Yıldız Technical University
Civil Engineering Department

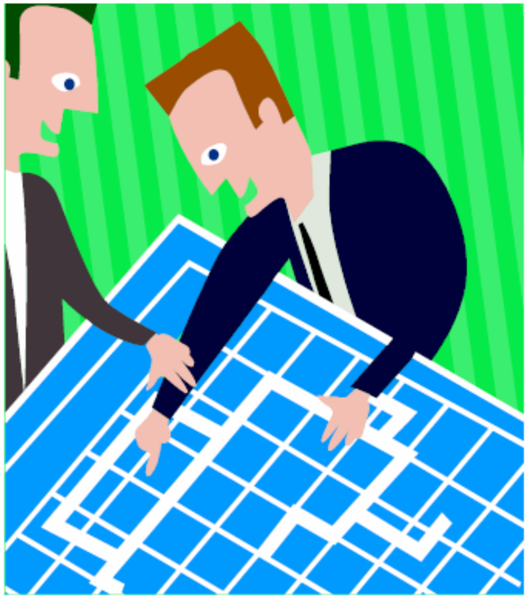
Engineering Economy

What is engineering?

- **Engineering** is the discipline, art, skill and profession of acquiring and applying scientific, mathematical, economic, social, and practical knowledge, in order to design and build structures, machines, devices, systems, materials and processes that safely realize improvements to the lives of people.
- Wellington defined Engineering as the science "of doing for a dollar what any fool can do with two, in a fashion."
- According to these definitions, engineers should consider the economic side of all processes performed in creating an output.

The role of an engineering in business life

- To participate in many decision making stages; (such as processes, manufacturing, marketing and finance),
- Making replacement and retention decisions,
- Design of products.



Economics

"Economics is the study of how people and society choose to employ scarce resources that could have alternative uses in order to produce various commodities and to distribute them for consumption, now or in the future, …"

Engineering economy

- Engineering economy involves formulating, estimating, and evaluating the economic outcomes when alternatives to accomplish a defined purpose are available.
- Engineering economy is at the heart of making decisions.
- The principles and methodologies of engineering economy can be used in wide range of application area, including design, technical and general management.
- If there are costs and revenues in a business, the principles of engineering economy can be exploited.

Why do engineers need to learn about engineering economy?

- The decisions made by engineers decide how the financial resources will be exploited. For example,
  - A new product development
  - Replacement of existing machine
  - Build or buy decisions
  - Select the best design alternative between different alternatives
- The engineers do not have unlimited resources, in other words they work with limited resources, therefore these resources should be used effectively.
- Consequently, these resources do not belong to the companies. Most of the financial resources are provided by using bank credits. Even, the capital of the companies are provided by the debts given by the shareholders of the company. All these financial resources have costs.
- Engineering economy provides systematic approach and tools in decision making process.

Decision making process

- Understand the problem
- Analyse the problem
  - Define the objectives and purposes
  - Collect relevant information
- Define the feasible alternative solutions and make realistic estimates.
- Identify the criteria for decision making using one or more attributes.
- Evaluate each alternative, using sensitivity analysis to enhance the evaluation.
- Select the best alternative.
- Implement the solution.
- Monitor the results.

Principles of Engineering Economy

1. Alternatives should be developed.
2. The differences between the alternatives should be considered.
3. The alternatives should be developed by following a logical perspective.
4. The alternatives should be evaluated by using a common unit.
5. The criterions should be determined in evaluation process.
6. The outputs of alternatives consist of risk and uncertainty.
7. The outputs determined from the alternatives should be compared with the planned outputs.

Break even analysis

Break even analysis

- Breakeven analysis determines the value of a parameter or decision variable that makes two relations equal. For example, breakeven analysis can determine the required years of use to recover the initial investment and annual operating costs.
- **Break even point** is the point where net profit is zero. In other words, the revenue is equal to the total costs.

$$\text{Profit} = 0$$

$$\text{Revenue} = \text{Costs}$$

- Break even analyses can be performed by using graphical method, trial and error method and mathematical calculations.

