KFUPM
BUSINESS SCHOOL

كلية الأعمال
جامعة الملك فهد للبترول والمعادن

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

BUSINESS SCHOOL

DEPARTMENT OF INFORMATION SYSTEM & OPERATIONS MANAGEMENT

**MANAGEMENT SCIENCE OM 511**

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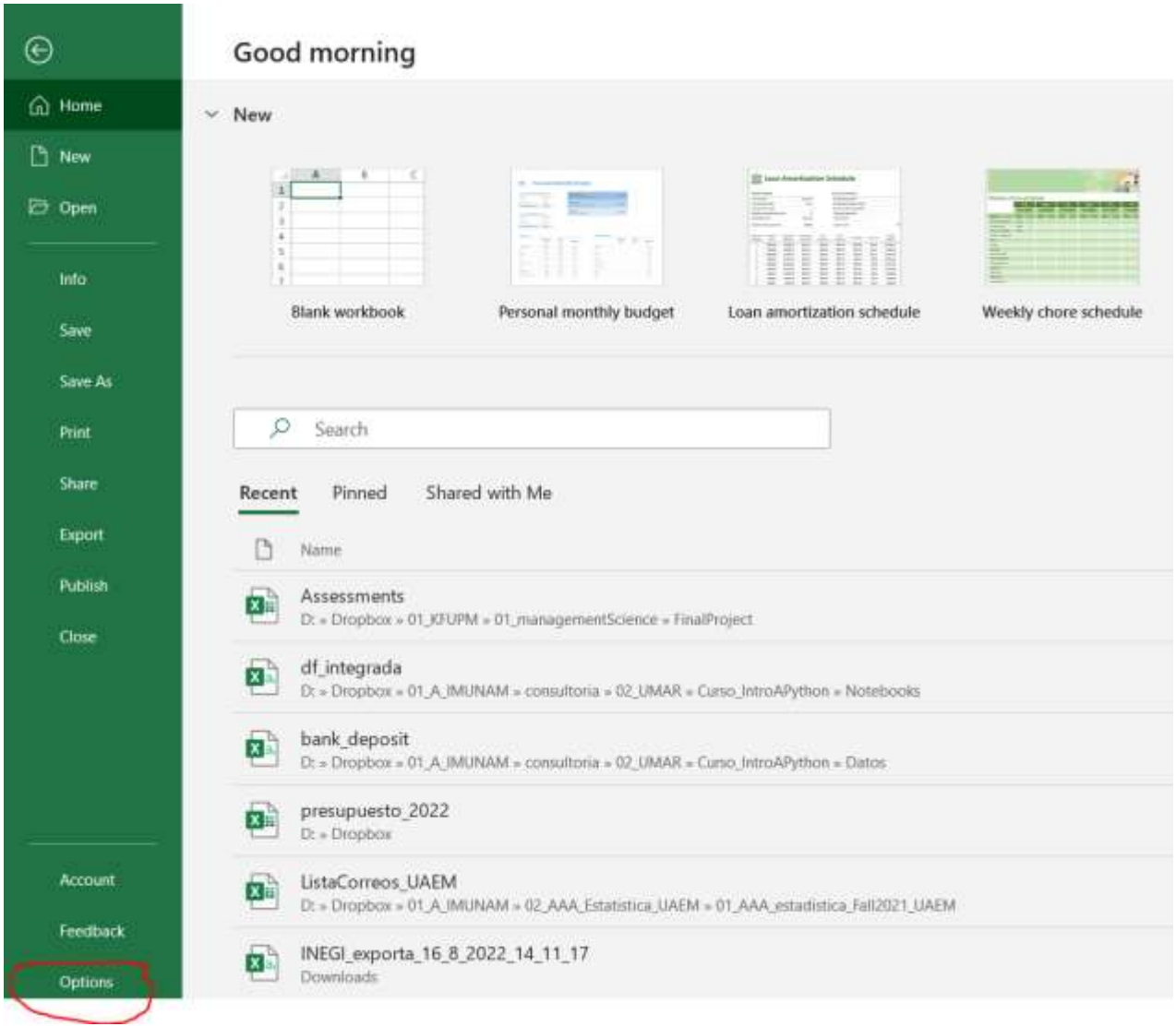
# 03 – Excel Solver and Pulp in Python

