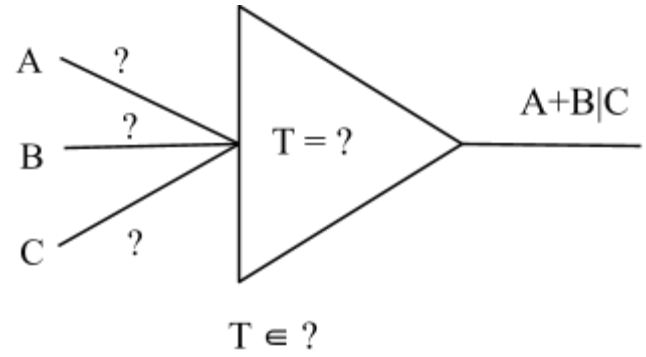
Homework No. 1 - Solution Sheet
Due Thursday, Feb. 16, 2022, noon

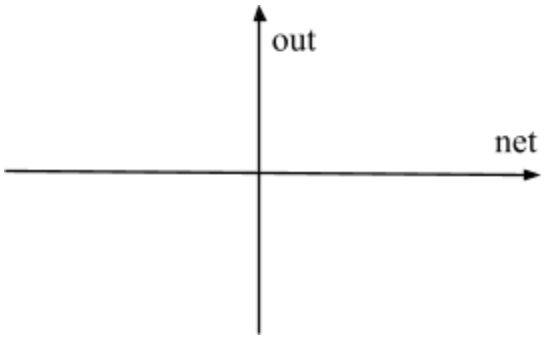
1.1 Getting to know you => email (1 pts)
Please include:

- Full name, student ID, and email address you want to be used for sending graded assignments back,
- Short info on your background,
- Your interests/expectations from this course.

1.2. McCulloch-Pitts neurons (4 pts)
Provide a solution for the neuron below (provide weight set and a threshold). The functionality is Out = A+B|C (A OR B AND NOT C).
Please do not provide results by trial and error. Instead, please use an analytical approach as described in Session 3).
Start with the neuron definition (net and output). Please consider the unipolar hard threshold activation function. Draw the threshold function. Explain and discuss.
Hint: Compose a truth table (use below example to start). Consider all possible cases for the input pattern. Consider possible ranges of values for weights and threshold. Possible inputs/outputs in case of unipolar hard activation function are 0 & 1.



$T \in ?$



A	**B**	**C**	***Out = A+B|C***	**inequalities**	**Possible values**
0	**0**	**0**	0	0 < T	0 < T
0	**0**	**1**	0	wc < T	+1 < T
.	.	.			
.	.	.			
.	.	.			
.	.	.			
.	.	.			
.	.	.			

Solution:

A	B	C	*Out = A+B|C*	inequalities	out	
0	**0**	**0**	0	0 < T	0 < T	0 <1
0	**0**	**1**	0	w_c < T	-3 < T	-3 < 1
0	**1**	**0**	1	w_b ≥T	+1 ≥T	+1 ≥1
0	**1**	**1**	0	w_b+w_c < T	-2 < T	-2 < 1
1	**0**	**0**	1	w_a ≥ T	+5 ≥ T	+5 ≥ 1
1	**0**	**1**	1	$w_a+ w_c$ ≥ T	+2 ≥ T	+2 ≥ 1
1	**1**	**0**	1	$w_a+ w_b$ ≥ T	+6 ≥ T	+6 ≥ 1
1	**1**	**1**	1	$w_a+ w_b+w_c$ ≥ T	+3 ≥ T	+3 ≥ 1

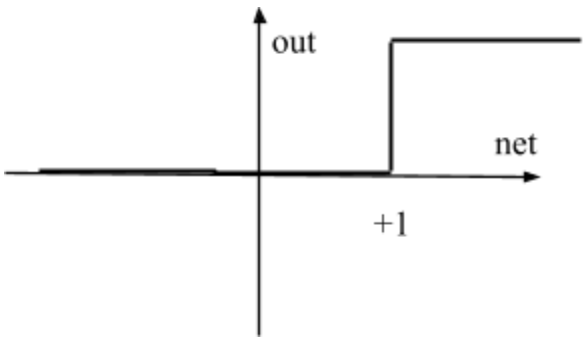
One approach could be the following:

1. From first condition, 0 < T, T must be positive. If, for ex. T=1, then,
   a. from w_a ≥ T, w_a could be 5 and satisfy that inequality.
2. From $w_b + w_c$ < T & w_a+w_c ≥ T, we can choose w_b =1, and w_c=-3.