Breakeven Applications

- Four major applications:

1. New product decisions
2. Pricing decisions
3. Modernization or automation decisions.
4. Expansion decisions.

Breakeven Applications

1. **New product decisions**
   - Determine sales volume required for firm (or individual product) to break even, given expected sales and expected costs

2. **Pricing decisions**
   - Study the effect of changing price and volume relationships on total profits

Breakeven Analysis

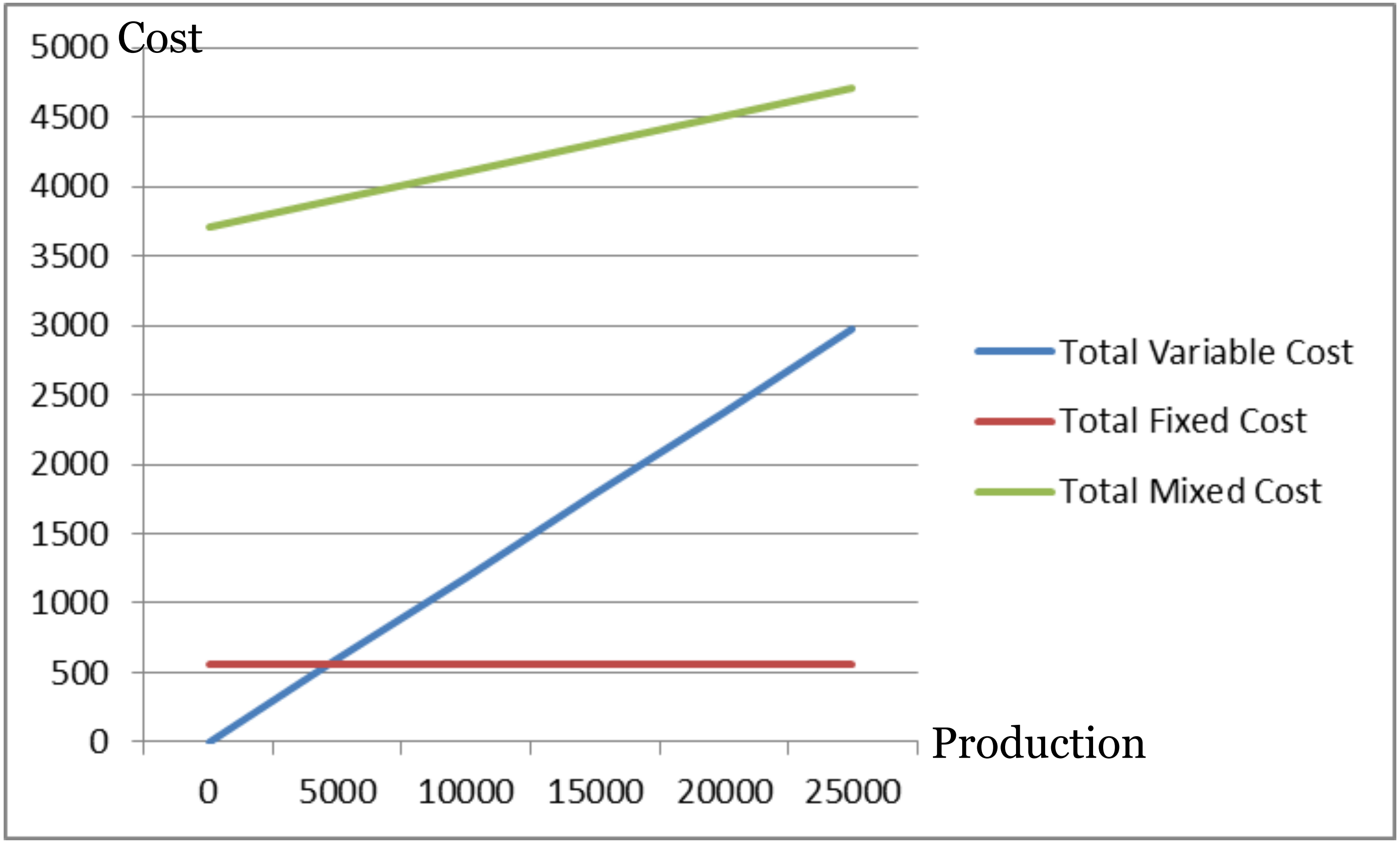
3. **Modernization or automation decisions**
   - Analyze profit implications of a modernization or automation program

4. **Expansion decisions**
   - Study aggregate effect of general expansion in production and sales

Costs

- Fixed Costs
  - The costs of providing a company's basic operating capacity are known as the company's fixed costs. The fixed costs do not change within a given time period, although volume may change. For example, insurance, taxes, rents and administration fees.
- Variable Costs
  - Variable costs have a close relationship to the level of volume of business. Direct labor and material, gasoline.
- Mixed Costs
  - Some costs do not fall precisely into either the fixed or variable costs category, but contain elements of both. Depreciation, electricity consumption.