DHAHRAN, SAUDI ARABIA

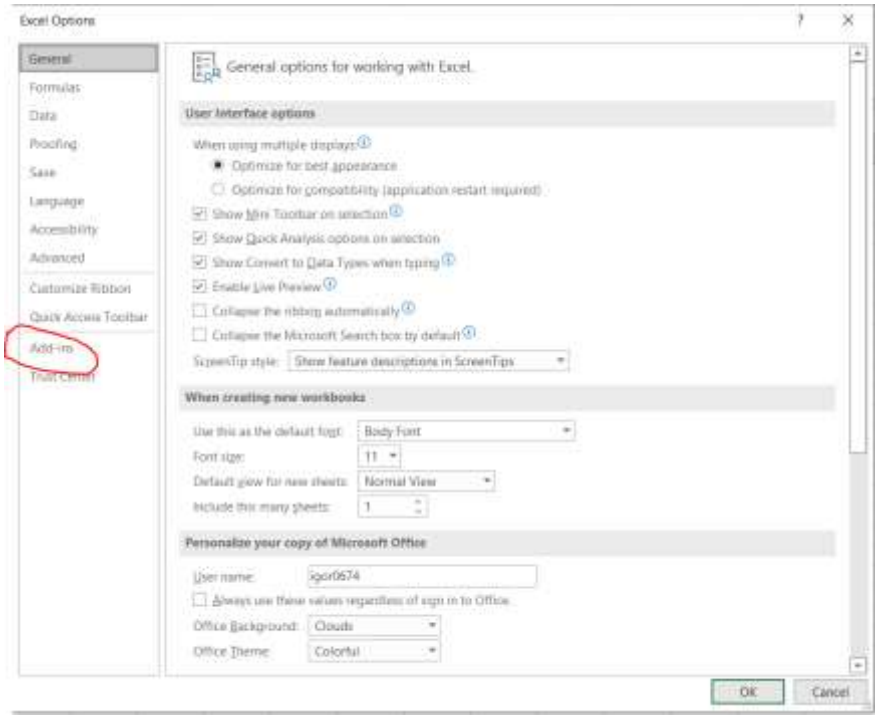
# Installing Excel Solver Add-in

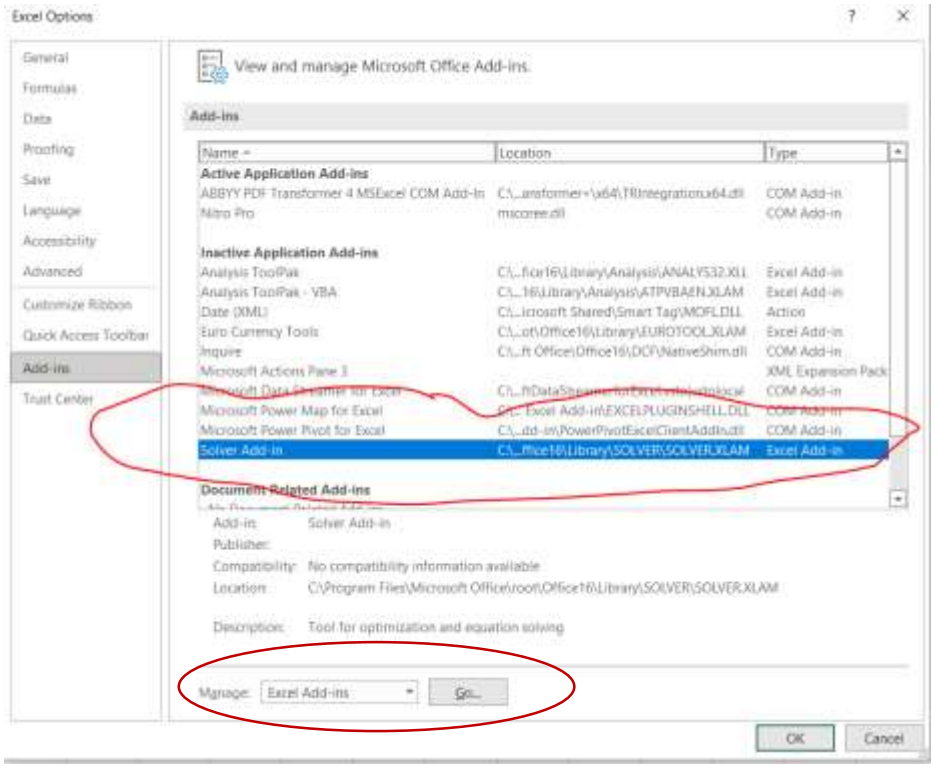
1. Go to File -- > Options



# Installing Excel Solver Add-in

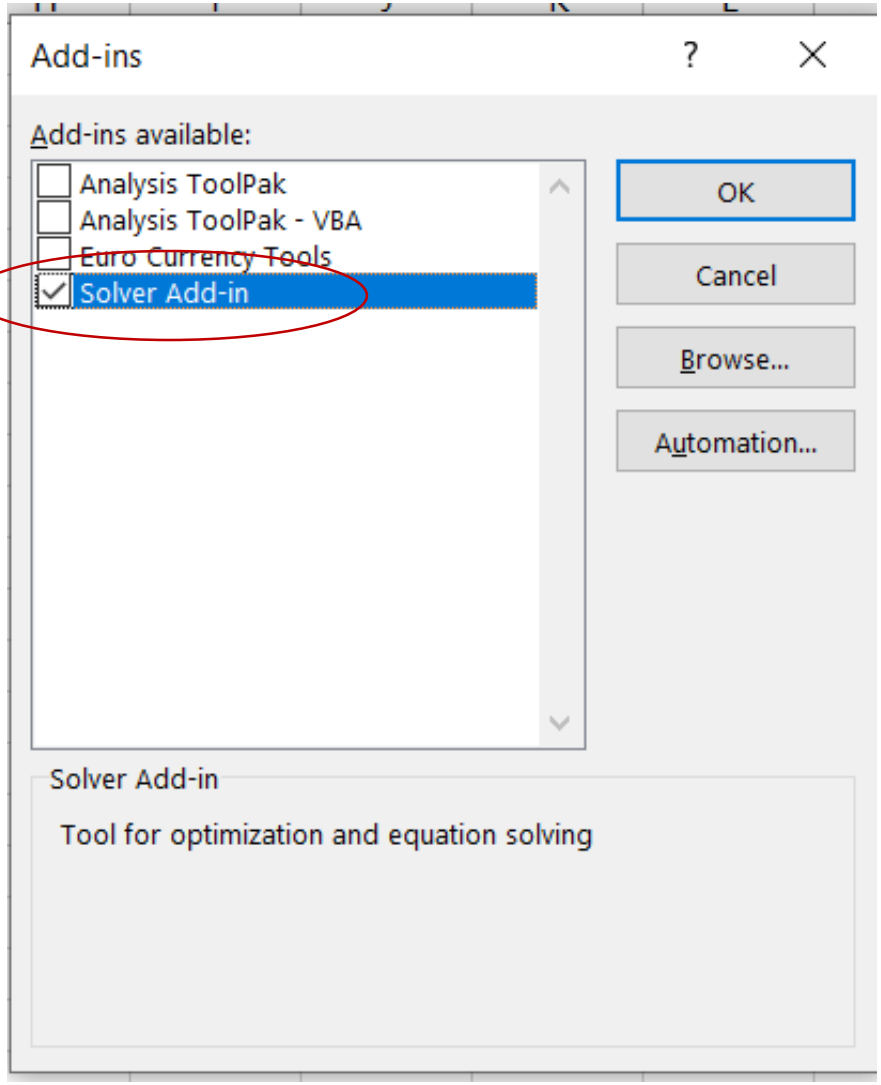
2. Add-Ins -- > Solver Add-In



# Installing Excel Solver Add-in

3. Add-Ins -- > Solver Add-In -- > Add-ins



# Finding the optimal solution

| | S | D | Z (Given solution) | | |
|---|---|---|---|---|---|
| Optimal Soluction | 540 | 252 | 7668 | | |
| Obj.Function | 10 | 9 | | | |
| | | | LH | Inequality | RH |
| Constratin 1 | 0.70 | 1.00 | 630 | <= | 630 |
| Constratin 2 | 0.50 | 0.83 | 480 | <= | 600 |
| Constratin 3 | 1.00 | 0.67 | 708 | <= | 708 |
| Constratin 4 | 0.10 | 0.25 | 117 | <= | 135 |

$$\text{Max} \quad 10S + 9D$$

subject to (s.t.)

