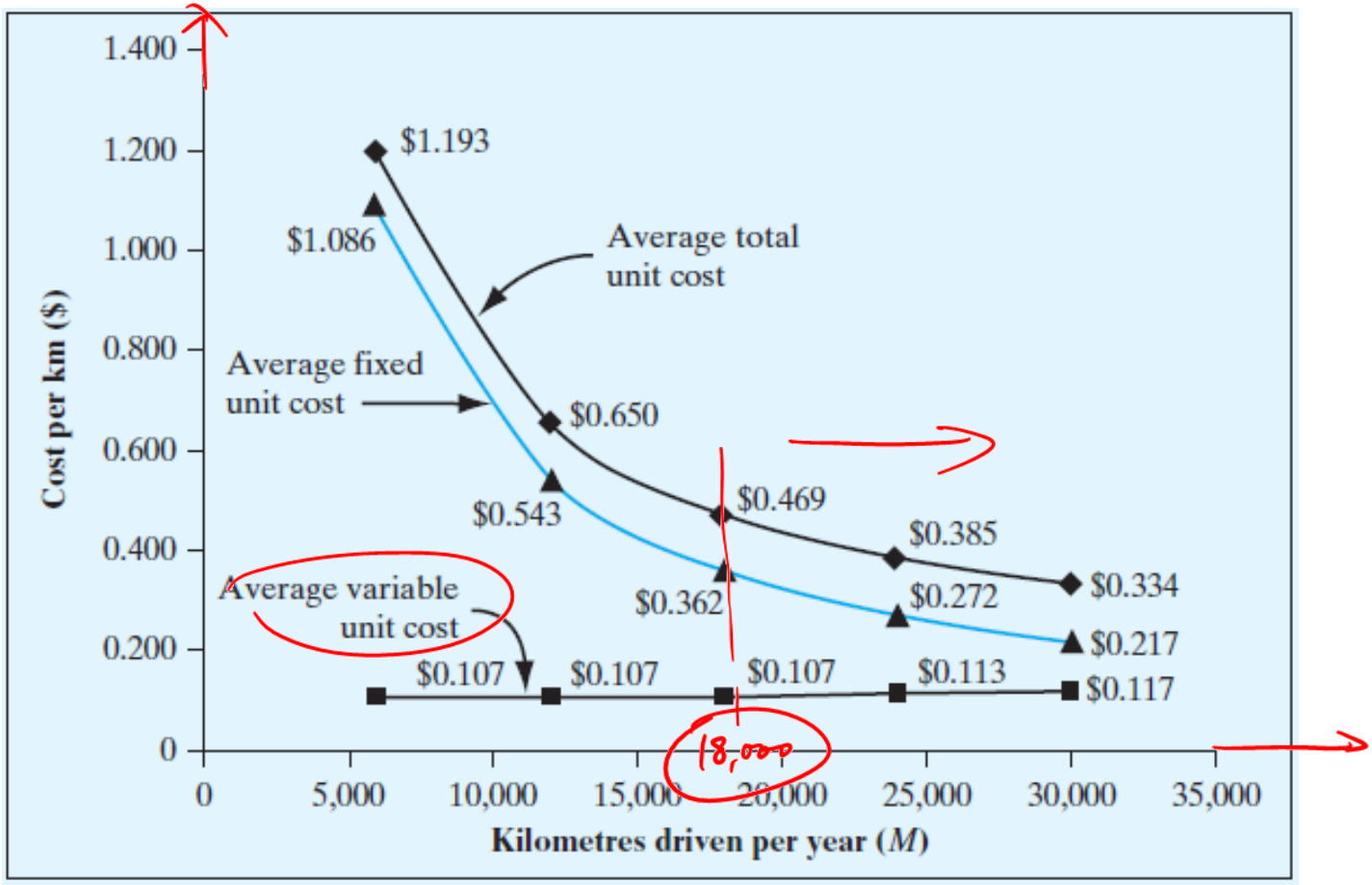
Example 7.2: Calculating Average Cost per Kilometre as a Function of Mileage (continued)

