ITTelkom Surabaya
Solution for The Nation

9th meeting

Introduction to Industrial Engineering Courses

Rules and Disclaimer !

- I stand up as a person that learned these topics before you
- I will deliver most of material in English, so you better prepare dictionary
- You may ask question after each topic is delivered or time that I permit, so you may write and compile your question

Score Breakdown

Quiz	10%
Assignment	30%
Mid-Term Test	25%
Final Test	35%
Class Awareness	10% (Bonus Score)

Hello Industrial People !

Today's Outline :

- Reflection from 1st – 7th meeting
- Final Project Progress
- Intro to Operation Research
- What's for next week

What is Industrial Engineering?

What is system?

**When everyone sees as a pizza,
You have to see as a bread, tomato sauce, pepperoni, and cheese, that be baked together in order to make a pizza**

Final Project Progress

Operation Research

History of Operation Research

Air Battle of Britain

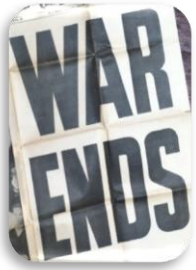
Battle of the North Atlantic

End of World War II

Ada kebutuhan mendesak untuk mengalokasikan sumber daya yang terbatas ke berbagai operasi militer dengan cara yang efektif (Hillier dan Lieberman, 2015).

Inggris merekrut para Ilmuwan untuk melakukan *research on military operations*, yang kemudian dikenal dengan nama *Operations Research* (Penelitian Operational).

History of Operation Research (cont.)



End of
World War II

Year 1950

Scientist of
Operations Research

- Business,
- Industry,
- Government

Continuous research on Computer Science, make Operations research more applicable

Steps for Using Operational Research

- Define The Problem
- Conceptual Model Generation & Data Collection
- Mathematical Model
- Mathematical Model Testing
- Interpreting and Presenting Result

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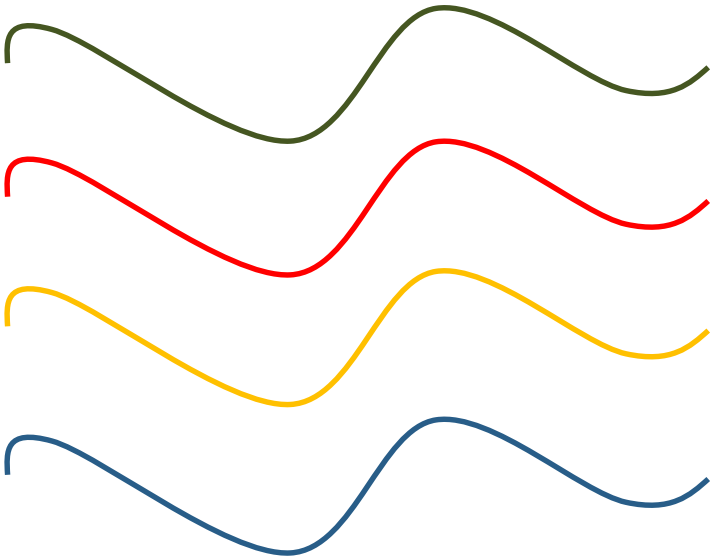
Define The Problem & Defining Variable