$$\tfrac{7}{10}S + 1D \le 630 \quad \text{Cutting and dyeing}$$

$$\tfrac{1}{2}S + \tfrac{5}{6}D \le 600 \quad \text{Sewing}$$

$$1S + \tfrac{2}{3}D \le 708 \quad \text{Finishing}$$

$$\tfrac{1}{10}S + \tfrac{1}{4}D \le 135 \quad \text{Inspection and packaging}$$

$$S, D \ge 0$$

# Additional material for excel solver

Short tutorials for installing and using Excel Solver

https://www.youtube.com/watch?v=ziVlZrTmtI4

https://www.youtube.com/watch?v=ziVlZrTmtI4

# Exercise in classroom

Chapter 2. Anderson. Pp 70 #14

RMC, Inc., is a small firm that produces a variety of chemical products. In a particular production process, three raw materials are blended (mixed together) to produce two products: **a fuel additive (F) and a solvent base (S)**.

Each ton of **fuel additive (F)** is a mixture of 2/5 ton of material 1 and 3/5 of material 3. A ton of **solvent base (S)** is a mixture of 1/2 ton of material 1, 1/5 ton of material 2, and 3/10 ton of material 3.

The profit contribution is $40 for every ton of **fuel additive (F)** produced and $30 for every ton of **solvent base (S)** produced.

RMC's production is constrained by a limited availability of the three raw materials. For the current production period, RMC has available the following quantities of each raw material:

| Raw Material | Amount Available for Production |
|---|---|
| Material 1 | 20 tons |
| Material 2 | 5 tons |
| Material 3 | 21 tons |

# Exercise in classroom

Assuming that RMC is interested in maximizing the total profit contribution, answer the following:

a. What is the LP model for this problem?

b. Find the optimal solution.

c. How many tons of each product should be produced, and what is the projected total profit contribution?

d. Is there any unused material? If so, how much?

# Exercise in classroom

Chapter 2. Anderson. Pp 74 #24

Kelson Sporting Equipment, Inc., makes two different types of baseball gloves: a **regular model (R)** and a **catcher's model (C)**. The firm has 900 hours of production time available in its **cutting and sewing department**, 300 hours available in its **finishing department**, and 100 hours available in its **packaging and shipping department**. The production time requirements and the profit contribution per glove are given in the following table:

| | Production Time (hours) | | | |
|---|---|---|---|---|
| **Model** | **Cutting and Sewing** | **Finishing** | **Packaging and Shipping** | **Profit/Glove** |
| Regular model | 1 | ½ | ⅛ | $5 |
| Catcher's model | 3/2 | ⅓ | ¼ | $8 |

# Exercise in classroom

Chapter 2. Anderson. Pp 74

Assuming that the company is interested in maximizing the total profit contribution, answer the following:

a. What is the LP model for this problem?

b. Find the optimal solution. How many gloves of each model should Kelson manufacture?

c. What is the total profit contribution Kelson can earn with the given production quantities?

d. How many hours of production time will be scheduled in each department?

e. What is the slack time in each department?

# Exercise in classroom

Chapter 2. Anderson. Pp 74 #26

The Sea Wharf Restaurant would like to determine the best way to allocate a monthly advertising budget of $1000 between **newspaper (N)** advertising and **radio (R)** advertising.

Management decided that at least 25% of the budget must be spent on each type of media, and that the amount of money spent on local newspaper advertising must be at least twice the amount spent on radio advertising.

A marketing consultant developed an index that measures audience exposure per dollar of advertising on a scale from 0 to 100, with higher values implying greater audience exposure.

If the value of the index for local **newspaper (N)** advertising is 50 and the value of the index for spot **radio (R)** advertising is 80, how should the restaurant allocate its advertising budget in order to maximize the value of total audience exposure?

a. Formulate a linear programming model that can be used to determine how the restaurant should allocate its advertising budget in order to maximize the value of total audience exposure.

b. Solve the problem and find the optimal solution.

