**Question 1. (12 points)**

1. Given the following Boolean function:

$$F\left(X,Y,Z\right)=\left(X+Y\right)\left(X+Z\right)(\overbar{X}+\overbar{Z})$$

* 1. **(2 points)** Express F as a **sum-of-minterms**, $F=\sum\_{}^{}m$.
	2. **(2 points)** Find the ***algebraic* product-of-Maxterms** expression for *F*.
1. **(4 points)** Given that $F(A,B,C)=\sum\_{}^{}m\left(0,3,5,7\right)$ and $G\left(A,B,C\right)=\prod\_{}^{}M\left(1,2,4,7\right).$ Express the function $F+\overbar{G}$ as a sum of minterms.
2. **(4 points)** Given the following two circuits representing the functions F and G. Determine whether the two functions F and G are equivalent or not. Justify your answer.



**Question 2. (10 points)**

1. Consider the circuit shown below. Assume that the propagation delay of a gate is related to its number of inputs, i.e. the propagation delays through an Inverter, through a 2-input AND, through a 3-input AND, and through a 2-input OR gates are 1 ns, 2 ns, 3 ns and 2 ns, respectively.
2. **(2 point)** What is the longest propagation delay from an input to the output?
3. **(3 points)** Assuming that the values at the following inputs are stable having the values A=0, B=1, C=1, D=1, and F=0, draw the signals that can be observed at the points G, H, and Y due to a change in signal E by completing the timing diagram given below.





1. **(2 points)** Given an inverter with the following parameters VOH=5v VOL=0v, VIH=2.8v, VIL=1.6, the noise margins NMH=\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ and NML= \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.
2. **(3 points)** The Boolean function implemented by the circuit given below expressed as a sum-of products is F = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