Graph of total cost vs production



Average Unit Cost

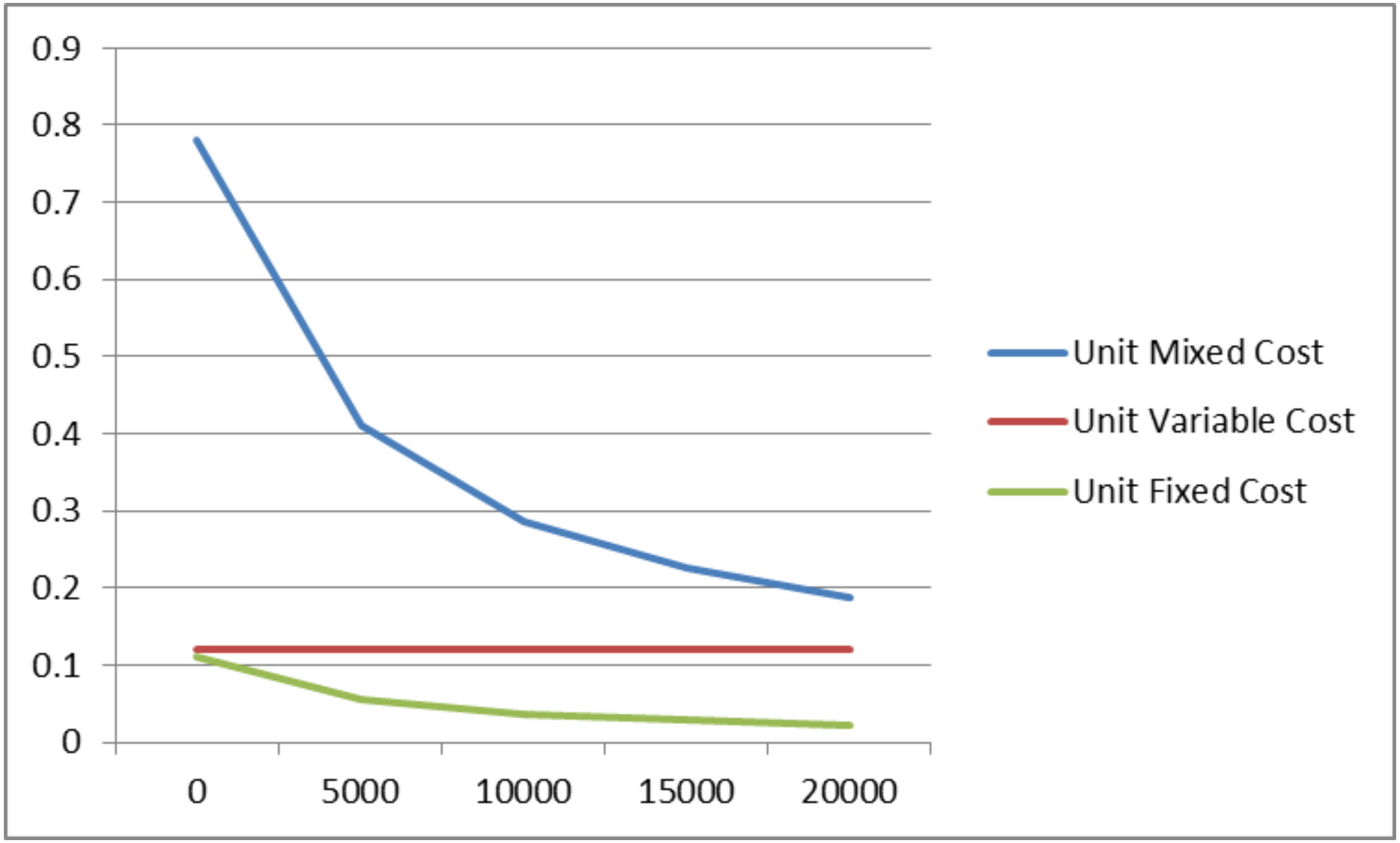
- The cost spent to produce a unit product. It is calculated by dividing the total cost of production to the total production.

- Fixed Costs
  - Fixed cost per unit varies with changes in volume: As the volume increases, the fixed cost per unit decreases.

- Variable Costs
  - The variable cost per unit of volume is a constant.

- Mixed Costs
  - The mixed cost per unit also changes as volume changes.