Synthesize into system elements to define the error

Steps for Using Operational Research

- Define The Problem
- Conceptual Model Generation & Data Collection
- Mathematical Model
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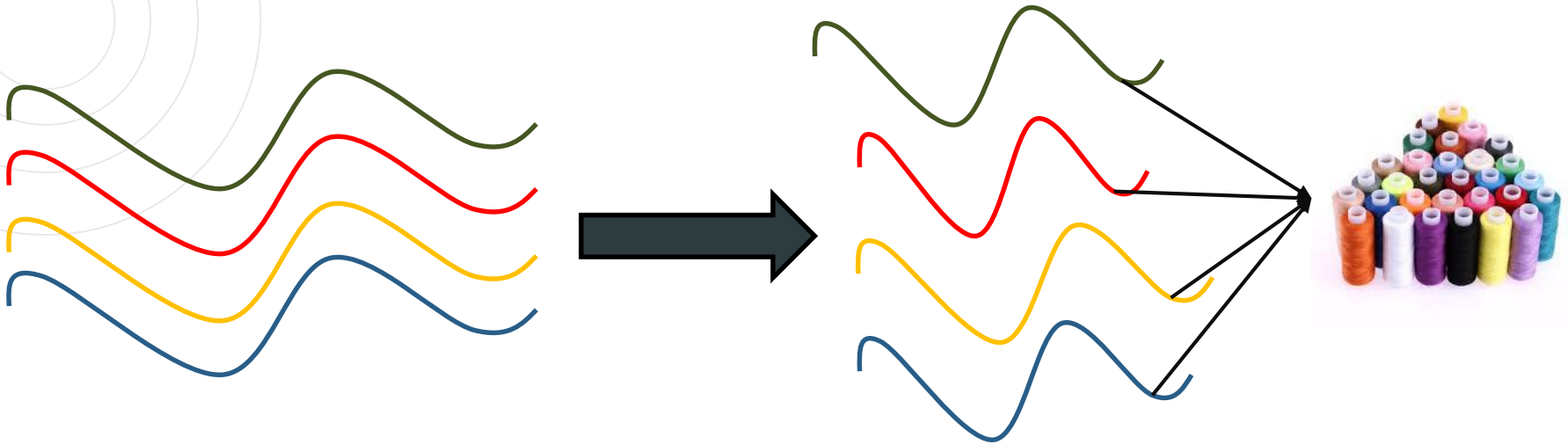
- Interpreting and Presenting Result

Conceptual Model & Data Collection



Model is representative from real case or problem that Describe graphically system elements and its interaction in order to make system and its objective

You can decide which data That should be gathered

Example : Paint Company Problem

China Paint Company has a production facility that produce interior and exterior paint. There are two kind of raw material that used to make a paint, which are material A and B. Each material are used in certain composition to make each type of product, 1 gallon of A for exterior and 2 gallon of A are required to make interior paint. Besides material A, 2 gallon of B are required for making exterior paint, and 1 gallon of B for interior paint. After interviewing the procurement department, known that material availability each day are 6 gallon of A and 8 gallon of B.

Model Assistance : Tabulation 1st step

Resources (x)	Resources required				Available Resources (b)
	Requirement Activity (a)				
	1	2	...	n	
1	a_{11}	a_{12}	...	a_{1n}	b_1
2	a_{21}	a_{22}	...	a_{2n}	b_2
:	...	...	...	...	:
m	a_{m1}	a_{m2}	...	a_{mn}	b_m

Answer :

Resources	Resources Required		Available Resources
	Exterior	Interior	
A	1	2	6
B	2	1	8

Example : Paint Company Problem (Cont.)

From market survey known that exterior paint price per gallon is Rp 300.000 and Rp 200.000.
Your Manager wants to maximize the revenue for company by selling these product. Finalize your model

Model Assistance : Tabulation 2nd step

Resources (x)	Resources required				Available Resources (b)
	Requirement Activity (a)				
	1	2	...	n	
1	a_{11}	a_{12}	...	a_{1n}	b_1
2	a_{21}	a_{22}	...	a_{2n}	b_2
:	...	...	...	...	:
m	a_{m1}	a_{m2}	...	a_{mn}	b_m
z	c_1	c_2	...	c_n	
Objective	Contribution to Objective				

Answer :

Resources	Resources Required		Available Resources
	Exterior	Interior	
A	1	2	6
B	2	1	8
Z	300.000	200.000	

Short Quiz (10 mins)

WYNDOR GLASS CO. produces high quality glass product, in this case there are two type of sold products, glass window and glass door. WYNDOR GLASS has 3 *plants* produce certain products. Glass window is produced by plant 1 and 3, while glass door is produced by plant 2 and plant 3. Plant 1 is small plant, hence it can only produce one glass window per hours, while plant 2 is medium plant, thu it can produce 2 glass door per hours. Plant 3 is high capacity plant, it can produce 3 glass window and 2 glass door. Due to machine condition, plant 1 is allowed to produce up to 4 products, while plant 2 is 12 products, and plant 3 is 18 products. Expected profit for product one that sold is Rp 450.000 and product two is Rp 750.000. Formulate the problem

Answer :

TABLE 3.1 Data for the Wyndor Glass Co. problem

Plant	Production Product 1	Production Product 2	Production Available
1	1	0	4
2	0	2	12
3	3	2	18
Profit	Rp 450.000	Rp 750.000	