Cost–volume relationships pertaining to annual automobile costs



Example 7.2: Calculating Average Cost per Kilometre as a Function of Mileage (continued)

Average cost per kilometre of owning and operating a car



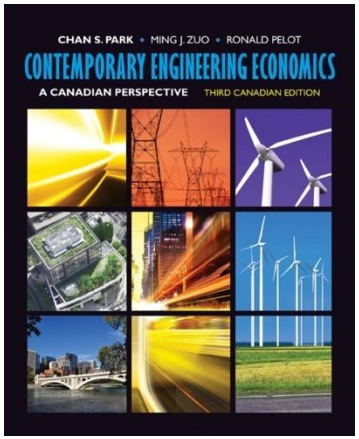
Period Cost or Product Cost?

- Storage and material handling costs for raw materials.
- Gains or losses on the disposal of factory equipment.
- Lubricants for machinery and equipment used in production.
- Depreciation of manufacturing equipment.
- Depreciation of the company president's automobile.
- Leasehold costs for land on which factory buildings stand.
- Inspection costs of finished goods.
- Direct labour cost.
- Raw-materials cost.
- Advertising expenses.

Fixed Cost or Variable Cost?

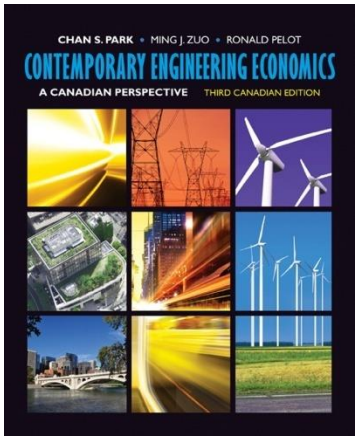
- Wages paid to temporary workers.
- Property taxes on a factory building.
- Property taxes on an administrative building.
- Sales commission.
- Electricity for machinery and equipment in the plant.
- Heating and air-conditioning for the plant.
- Salaries paid to design engineers.
- Regular maintenance on machinery and equipment.
- Basic raw materials used

Summary



Manufacturing companies divide manufacturing costs into three broad categories: direct materials, direct labour, and manufacturing overhead. Nonmanufacturing costs are classified into two categories: marketing or selling costs and administrative costs. For inventories and expenses, costs are commonly classified as either product costs or period costs.

Cost-Volume-Profit Analysis



Lecture No. 21
Chapter 7
Contemporary Engineering Economics
Third Canadian Edition

Lecture 21 Objectives

- What are the types of cost data that management needs to choose between alternative courses of action?
- What are the types of economic studies frequently performed by engineers in manufacturing and business environments?

Future Costs for Business Decisions

As an engineer

- Differential (Incremental) cost: costs that represent the differences in total costs, which results from selecting one alternative instead of other; increase or decrease with the overall change that a company experiences by producing one additional unit of good
- Opportunity cost: the benefits you could have received by taking an alternative solution

Future Costs for Business Decisions (continued)

- Sunk cost: a cost that has been incurred and cannot be reversed; not relevant to current and future decisions
  - Example: $200 spent 5 months ago to replace a water pump — not relevant in making a decision on this pump today or in the future

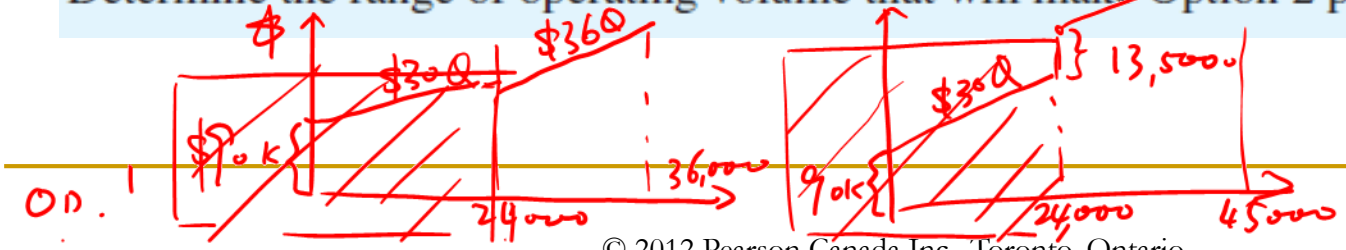
- Marginal cost: the cost associated with one additional unit of production

