PRINT NAME (Last, First): ______________________

SIGN YOUR NAME: ______________________

STUDENT ID #: ______________________

# 1	# 2	# 3	# 4	5	6	TOTAL
25	10	10	10	10	10	75

Intructions:

1 You have 90 minutes to complete this exam.

2 Print and sign your name, enter your student ID number.

3 Read the questions carefully.

4 Write your solution clearly.

5 You must supply units for all your answers (i.e. kΩ, μA)

6 This exam has 6 questions worth 75 points, so you should proceed at around 1 point per minute.

Problem # 1 (25 points)

(a) Simplify the following Boolean expression:

$$Q = AB + \overline{B} + \overline{(A + C)}B + \overline{A}BC$$

Q =	4 points

(b) What do these acronyms stand for?

CMOS:	1 point	RAM:	1 point
FET:	1 point	PSK:	1 point

(c) What is the principal advantage of CMOS logic circuits?

Answer:	1 point

(d) Draw a comparator and explain what it does.

Answer:	2 points

(e) You want to build a digital thermometer capable of measuring temperatures in the range from 0° to 212°. Your digital thermometer can have a quantization error of ±0.001°. How many binary lines are needed in the output data bus of the digital thermometer?

Answer:	2 points

(f) List any two uses for coding in communication systems.

	2 points
1	
2	

(g) Consider the following code.
We transmit the five bits 00000 for the digital **0** and the five bits 11111 for **1**.

How many bit errors can this code correct?	1 point

How many bit errors can this code detect?	1 point

(h) What dopant material is typically used to make a p-type semiconductor?

Answer:	1 point

(i) What dopant material is typically used to make an n-type semiconductor?

Answer:	1 point

(j) Is coding used for communication of analog signals?

Answer:	1 point

(k) Do diodes require an external power supply?

Answer:	1 point

(l) What is the purpose of a commutator in a brushless DC motor?

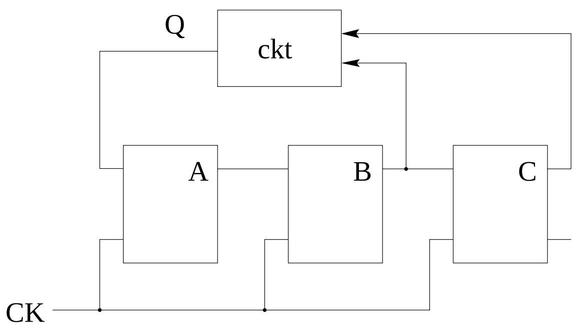
Answer:	2 point

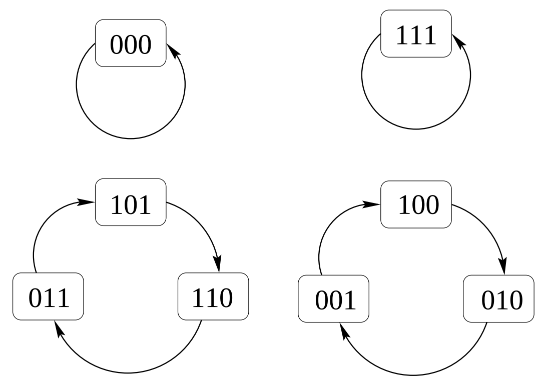
(m) What is the purpose of a quadrature encoder for motor?

Answer:	2 point

Problem # 2 (10 points)

Consider the counter circuit shown below. There are three D-type flip flops, and the state of the counter is labeled **ABC**. Design the combinatorial circuit labeled **ckt** that will realize the state transition diagram shown below.





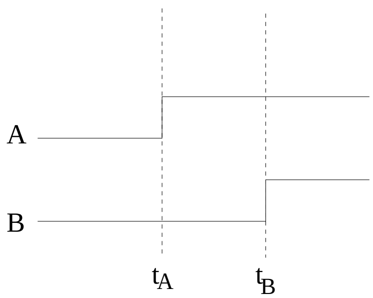
Draw your circuit here:

Problem # 3 (10 points)

Tiffany and Riley are playing Jeopardy on national TV. They each have a little button that they can press which generates the signals A and B. When they press their button, a signal changes from 0 to 1. For example, in the figure shown below Tiffany hits her button at time t_A while Riley hits his button at the later time t_B.
You can assume that they never push their buttons at exactly the same time.