Unit Cost-Production



The cost of using a car

Cost classification		Reference	Cost
Variable cost			
The mile driven per gallon		20 mile/gallon	
The average fuel price		$1.34/galon	
Fuel consumption per mile			$0.0689
Maintenance cost per mile			$0.0360
Wheel cost per mile			$0.0141
Annual fixed costs			
Insurance			
Compulsory			$90
Private			$147
Personnel injuries and asset damage			$960
License plate			$95
Taxes			$372
Mixed Costs (Depreciation)			
Annual Fixed Cost			$3,703
Variable Cost per mile			$0.04

Produce or buy decision

- Company A produces 20,000 units of gas filters for engines annually. The predicted annual production costs are tabulated.

The direct material cost	\$100,000
The direct labor cost	\$9.5/unit
Energy and water	\$1.75/unit
Rent for the factory	\$20,000
Administration costs	\$20,000
Depreciation	\$100,000

Produce or buy decision

Company B proposes that they can sell 20,000 units of gas filters whose unit cost is $17.00/ unit. If Company A accepts this offer, they can rent the factory to a third party with $35,000 price per year.

Should the Company A accept this offer or should they keep producing?

Produce or buy decision

	Produce option	Purchase option	Difference
Variable costs			
Direct material cost	$100,000		-$100,000
Direct labor cost	$190,000		-$190,000
Energy and water	$35,000		-$35,000
Gas filters		$340,000	$340,000
Fixed costs			
Lighting	$20,000	$20,000	0
Depreciation	$100,000	$100,000	0
Rent		-$35,000	-$35,000
Total Cost	$445,000	$425,000	-$20,000
Unit Cost	$22.25	$21.25	-$1.00

Cost Function

- Fixed cost (s_1)
- Variable cost ($d_1 * q$)
- Mixed cost ($s_2 + d_2 * q$)

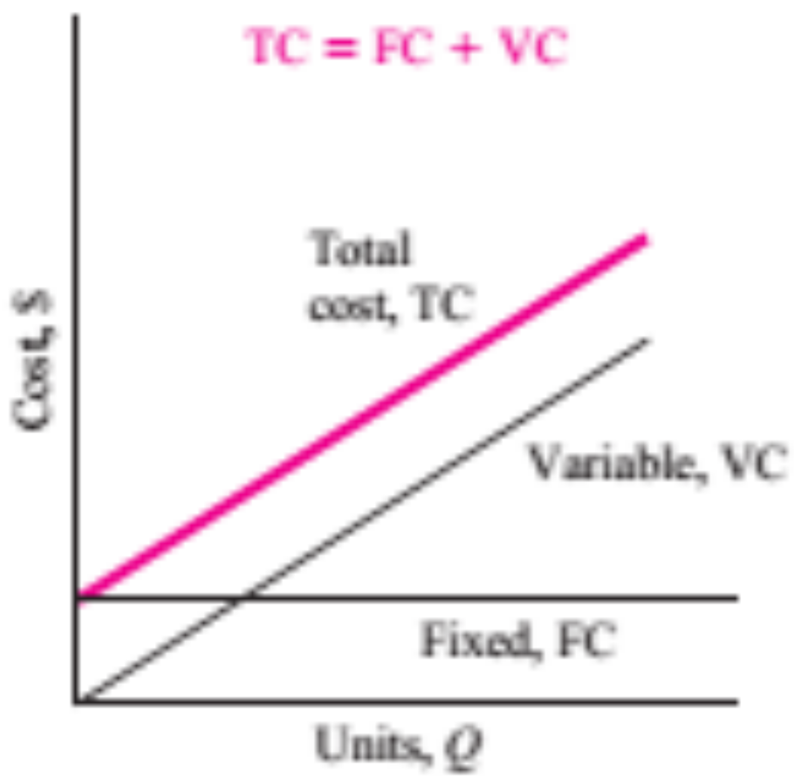
$C(q) = s_1 + d_1 * q + s_2 + d_2 * q \rightarrow$

$C(q) = (s_1 + s_2) + q * (d_1 + d_2) \rightarrow$

$C(q) = S + q * D$

(If it is constant)