Example 7.4: Break-Even Analysis

Sandstone Corporation has one of its manufacturing plants operating on a single-shift five-day week. The plant is operating at its full capacity (24,000 units of output per week) without the use of overtime or extra shifts. Fixed costs for single-shift operation amount to $90,000 per week. The average variable cost is a constant $30 per unit, at all output rates, up to 24,000 units per week. The company has received an order to produce an extra 4000 units per week beyond the current single-shift maximum capacity. Two options are being considered to fill the new order:

- **Option 1.** Increase the plant's output to 36,000 units a week by adding overtime, by adding Saturday operations, or both. No increase in fixed costs is entailed, but the variable cost is $36 per unit for any output in excess of 24,000 units per week, up to a 36,000-unit capacity.
- **Option 2.** Operate a second shift. The maximum capacity of the second shift is 21,000 units per week. The variable cost of the second shift is $31.50 per unit, and the operation of a second shift entails additional fixed costs of $13,500 per week.

Determine the range of operating volume that will make Option 2 profitable.

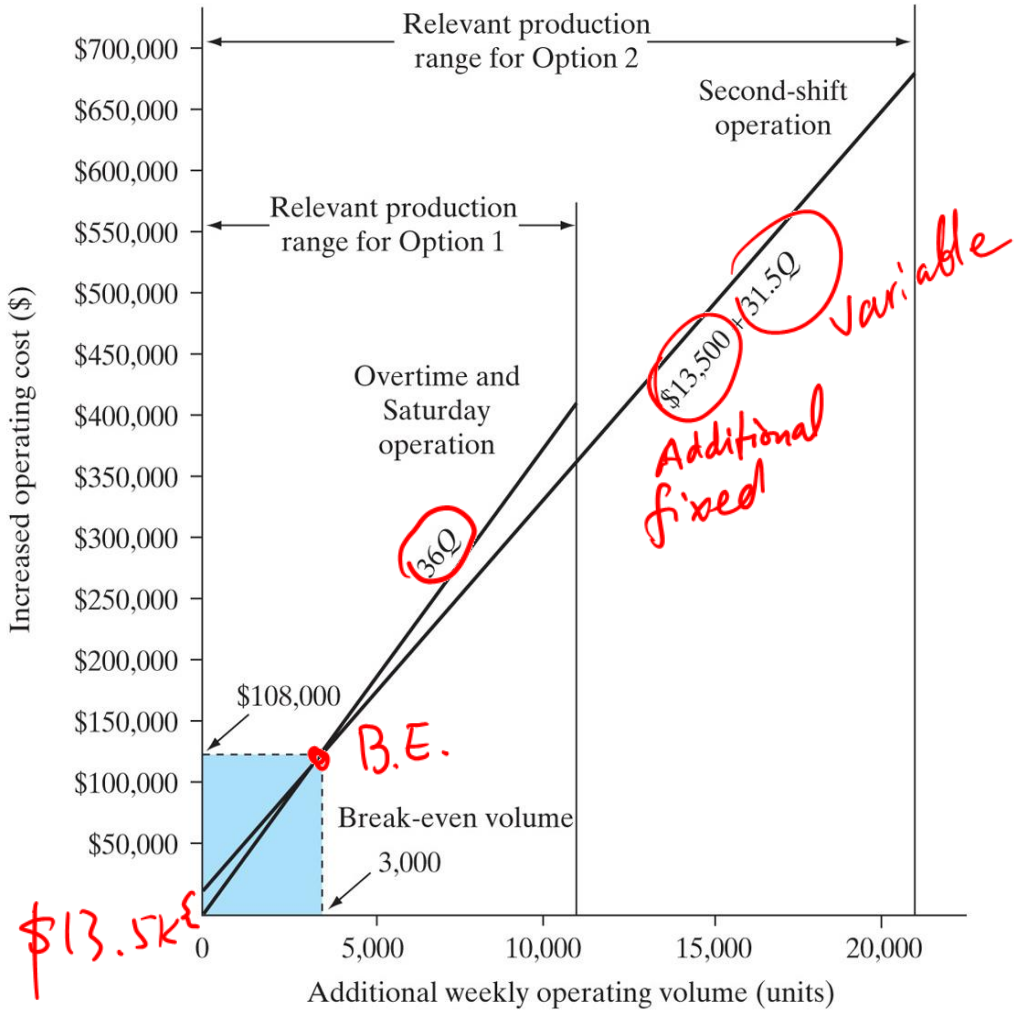


Example 7.4: Break-Even Analysis (continued)

- Option 1: Adding overtime or Saturday operations: 36Q
- Option 2: Second-shift operation: $13,000 + 31.50Q
- Break-even volume:

  36Q = $13,000 + 31.50Q

Q = 3,000 units



Example 7.5: Opportunity Cost: Lost Rental Income

Benson Company is a farm equipment manufacturer that currently produces 20,000 units of gas filters annually for use in its lawn mower production. The expected annual production cost of the gas filters is summarized as follows:

Variable costs:	
Direct materials	$100,000
Direct labour	190,000
Power and water	35,000
Fixed costs:	
Heating and light	20,000
Depreciation	100,000
Total cost	$445,000

Tompkins Company has offered to sell Benson 20,000 units of gas filters for $17 per unit. If Benson accepts the offer, some of the manufacturing facilities currently used to manufacture the filters could be rented to a third party at an annual rent of $35,000. Should Benson accept Tompkins's offer, and why?