# Laboratory. Arabic restaurant

An Arabic restaurant is planning its menu to maximize profit while considering ingredient availability, cost, and dietary restrictions. The goal is to identify the suitable combination of different plate to be prepared in order to maximize the utilities. In order to achieve, the manager hired a consultant from KFUPM – OM511 and expert on Management Science. After several meeting with restaurant's staff, the following variables were defined.

$X_1$ = be the number of plates of Shawarma. Price = $60

$X_2$ = be the number of plates of Falafel with chicken. Price =$40

$X_3$ = be the number of plates of Hummus with chicken. Price = $30

$X_4$ = be the number of plates of Baklava. Price =$15

**Objective:** Maximize the total profit (in SAR) from the menu items.

**Material requirements**

Shawarma requires 1 pound of meat, 0.5 pounds of vegetables, and 0.2 cups of sauce per serving and 0.01 herbs.

Falafel requires 0.2 pounds of chicken, 0.2 pounds of vegetables (chickpeas), 0.1 cups of sauce, and 0.25 cups of tahini per serving.

Hummus requires 0.3 pounds of chicken, 0.3 cups of vegetables (chickpeas), 0.03 herbs and 0.2 cups of olive oil per serving.

Baklava requires 0.1 cups of honey, 0.2 cups of nuts, and 0.2 cups of phyllo dough per serving.

# Laboratory. Arabic restaurant

Stakeholders budgeted the following quantities for each ingredient per week.

- 50 pounds of meat
- 60 pounds of vegetables
- 15 cups of sauce
- 5 pounds of herbs
- 5 cups of tahini
- 10 cups of olive oil
- 10 cups of honey
- 10 cups of nuts
- 15 cups of phyllo dough

There is a dietary restriction that limits the total number of servings of Falafel and Baklava to be no more than 20 servings combined.

- Write the mathematical model
- Solve the model using Excel Solver
- Solve the problem using python pulp

# Quiz #1. Mexican restaurant

“El Burrito Amable” is a restaurant located on Khobar downtown that serves two products: “Supre Taco” **(T)** and “Baja Taco” **(B)** . It only serves “take-aways meals”.

For preparing an order of Supreme Taco (S) is required 50% of meat, 30% spicy sauce and 20 of vegetables. On the other hand, Baja Taco (B) requires 70% of meat, 10% of spicy sauce and 20% of vegetables. Each taco order weights 10 ounces.

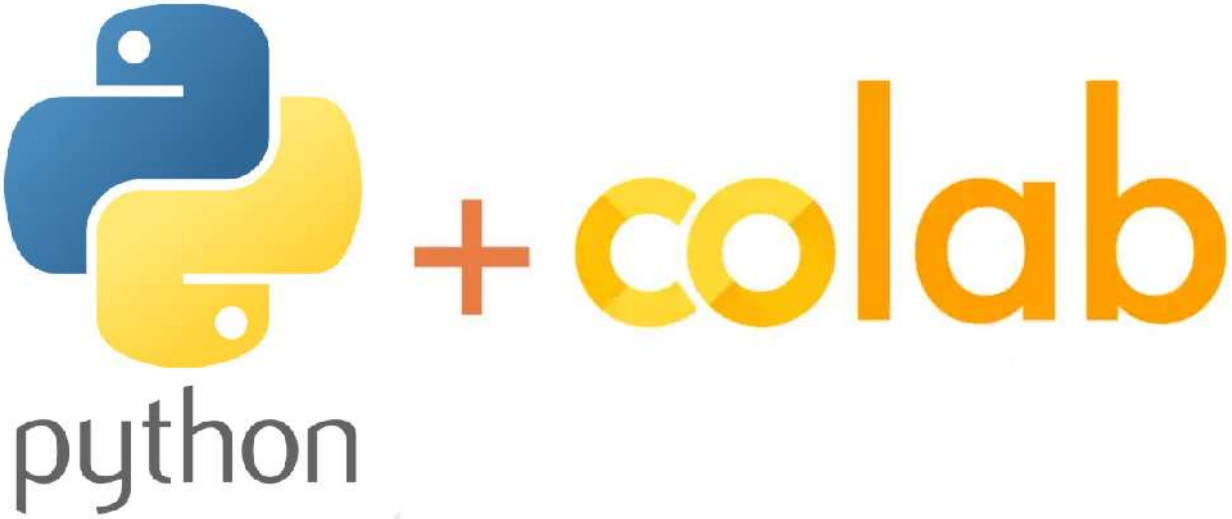
The restaurant owner can purchase up to 280 of meat, 130 of spicy sauce, and 100 of vegetables. The price per pound for each ingredient is $0.96, $0.64, and $0.56, respectively.