Therefore, one solution could be: **T=1 and W=[5, 1, -3].**

Let us check for:

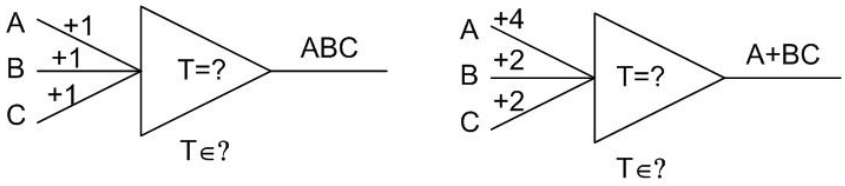
- $w_a+ w_c \geq T$ => 5-3≥1, ok!
- $w_a+ w_b \geq T$ => 5+1≥1, ok!
- $w_a+ w_b+w_c \geq T$ => 5+1-3≥1, ok!



1.3. McCulloch-Pitts neurons (4 pts)

Inspect the two neurons below (ABC and A+BC) and consider unipolar hard threshold activation function. *Hint: start with the tables similar to the one used in previous task.*

- What makes these neurons different (they both have 3 inputs)?
- What is the possible range of thresholds for the following McCulloch-Pitts neurons?



Solution:

Assuming following output definition:

$$net = \sum_{i=1}^{n} w_i x_i + w_{n+1}; \qquad o = \begin{cases} 1, & if\ net \geq 0 \\ 0, & if\ net < 0 \end{cases}$$

A	B	C	*out = ABC*	inequalities	out
0	**0**	**0**	0	0 < T	0 < T
0	**0**	**1**	0	wc < T	+1 < T
0	**1**	**0**	0	wb < T	+1 < T
0	**1**	**1**	0	wb+wc < T	+2 < T
1	**0**	**0**	0	wa < T	+1 < T
1	**0**	**1**	0	wa+ wc < T	+2 < T
1	**1**	**0**	0	wa+ wb < T	+2 < T
1	**1**	**1**	1	wa+ wb+wc ≥ T	+3 ≥ T

This table puts the following constraints on first neuron's threshold:
+2 < T and +3 ≥ T, i.e. **+2.0 < T ≤ +3.0**

A	B	C	$out = A + B \cdot C$	inequalities	out
0	**0**	**0**	0	0 < T	0 < T
0	**0**	**1**	0	wc < T	+2 < T
0	**1**	**0**	0	wb < T	+2 < T
0	**1**	**1**	1	$wb+wc$ ≥ T	+4 ≥ T
1	**0**	**0**	1	wa ≥ T	+4 ≥ T
1	**0**	**1**	1	$wa+ wc$ ≥ T	+6 ≥ T
1	**1**	**0**	1	$wa+ wb$ ≥ T	+6 ≥ T
1	**1**	**1**	1	$wa+ wb+wc$ ≥ T	+8 ≥ T

This table puts the following constraints on second neuron's threshold:
+2 < T and +4 ≥ T, i.e. **+2 < T ≤ +4**

1.4 Design McCulloch-Pitts neuron, which implements the following truth table (5 pts):

A	B	C	out
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

Note: You may want to use Karnaugh maps minimization online from *ShurikSoft* (shareware) and by *Kovacevic* (freeware). These used to be free but perhaps not any more.

Report: Describe your approach and provide weights for the designed neuron.

Solution:

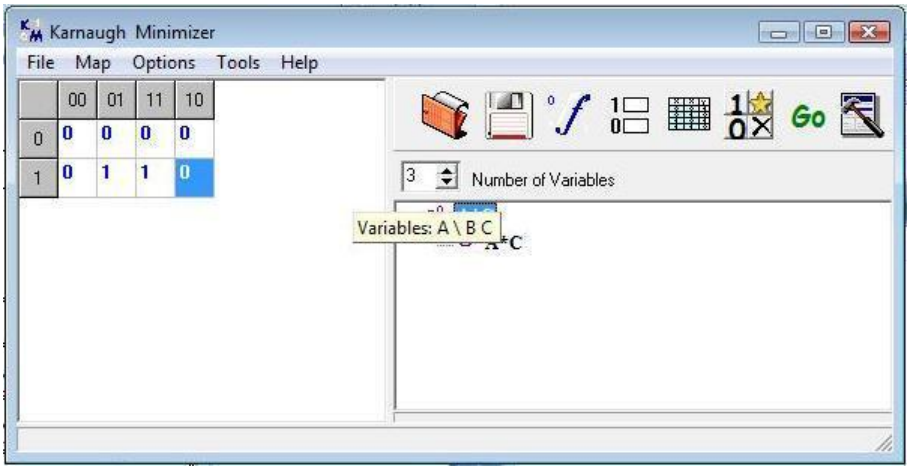
Assuming following output definition:

$$net = \sum_{i=1}^{n} w_i x_i + w_{n+1}; \qquad o = \begin{cases} 1, & if\ net \geq 0 \\ 0, & if\ net < 0 \end{cases}$$

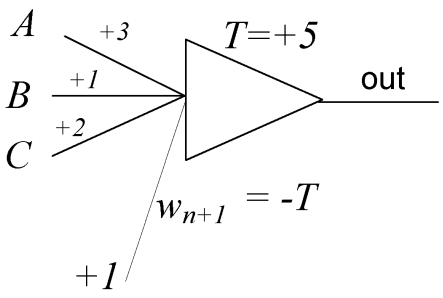
Truth table results in 8 inequalities.

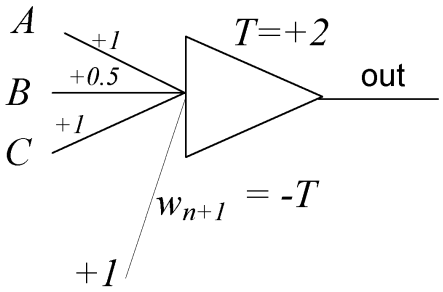
A	**B**	**C**	$\sum_{i=1}^{n} w_i x_i$	$o = \begin{cases} 1, & if\ net \geq 0 \\ 0, & if\ net < 0 \end{cases}$	**out**
0	**0**	**0**	<T	0	$0 < T$
0	**0**	**1**	<T	0	$wc < T$
0	**1**	**0**	<T	0	$wb < T$
0	**1**	**1**	<T	0	$wb+wc < T$
1	**0**	**0**	<T	0	$wa < T$
1	**0**	**1**	≥ T	1	$wa+ wc \geq T$
1	**1**	**0**	<T	0	$wa+ wb < T$
1	**1**	**1**	≥ T	1	$wa+ wb+wc \geq T$

Consequently, MDF= $A \cdot C$, or using Karnaugh Minimizer software:



Therefore, some possible solutions are:





1.5 Python and Perl installation (1 pts)

Install Python3 (https://www.python.org/) and Perl (https://www.perl.org/). Attach a screenshot demonstrating successful installation (for example, Fig. 1 shows a screenshot of the python console executing the command print('hello world')).

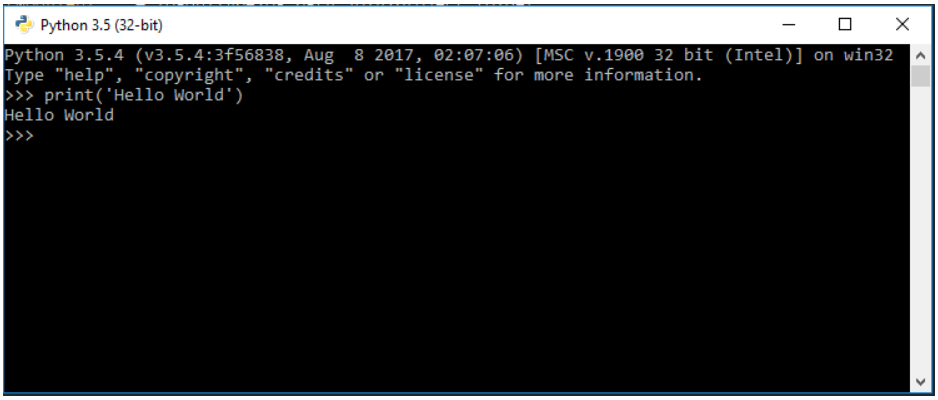


Fig. 1 Example of proof for successful installation for Python3

Deliverables/Report:

- Once you have completed sections from above, submit to Canvas.
- Provide your names in header/footer of every page of assignment.
- Compile your results into a **single** file only.
- This assignment is worth 15 points.