Steps for Using Operational Research

- Define The Problem
- Conceptual Model Generation & Data Collection
- **Mathematical Model (Linear Programming)**
- Mathematical Model Testing
- Interpreting and Presenting Result

How to Formulate Mathematically

Z	=	**Objective Function**
x_j	=	**Decision Variable**
c_j	=	**Variable that affect objective**
		Every increments on *j* activity
b_i	=	**Resource Availability / Limitation**
		For activity on *i*
a_{ij}	=	**Quantity of resource *i* that used by activity or product *j***

KNOW SYMBOLS AND INDEXES THAT COMMONLY USED

How to Formulate Mathematically

- **Decision Variable** : x_j
- **Model Parameter** : c_j, b_i, a_{ij}
- **Objective Function**
  - Max $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$
  - Min $Z = c_1x_1 + c_2x_2 + \ldots + c_nx_n$
- **Constraints**
  - **Functional Constraints**
    - $a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \leq b_m$
    - $a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n \geq b_m$
    - $a_{m1}x_1 + a_{m2}x_2 + \ldots + a_{mn}x_n = b_m$
  - **Non-negativity Constraints**
    - $x_j \geq 0$

How to Formulate Mathematically

$$\max Z = \sum_{j=1}^{n} c_j x_j$$

$$ST:$$

$$\sum_{j=1}^{n} a_{ij} x_j \le b_i; i = 1,2,\ldots,m$$

$$x_j \ge 0; j = 1,2,\ldots,n$$

Profit, revenue, quantity

$$\min Z = \sum_{j=1}^{n} c_j x_j$$

$$ST:$$

$$\sum_{j=1}^{n} a_{ij} x_j \ge b_i; i = 1,2,\ldots,m$$

$$x_j \ge 0; j = 1,2,\ldots,n$$

Cost, Hours, Material

Lets recall this

Resources	Resources Required		Available Resources
	Exterior	Interior	
A	1	2	6
B	2	1	8
Z	300.000	200.000	

Mathematical Model Breakdown

Decision Variable Xj : Quantity of Each Type of Paint Produced

Model Parameter 3000 ; 2000 ; 2 ; 1 ; 1 ; 2 ; 6 ; 8

Objective Function

$$\max z = 2000\,X1 + 3000\,X2$$

Constraints

Functional Constraints

$$2\,X1 + X2 \leq 6$$

$$X1 + 2\,X2 \leq 8$$

Non-negativity Constraints

$$X1 \geq 0 \quad X2 \geq 0$$

Steps for Using Operational Research

- Define The Problem
- Conceptual Model Generation & Data Collection
- Mathematical Model (Linear Programming)
- **Mathematical Model Testing**
- Interpreting and Presenting Result

Mathematical Model Testing : Graph Help Solution

Find Intersection of Constraints Function with X & Y axes

Define Feasible Solution Region

Drag or calculate objective function line

Define Optimal Solution

Find The Coordinates

$$2\,X1 + X2 \leq 6$$

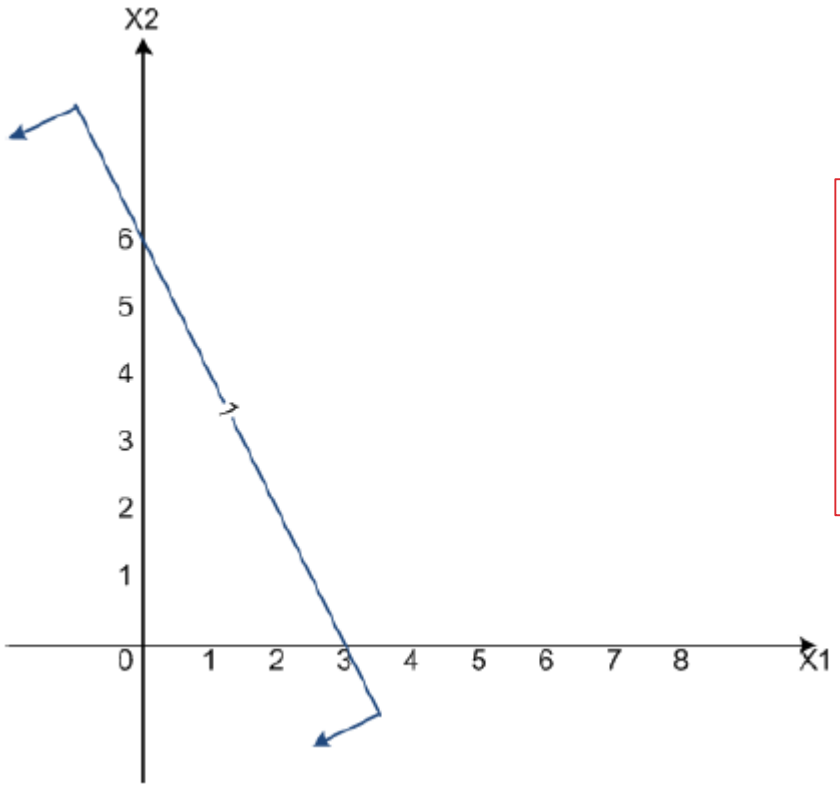
Find Value of X1 (intersection with X-axes)