The cost of packaging and napkins is approximately $0.10 per order. The restaurant buys empty carton-boxes for $0.02 each, delivering cost is estimated to be $0.03 for each order. The restaurant calculated a revenue equal to $1.64 for each Supreme Taco and $1.93 for each Baja Taco.

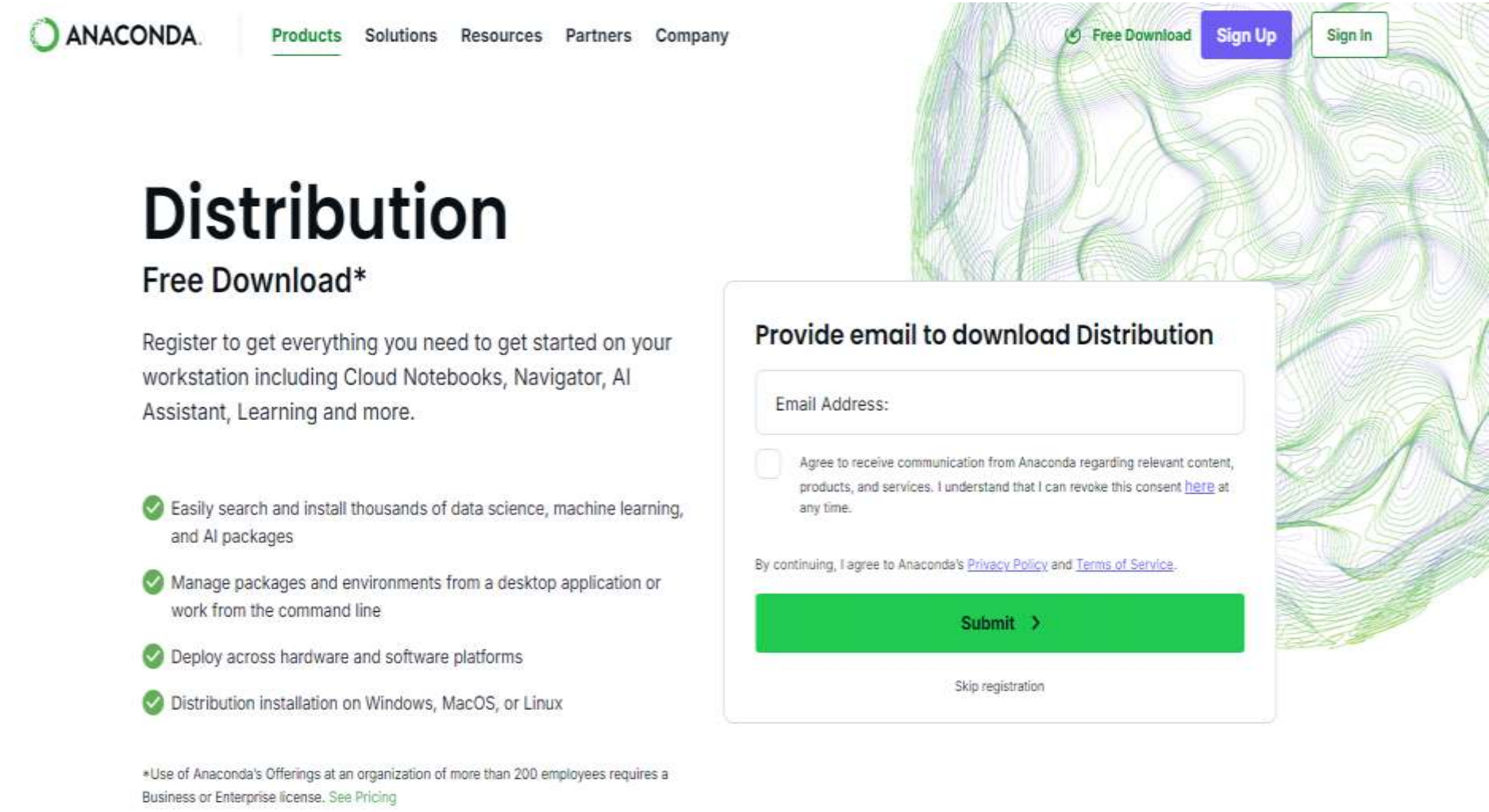
a) Develop a linear programming model to determine the mix of Tacos that will maximize the total profit contribution.

b) Find the optimal solution.