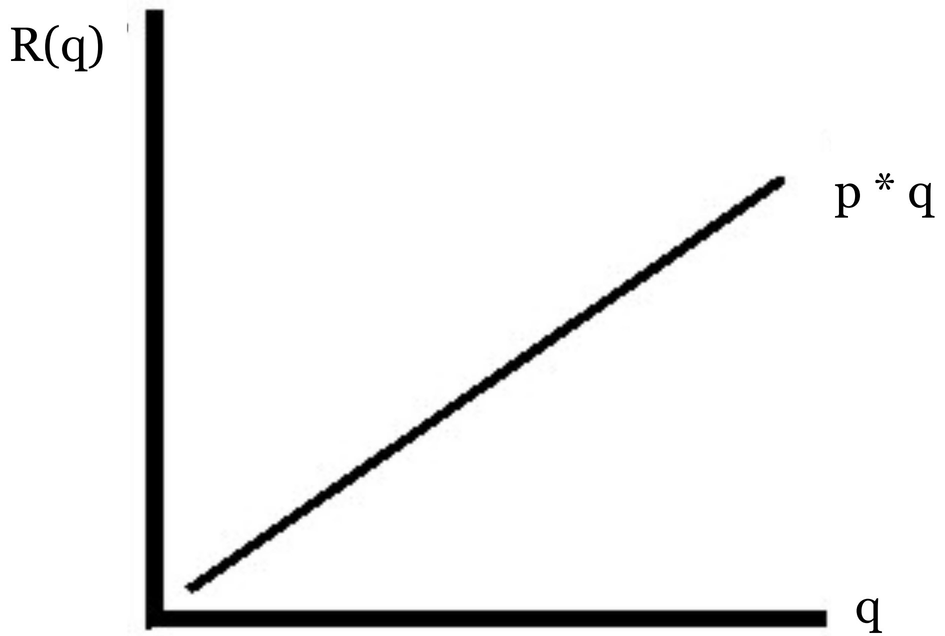
Cost Function



Revenue Function

- $R(q , p) = q*p$

(If it is constant)



Profit Function

- $K(q) = R(q) - C(q)$
- $K(q) = p*q - (s + d*q)$
- $K(q) = q*(p-d) - s$

Example 1

- A toy company has to spend \$10.25 to produce a toy. In addition, the fixed cost of this company is determined as \$1,302. The price of each toy is \$15.50;

  1. What is the cost function of this toy?
  2. What is the revenue function of this toy?
  3. What is the profit function of this toy?

Example 1

- $C(q) = 10.25q – 1{,}302$

- $R(q) = 15.50q$

- $K(q) = 15.50q- 10.25q -1{,}302$
- $K(q) = 5.25q – 1{,}302$

Example 2

- X company wants to calculate the capacity for producing product M. According to the studies,
- The revenue function of M product is determined as $r(q) = 0{,}13q^2 - 15q + 50$ and,
- Unit cost function is calculated as $c(q) = 0{,}10q^2 - 10q + 40$.
- Determine the capacity in order to earn maximum profit.

Example 2

- $TK = (0{,}13q^2-15q+50)*q-(0{,}10q^2-10q+40)*q$
- $TK = 0{,}03q^3 - 5q^2 + 10q$

- Calculate the derivative for maximum profit:
- $= 0{,}09q^2 - 10q + 10$
- $0{,}09q^2 - 10q + 10 = 0$

$q_1 = 1{,}01$ $q_2 = 110{,}1$

Example 3

- A watch company spends \$73,000 monthly as a fixed cost to produce watches whose variable cost per unit is \$83.
- The selling price is calculated by using this function, p=\$180-0,02q.
- Determine the total quantity of product to maximize the profit and break even point.

Example 3

- $C(q) = 73000+83 * q$
- $R(q) = (180 -0,02q) * q$
- $TK (q) = (180q -0,02q^2)- 73000 – 83q$
- $TK (q) = 97q – 0,02q^2 -73000$
- $dTK/dq = 97 -0,04q$
- $97 -0,04q = 0$
- $q=2425$ unit
- $TK = (180q -0,02q^2)- 73000 – 83q$
- $TK = (180*2425 – 0,02*2425^2) – 73000- 83*2425$
- $TK = 44612$

Example 3

- 97q – 0,02q^2 -73000 =0
- $-b \pm \sqrt{\Delta}/2a$ ➔ $\Delta = b\uparrow 2 \; -4ac$
- q_1 = 931,48 q_2 = 3918,53

Example 4

- Company X wants to publish an engineering economy book. What is the break even point of this book according to the data given below.
- **Price of the book** = 500 TL
- **Fixed Costs;**
    - Royalty costs = 300 000 TL
    - Editing costs = 80 000 TL
    - Typography costs = 150 000 TL