Example 7.5: Solution

Given: Financial data; production volume = 20,000 units.

Find: Whether Benson should outsource the gas filter operation.

	Make Option	Buy Option	Differential Cost (Make-Buy)
Variable costs:			
Direct materials	$100,000		$100,000
Direct labour	190,000		190,000
Power and water	35,000		35,000
Gas filters		340,000	−340,000
Fixed costs:			
Heating and light	20,000	20,000	0
Depreciation	100,000	100,000	0
Rental income lost	35,000		35,000
Total cost	$480,000	$460,000	$20,000
Unit cost	$24.00	$23.00	$1.00

$17/unit

This problem is unusual in the sense that the buy option would generate a rental fee of $35,000. In other words, Benson could rent out the current manufacturing facilities if it were to purchase the gas filters from Tompkins. To compare the two options, we need to examine the cost of each option.

The buy option has a lower unit cost and saves $1 for each use of a gas filter. If the lost rental income (opportunity cost) were not considered, however, the decision would favor the make option.

Example 7.6: Marginal Costs versus Average Costs

Consider a company that has an available electric load of 37 horsepower and that purchases its electricity at the following rates:

	kWh/Month	@$/kWh	Average Cost ($/kWh)
(1)	First 1500	$0.050	$0.050
(2)	Next 1250	0.035	$\frac{\$75 + 0.0350(X - 1500)}{X}$
(3)	Next 3000	0.020	$\frac{\$118.75 + 0.020(X - 2750)}{X}$
(4)	All over 5750	0.010	$\frac{\$178.25 + 0.010(X - 5750)}{X}$

According to this rate schedule, the unit variable cost in each rate class represents the marginal cost per kilowatt-hours (kWh). Alternatively, we may determine the average costs in the third column by finding the cumulative total cost and dividing it by the total number of kWh (X). Suppose that the current monthly consumption of electric power averages 3200 kWh. On the basis of this rate schedule, determine the marginal cost of adding one more kWh and, for a given operating volume (3200 kWh), the average cost per kWh.