- $X2 = 0$
- $X1 = 3$

Find Value of X2 (intersection with Y-axes)

- $X1 = 0$
- $X2 = 6$

Graphic Plotting



Prove the linear,
If we use 0 in x1 and x2. then
Then the linear equation is true

Hence, the tendency arrow of the line is moving close to 0

Find The Coordinates (cont.)

$X1 + 2\,X2 \leq 8$

Find Value of X1 (intersection with X-axes)

- $X2 = 0$
- $X1 = 8$

Find Value of X2 (intersection with Y-axes)

- $X1 = 0$
- $X2 = 4$

$X1 \geq 0$

$X2 \geq 0$

Non-negativity Constraint

Mathematical Model Testing : Graph Help Solution

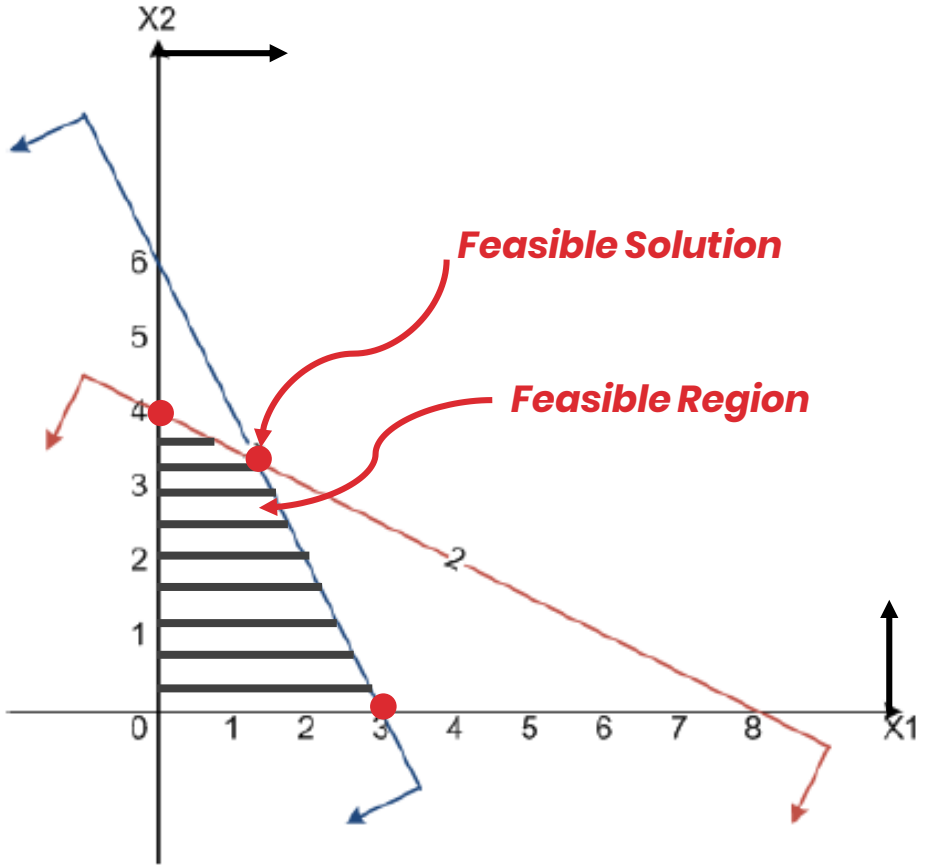
Find Intersection of Constraints Function with X & Y axes

