**HW 3 – Business analytics (6 pts maximum).**

To solve part b) of the problem you will need to do the following:

* 1. Use the Generalized Analytics Procedure (GAP) to set up your problem as follows:
     1. Define your model in words
        1. Identify the objective function in words
        2. Identify the random variables in words (none in this HW)
        3. Identify the decision variables in words
        4. Identify the constraints in words
     2. Formulate your model mathematically
        1. Define the random variables (none in this HW)
        2. Define the decision variables
        3. Define the objective function in terms of decision variables
        4. Define the constraints in terms of the decision variables. Please include any non-negativity constraints in your formulation
  2. Set up the problem in Excel and use Solver to find the optimal values of the decision variables. Ask Solver to create an Answer Report and, if necessary, a Sensitivity Report.
  3. Answer the questions stated in the problem (in words).

Please submit only one file in PDF format with your write-up. Do not submit your Excel file. Your writeup must include the answer report generated by Excel Solver. If you make any additional assumptions, state them clearly.

**Joe’s Lawn Sign Co**

Your entrepreneurial uncle Joe is running a lawn sign business. Joe manufactures the following three types of lawn signs:

* Political Party signs (PP)
* Environmental Consciousness signs (EC)
* Owl Watching signs (OW)

To help Joe sell his products you decided to develop a new online ad placement strategy. Currently, the following channels offer to host ads at the following base price:

* Facebook (F): at most 5000 ads at 35 cents per impression
* Instagram (I): at most 5000 ads at 40 cents per impression
* Tiktok (T): at most 5000 ads at 50 cents per impression

Additionally, Facebook has a surcharge of 10 cents per impression for political ads, which would apply for PP but not for EC or OW.

1. Draw a network diagram to represent the problem. You can either draw the diagram by hand and take a picture of your drawing, or use Word/PPT. Indicate the decision variables on the diagram.

Chart

Description automatically generated

Each arrow corresponds to the number of ads of each type used for each channel. For example, PPF is the number of PP ads on Facebook, etc. for the remaining eight variables.

1. If Joe has a budget of $5K for this fall’s advertising campaign, how should he allocate ads to channels to generate the greatest number of impressions?

GAP:

Define model in words:

Objective: maximize number of impressions

Decision variables: number of ads of each type shown on each channel

Constraints: capacity of each channel, total budget, non-negative and integer constraints

Formulate model mathematically:

Decision variables: PPF, ECF, OWF, PPI, ECI, OWI, PPT, ECT, OWT

Objective function: PPF+ECF+OWF+PPI+ECI+OWI+PPT+ECT+OWT

Constraints:

Facebook capacity: PPF+ECF+OWF<=5000

Instagram capacity: PPI+ECI+OWI<=5000

TikTok capacity: PPT+ECT+OWT<=5000

Budget: 45\*PPF+35\*ECF+35\*OWF+40\*PPI+40\*ECI+40\*OWI+50\*PPT+50\*ECT+50\*OWT<=500,000

Non-negative: PPF, ECF, OWF, PPI, ECI, OWI, PPT, ECT, OWT >=0

Integer: PPF, ECF, OWF, PPI, ECI, OWI, PPT, ECT, OWT

Answer: 5000 environmental consciousness signs on Facebook, 5000 political party signs on Instagram, and 2500 political party signs on TikTok. The impressions can reach 12,500.

Table

Description automatically generated

1. If Joe decides to advertise on Tiktok, he will need to hire someone to produce ads (since Tiktok ads run in video format). Your friend Silvia offered to help with the production of ads for Tiktok for a fee of 20 cents per impression. You can assume that ads for other channels can be produced at no cost. How would this change your solution from b)?

The budget constraint changes to 45\*PPF+35\*ECF+35\*OWF+40\*PPI+40\*ECI+40\*OWI+70\*PPT+70\*ECT+70\*OWT<=500,000

There should be 5 political party signs on Facebook, 4995 environmental consciousness signs on Facebook, 5000 political party signs on Instagram, and 1785 political party signs on TikTok. The impressions can reach 11,785.

Table

Description automatically generated

1. Market research has shown that political party ads (PP) are not particularly interesting for Tiktok users. In particular, the clickthrough rate on PP is half of the rate for OW types of ads. In contrast, the clickthrough rate for environmental consciousness ads (EC) is double the OW ads. All clickthrough rates on the remaining channels (F and I) are equal to OW rates on Tiktok.

How should Joe spend $5K to maximize the number of clicks on his ads? Assume the costs from part c).

GAP:

Define model in words:

Objective: maximize total clicks

Decision variables: number of ads of each type shown on each channel

Constraints: capacity of each channel, total budget, non-negative constraints

Formulate model mathematically:

Decision variables: PPF, ECF, OWF, PPI, ECI, OWI, PPT, ECT, OWT

Objective function: 1\*PPF+1\*ECF+1\*OWF+1\*PPI+1\*ECI+1\*OWI+0.5\*PPT+2\*ECT+1\*OWT

Constraints:

Facebook capacity: PPF+ECF+OWF<=5000

Instagram capacity: PPI+ECI+OWI<=5000

TikTok capacity: PPT+ECT+OWT<=5000

Budget: 45\*PPF+35\*ECF+35\*OWF+40\*PPI+40\*ECI+40\*OWI+70\*PPT+70\*ECT+70\*OWT<=500,000

Non-negative, integer: PPF, ECF, OWF, PPI, ECI, OWI, PPT, ECT, OWT

Answer: 4857 environmental consciousness signs on Facebook and 4714 environmental consciousness signs on TikTok. Total clicks can reach 14,285.

Note that for this problem Solver runs much faster using GRG nonlinear algorithm than if you use LP Simplex (You should normally use LP Simplex to solve linear problems; however, in this case GRG is faster. It’s OK to use GRG on linear problems, but not the other way around).

Table

Description automatically generated