Example 7.6: Solution

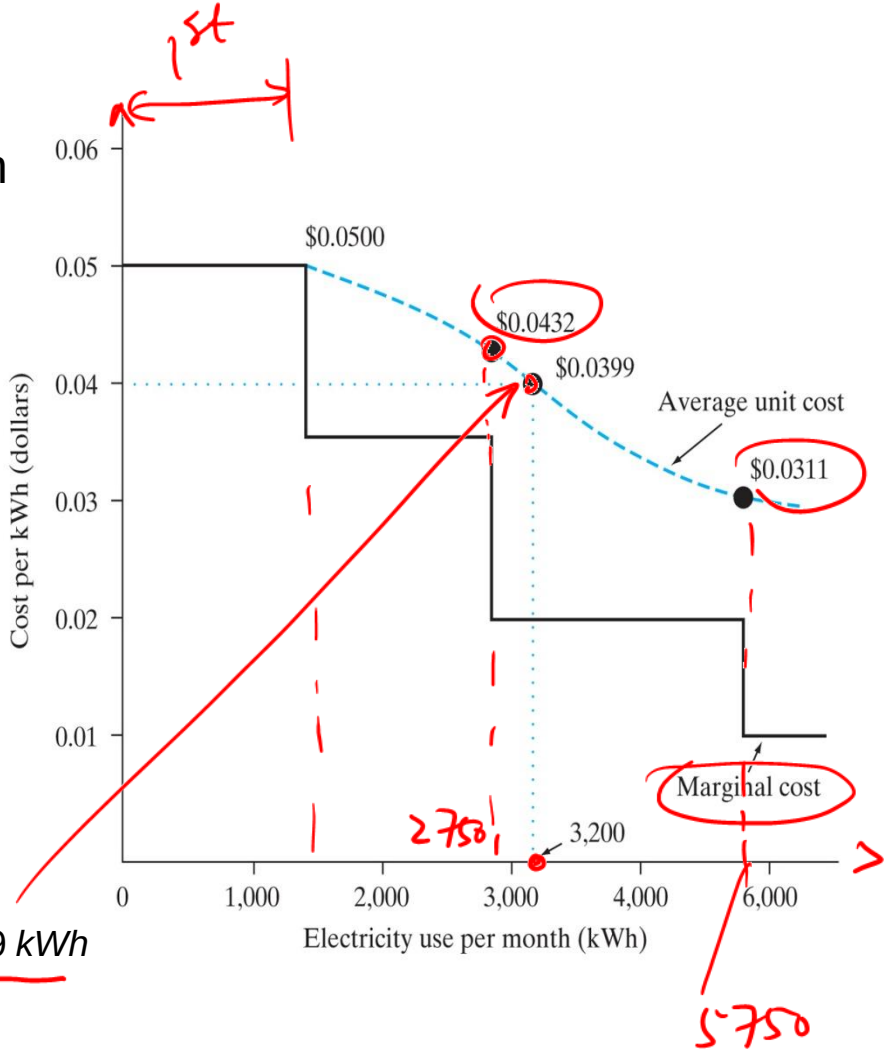
Given: Marginal cost schedule for electricity; operating volumene = 3200 kWh

Marginal cost of adding 1 more kWh = $0.02. Average cost is as follows:

kWh	Rate ($/kWh)	Cost
First 1500	0.050	$75.00
Next 1250	0.035	43.75
Remaining 450	0.020	9.00
Total		$127.75

The average variable cost per kWh is $127.75/3200 kWh = $0.0399 kWh

$$\frac{\$118.75 + 0.020(3200 - 2750)}{3200} = \frac{\$127.75}{3200\ kWh} = \$0.0399\ kWh$$



Example 7.7: Profit-Maximization Problem: Marginal Analysis

- Pharmaceutical company wants to maximize its profits when producing brand-name and generic aspirin with the following information:

- *Generic aspirin.* Each day, you can make 1000 cases of generic aspirin. You can sell as many as you make, for the market price of $10 per case. Every week you have fixed costs of $5000 (property tax and insurance). No matter how many cases you manufacture, the cost of materials and supplies is $2 per case; the cost of labour is $5 per case, except on Sundays, when it is $10 per case.
- *Brand-name aspirin.* Your order for the brand-name aspirin requires that you manufacture 1000 cases per week, which you sell for $30 per case. The cost for the brand-name aspirin is identical to the cost of the generic aspirin.