Define Feasible Solution Region

Drag or calculate objective function line

Define Optimal Solution

Define Feasible Solution Region



Several categories for solution :

1. **Feasible Region**
2. **Feasible Solution**
3. **Alternative Optima Finite Solution**
4. **Unique Optima Finite Solution**

Miscellaneous categories for solution (*Operation Research Course*)

1. **Unbounded**
2. **Empty Feasible Region**
3. **Infeasible**

Mathematical Model Testing : Graph Help Solution

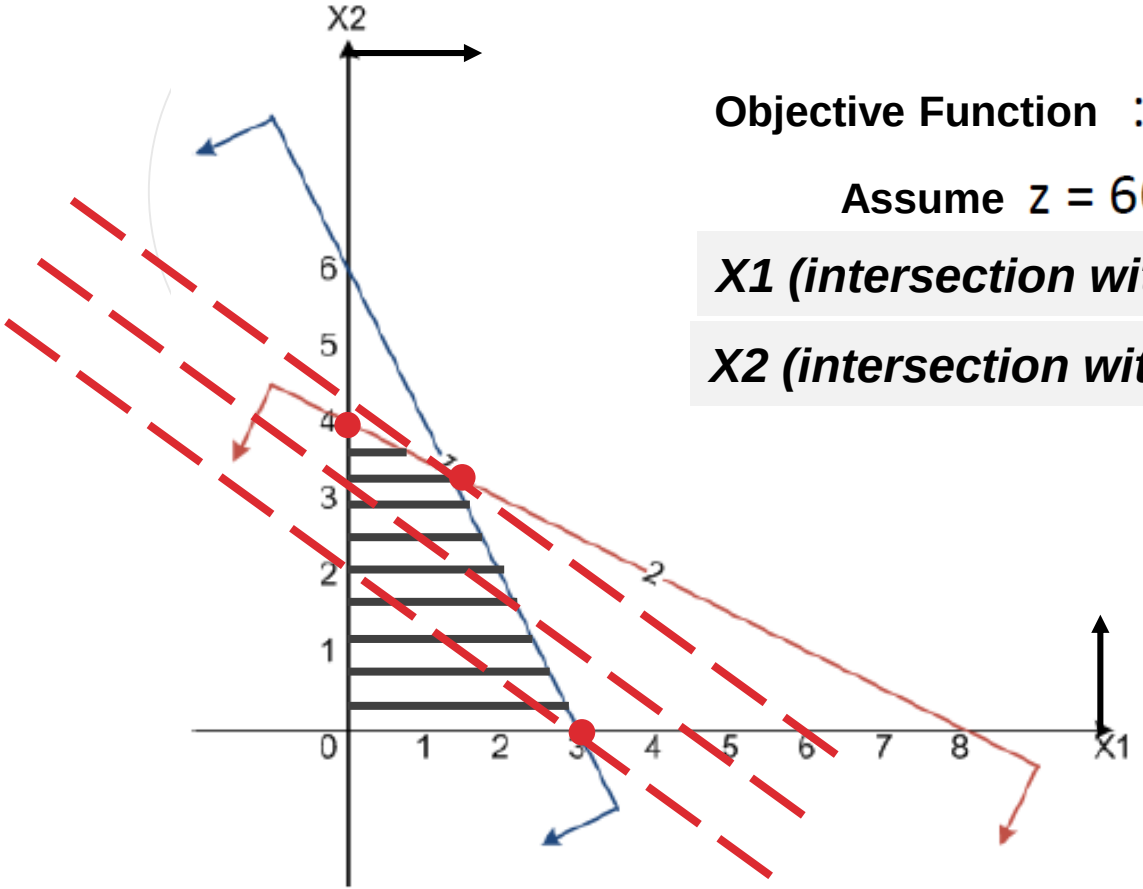
Find Intersection of Constraints Function with X & Y axes