Design a circuit to detect who hit their button first. The circuit should have two outputs:

$$P = \begin{cases} 1 & \text{if Tiffany pressed her button first} \\ 0 & \text{if no one has pressed a button yet} \end{cases} \qquad Q = \begin{cases} 1 & \text{if Riley pressed his button first} \\ 0 & \text{if no one has pressed a button yet} \end{cases}$$



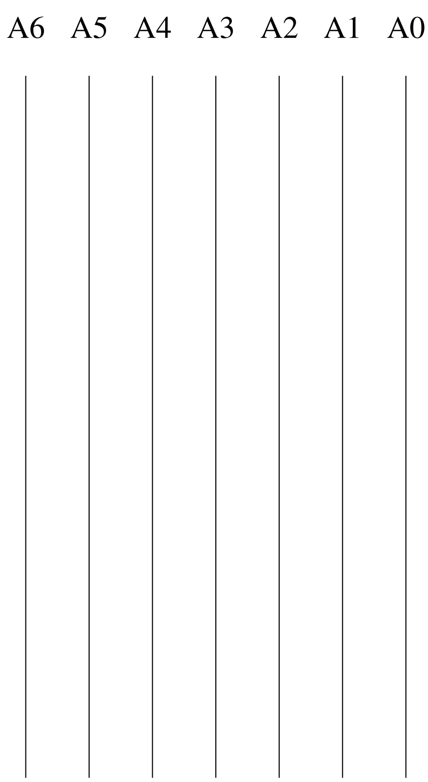
Draw your circuit here:

Problem # 4 (10 points)

In this problem, you are asked to design a digital circuit. There is parallel binary data arriving at an seven line bus **A6, A5, A4, A3, A2, A1, A0**. The data on the bus represents a number x between 0_{10} and 127_{10}. The least significant bit is $A0$ and the most significant bit is $A6$.

You have to build a digital circuit whose output is **F**. The output **F** should be **1** if and only if the number x represented on the bus is exactly divisible by 4. For example, if the current data is **1100**, the number represented is 76 which is divisible by 4 and so **F = 1**. Otherwise **F = 0**.

Draw your circuit here:



Problem # 5 (10 points)

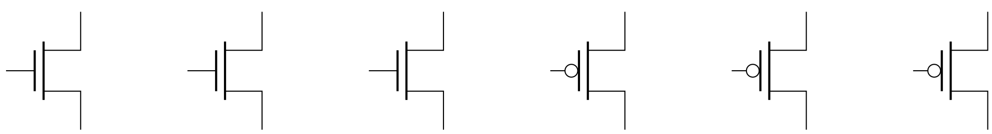
You have three binary signals A, B, and C.

Design a CMOS gate to realize the logical expression

$$F = A \cdot B + C$$

Your can use the 6 FET switches shown below.
You also have access to logical **0** and logical **1** signals.

There will be no partial credit for this problem.



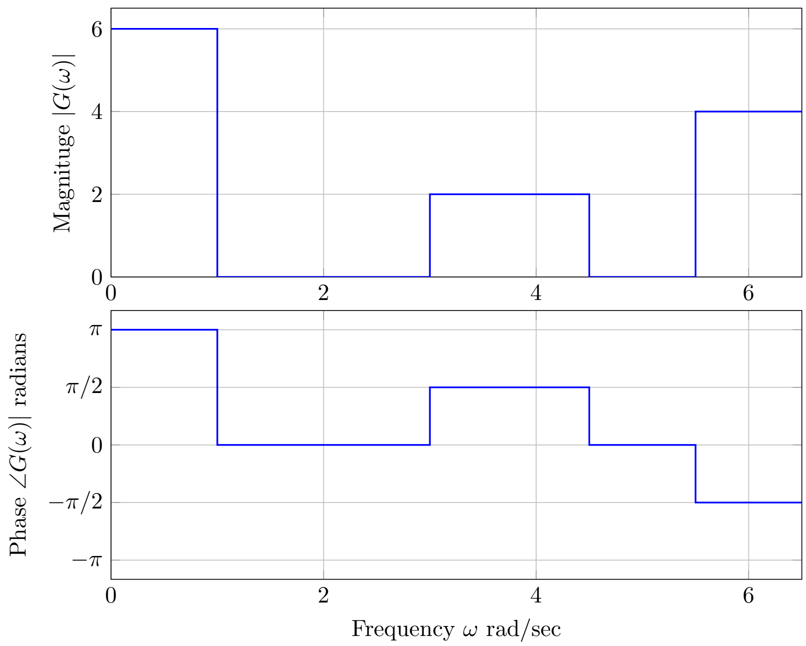
Answer:

Problem # 6 (3+3+4 = 10 points)

A filter with input voltage $v_i(t)$ and output voltage $v_o(t)$ has voltage gain $\mathbb{G}(\omega)$. In other words,

$$\mathbb{V}_o(\omega) = \mathbb{G}(\omega)\mathbb{V}_i$$

where $\mathbb{V}_i$ and $\mathbb{V}_o$ are the phasors of $v_i(t)$ and $v_o(t)$ respectively.



The magnitude and phase of $\mathbb{G}(\omega)$ are plotted above. In each of the following cases, compute the voltage output $v_o(t)$:

(a) $v_i(t) = \cos(4t)$

$v_o(t) =$

(b) $v_i(t) = \cos(4t) + \cos(6t)$

$v_o(t) =$

(c) $v_i(t) = 1 + \sin(4t - \pi/2))$

$v_o(t) =$