- Maximum weekly production capacity: 7000 cases of aspirin possibly including maximum1000 cases of brand name aspirin
- What is the optimal production mix?

Example 7.7: Solution

Product Brand-name aspirin — Volume of production per week — On Monday

Total revenue function:
$$\begin{cases} 30Q & \text{for } 0 \le Q \le 1{,}000 \\ 30{,}000 + 10(Q - 1{,}000) & \text{for } 1{,}000 < Q \le 7{,}000 \end{cases}$$

Base Rev. — Brand name — Generic

Total cost function:
$$\begin{cases} 5{,}000 + 7Q & \text{for } 0 \le Q \le 6{,}000 \\ 47{,}000 + 12(Q - 6{,}000) & \text{for } 6{,}000 < Q \le 7{,}000 \end{cases}$$

F — V — last 6 days — (5000 + 7×6000 = 47,000 V.) — incremental

Brand-name asprin first: $30Q - 7Q - 5{,}000 = 0$ — $23Q - 5000 = 0$

$Q_b = 217.39 = \frac{5000}{23} = \$217.39 = \$218$ ✓

Generic asprin first: $10Q - 7Q - 5{,}000 = 0$ — Before Saturday

$Q_b = 1666.67$

1667 ✓

Example 7.7: Solution

Assume we produce Brand-named aspirin first

Net Profit Calculation as a Function of Production Volume

	Production Volume (Q)	Product Mix	Revenue	Total Revenue	Variable Cost	Fixed Cost	Total Cost	Net Profit
	0		0	0	0	$5,000	$5,000	−$5,000
Mon	1,000	Brand name	$30,000	$30,000	$7,000	0	12,000	18,000
Tue	2,000	Generic	$10,000	40,000	7,000	0	19,000	21,000
Wed	3,000	Generic	10,000	50,000	7,000	0	26,000	24,000
Thu	4,000	Generic	10,000	60,000	7,000	0	33,000	27,000
Fri	5,000	Generic	10,000	70,000	7,000	0	40,000	30,000
Sat	6,000	Generic	10,000	80,000	7,000	0	47,000	33,000
Sun	7,000	Generic	10,000	90,000	12,000	0	59,000	31,000