Define Feasible Solution Region

Drag or calculate objective function line

Define Optimal Solution

Drag Or Calculate Objective Function Line

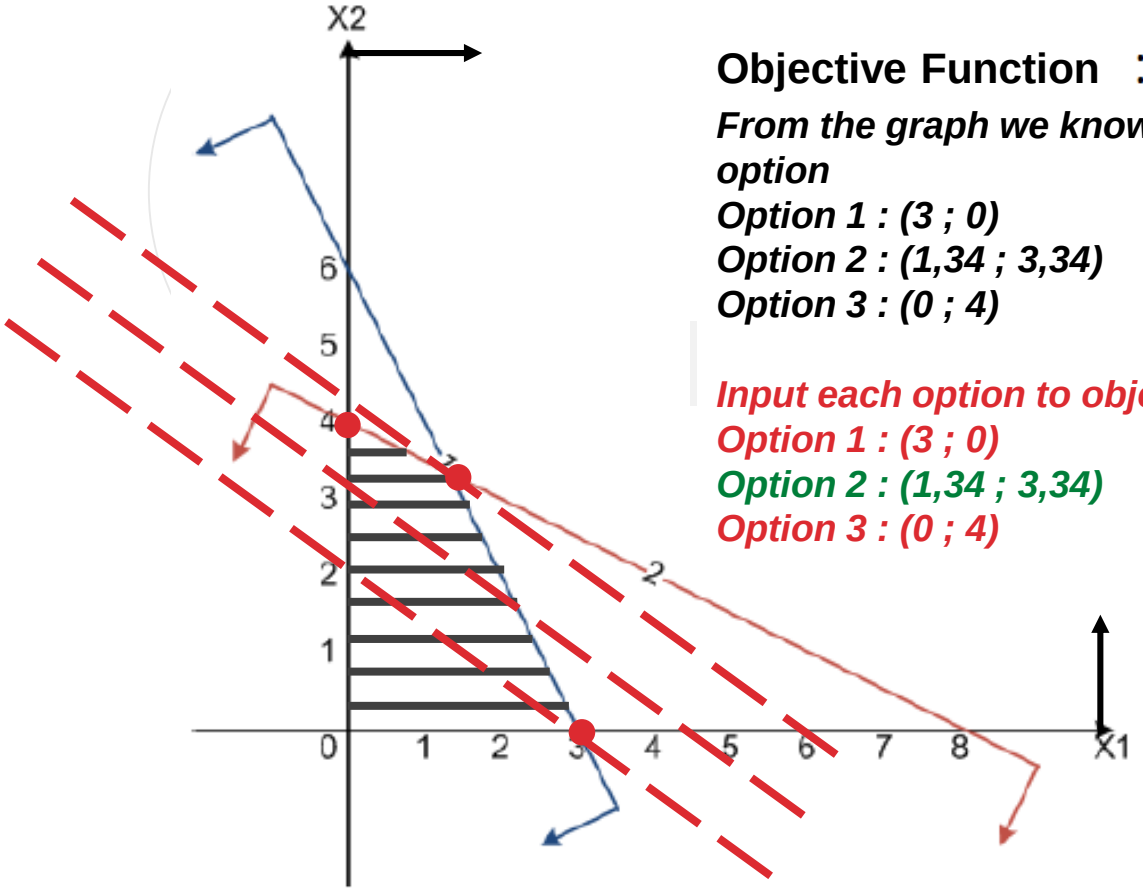


Objective Function : max z = 2000 X1 + 3000 X2

Assume z = 6000

X1 (intersection with X-axes)	X1 (3,0)
X2 (intersection with Y-axes)	X2 (0,2)

Drag Or Calculate Objective Function Line



Objective Function : max z = 2000 X1 + 3000 X2

From the graph we known several intersection (X1 , X2) option

Option 1 : (3 ; 0)
Option 2 : (1,34 ; 3,34)
Option 3 : (0 ; 4)

Input each option to objective function, then find the z value

Option 1 : (3 ; 0) → ***Z = 6000***
Option 2 : (1,34 ; 3,34) → ***Z = 12.700***
Option 3 : (0 ; 4) → ***Z = 12.000***

Short Quiz (20 mins)
Formulate & Find Solution

TABLE 3.1 Data for the Wyndor Glass Co. problem

Plant	Production Product 1	Production Product 2	Production Available
1	1	0	4
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3	3	2	18
Profit	Rp 450.000	Rp 750.000	

Thanks!

d

Next Week Agenda :

- Create Model of Business Process that your object used