Total = **530 000 TL**

Example 4

- **Variable Costs;**
  - Printing = 35 TL
  - Ink and paper = 110 TL
  - Discounts = 50 TL
  - Other variable costs = 5 TL

Total = 200 TL

Cost(q)= 530000+200q

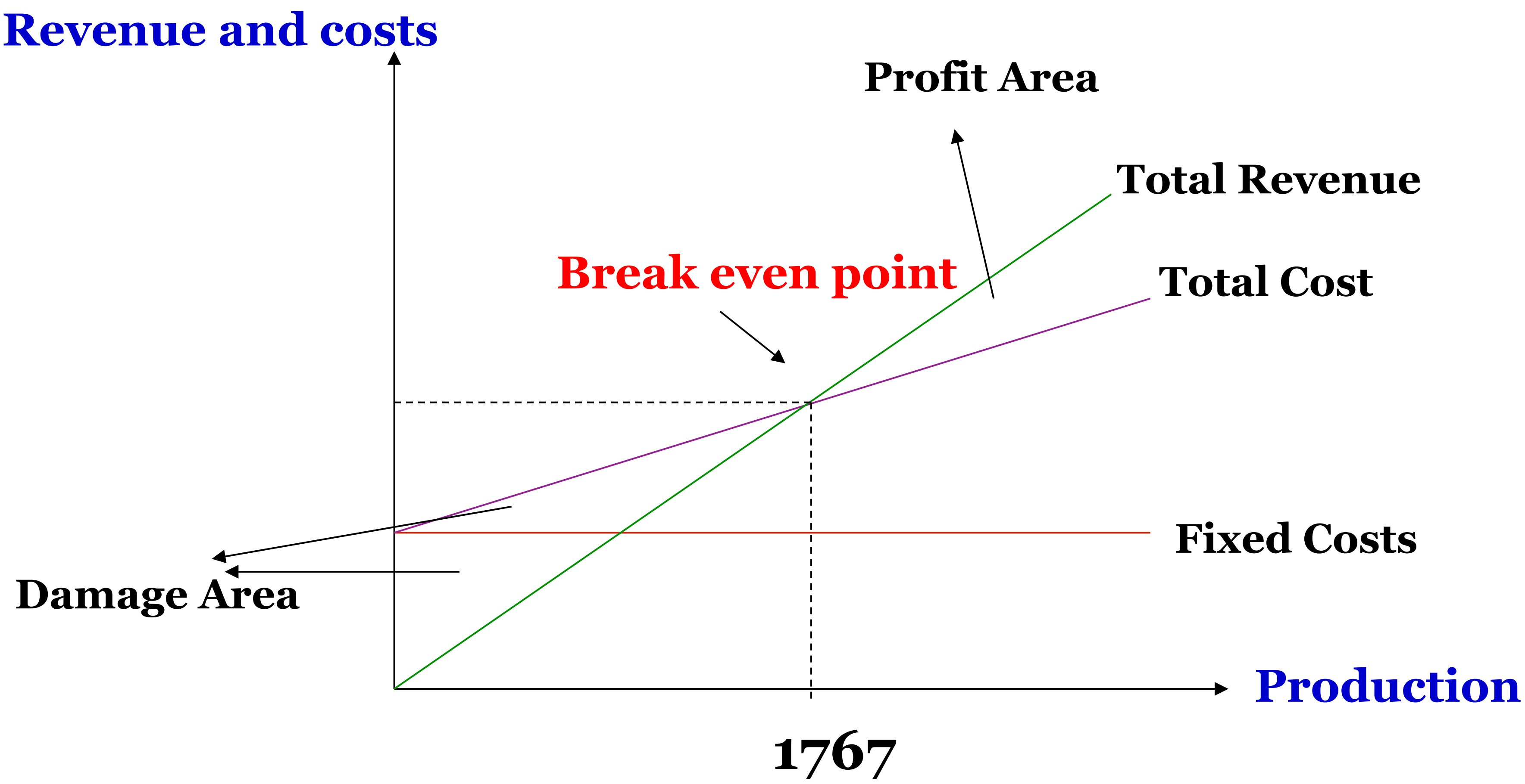
Revenue(q)= 500q

Profit(q)=500q-530000-200q =0 for break even point

q = 530 000 / (500 – 200)

= 1767 units

Example 4


Revenue and costs
Profit Area
Total Revenue
Break even point
Total Cost
Fixed Costs
Damage Area
Production
1767