Cumulated

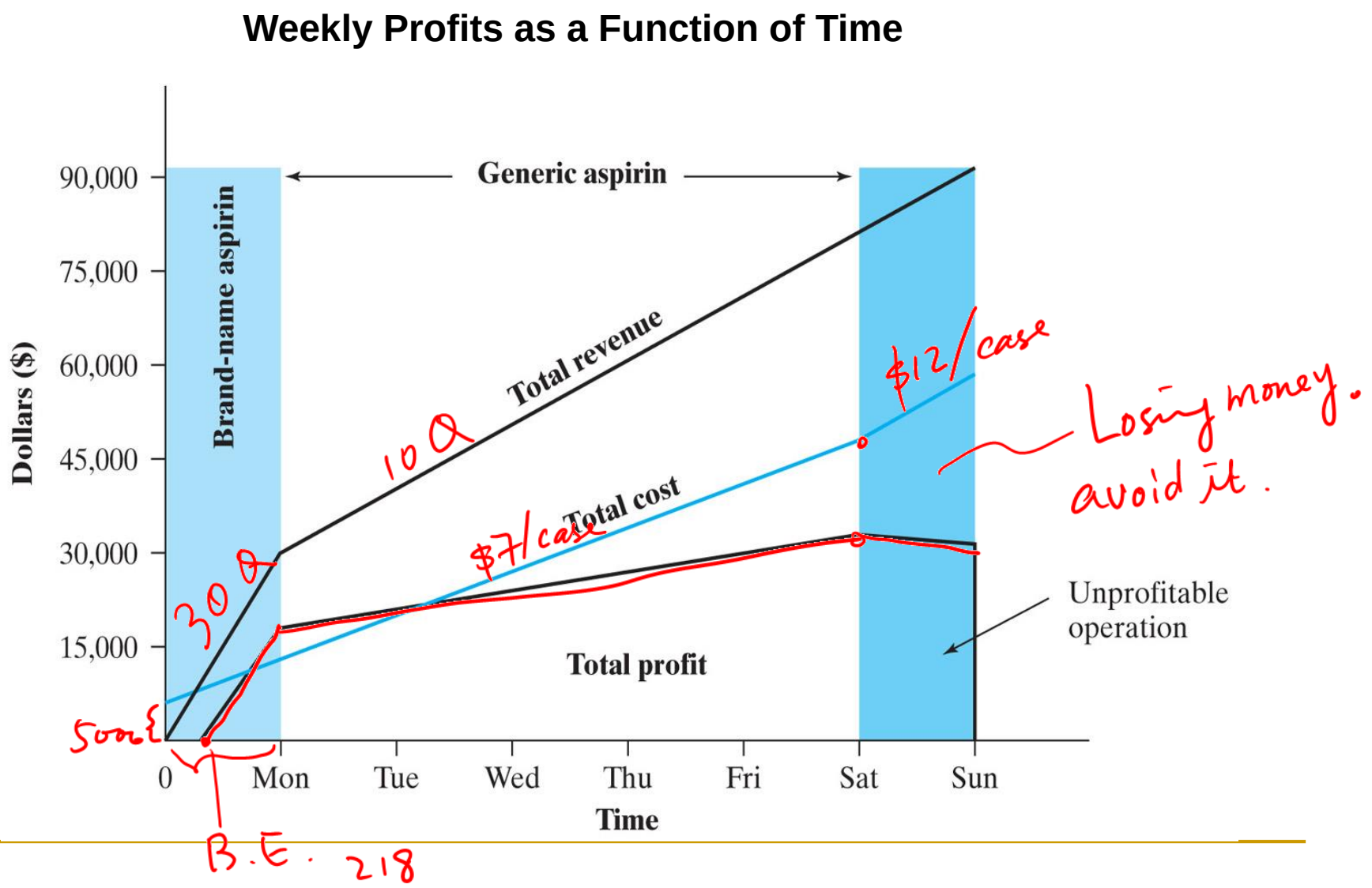
$30

(2+5)·1000

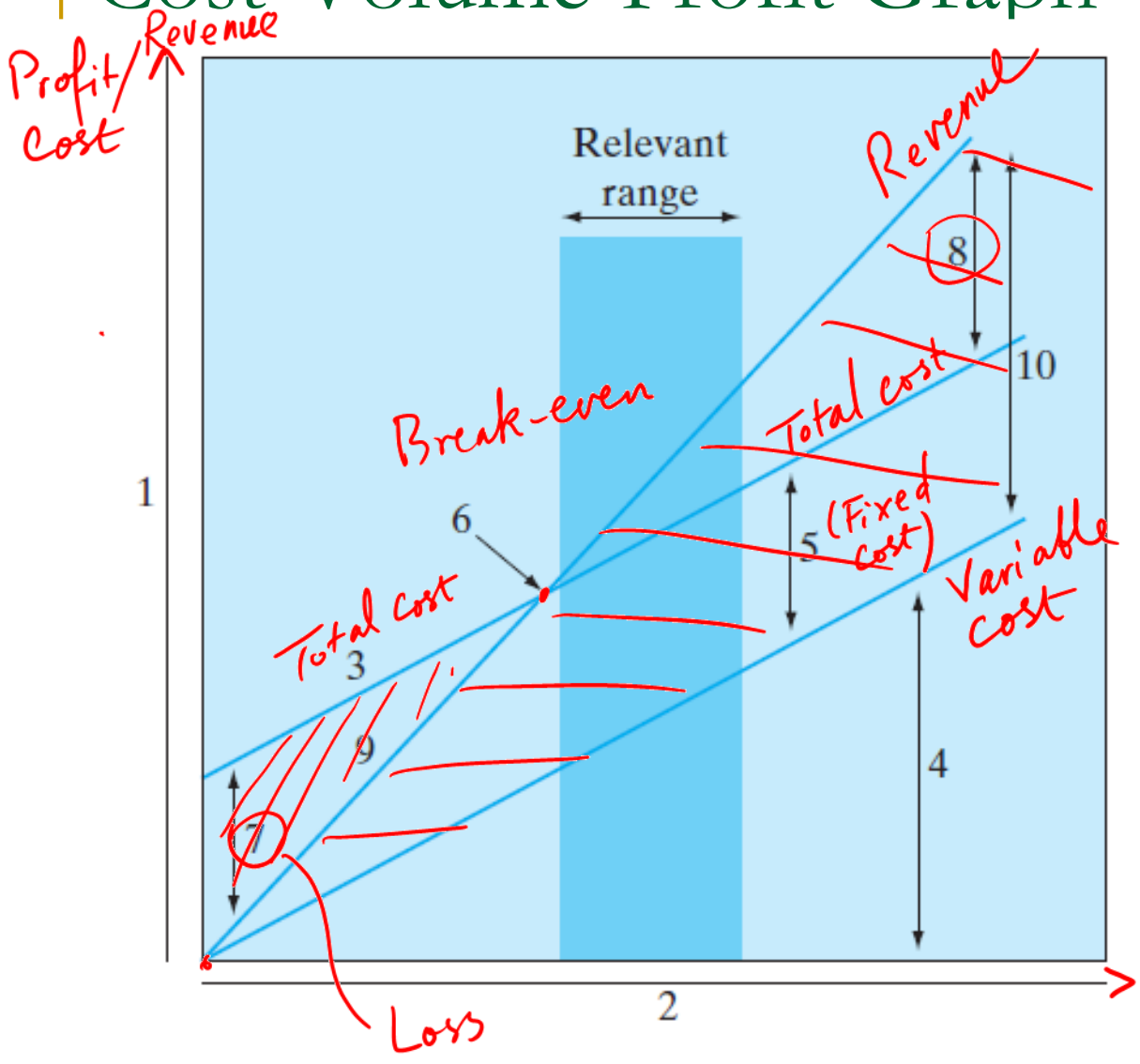
$10

Labor Cost double

Example 7.7: Solution

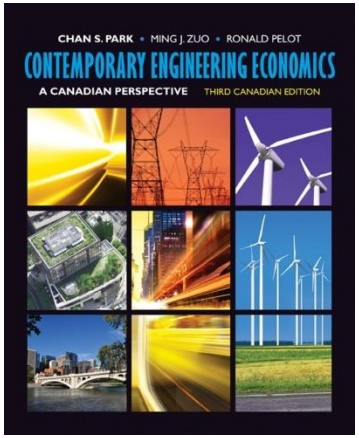


Cost-Volume-Profit Graph



- X-axis: Volume – 2
- Y-axis: Cost or Profit – 1
- Fixed cost – 5
- Variable cost – 4
- Total cost – 3
- Total revenue – 9
- Profit – 8
- Loss – 7
- Break-even point – 6
- Marginal contribution – 10 (Revenue – Variable Cost)

Summary



An understanding cost–volume relationships is essential to developing successful business strategies and to planning future operations. Marginal analysis asks the question “Will the benefits of an action be greater than its costs?”