# Anaconda and Google Colab

# Install Anaconda



# Library Pulp

$$\text{Max} \quad 10S + 9D$$

subject to (s.t.)

$$\begin{aligned}
\tfrac{7}{10}S + 1D &\leq 630 && \text{Cutting and dyeing} \\
\tfrac{1}{2}S + \tfrac{5}{6}D &\leq 600 && \text{Sewing} \\
1S + \tfrac{2}{3}D &\leq 708 && \text{Finishing} \\
\tfrac{1}{10}S + \tfrac{1}{4}D &\leq 135 && \text{Inspection and packaging}
\end{aligned}$$

$$S, D \geq 0$$

# Exercise in classroom

Chapter 2. Anderson. Pp 74 #26

$$
\begin{aligned}
\text{Max} \quad & 50N + 80R \\
\text{s.t.} \quad & \\
& N + R = 1000 \\
& N \geq 250 \\
& R \geq 250 \\
& N - 2R \geq 0 \\
& N, R \geq 0
\end{aligned}
$$

| | | N | R | | | |
|---|---|---|---|---|---|---|
| | | 50 | 80 | | Optimal Solution | |
| | | 666.7 | 333.3 | | 60000 | |
| | | | | | | |
| | | | | LH | Inequality | RH |
| C1 | | 1 | 1 | 1000 | = | 1000 |
| C2 | | 1 | | 666.6667 | >= | 250 |
| C3 | | | 1 | 333.3333 | >= | 250 |
| C4 | | 1 | -2 | 0 | >= | 0 |

# 7 step process for solving a LP problem with pulp

**Step 1. Install the Pulp library. This library will allow us to perform the calculations and solve the linear problem**

In [2]:
```
!pip install pulp
```

```
Collecting pulp
  Downloading PuLP-2.7.0-py3-none-any.whl (14.3 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 14.3/14.3 MB 44.8 MB/s eta 0:00:00
Installing collected packages: pulp
Successfully installed pulp-2.7.0
```

**Step 2. Import the library to the environtment and get it ready for calculations**

In [3]:
```
import pulp
```

**Step 3. Declare object that will store the resuls ###the**

In [4]:
```
###declare the problem
my511_problem = pulp.LpProblem('Max problem', pulp.LpMaximize)
```

```
/usr/local/lib/python3.10/dist-packages/pulp/pulp.py:1352: UserWarning: Spaces are not permitted in the name. Converted to
'_'
  warnings.warn("Spaces are not permitted in the name. Converted to '_'")
```

# 7 step process for solving a LP problem with pulp

**Step 4. Declare the variables that comprise our solution**

In [5]:
```
### declaring my variables
N = pulp.LpVariable('N', lowBound=0)
R = pulp.LpVariable('R', lowBound=0)
```

**Step 5. Declare write down the objective function and constrains**

In [6]:
```
### objective fuction
my511_problem += 50*N + 80*R
```

In [7]:
```
my511_problem += N >= 250
my511_problem += R >= 250
my511_problem += N + R == 1000
my511_problem += N - 2*R >= 0
```

# 7 step process for solving a LP problem with pulp

**Step 6. With the following instruction you will obtain the results**

In [8]:
```
my511_problem.solve()
```

Out[8]: 1

**Step 7. Now you will print the results and the optimal value**

In [9]:
```
print("N budget allocated to newpaper " , N.varValue)
print("R budget allocated to  radio " , R.varValue)
```

```
N budget allocated to newpaper  666.66667
R budget allocated to  radio  333.33333
```

In [13]:
```
print('Mi objective function is', my511_problem.objective)
print('Mi optimal value is', pulp.value(my511_problem.objective))
```

```
Mi objective function is 50*N + 80*R
Mi optimal value is 59999.999899999995
```