Name: _____

Read each question carefully before answering. Answer all parts. Show all work, calculations, and/or reasoning, otherwise no points will be awarded. Properly labeled loops must be shown on K-maps. Point values are as indicated.

1. (20 points) You receive two 2-bit numbers designated as $AB$ and $CD$. If $AB \geq CD$, an LED should turn on. The output of this function, $F$, will therefore be 1 if the LED should be on. Otherwise $F$ will be 0. Implement this using a 4 to 1 MUX and a minimum number of external gates. Fill in the corresponding circuit diagram. Clearly indicate your control bits, and include your multiplexer equation at the bottom of the page.

$$AB$$

| $CD$ | 00 | 01 | 11 | 10 |
|------|----|----|----|----|
| 00 |  |  |  |  |
| 01 |  |  |  |  |
| 11 |  |  |  |  |
| 10 |  |  |  |  |

4 to 1
MUX
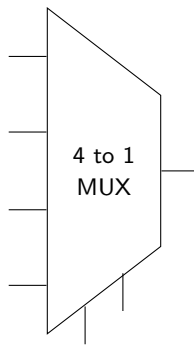
$F =$ _____

2. (20 points) Your buddy wired up a 3 to 8 decoder using only 2 to 4 decoders as follows. The MSB of the control bits is $A$, and the LSB of the control bits is $C$. Label the circuit diagram with the correct outputs from $F_0 - F_7$.
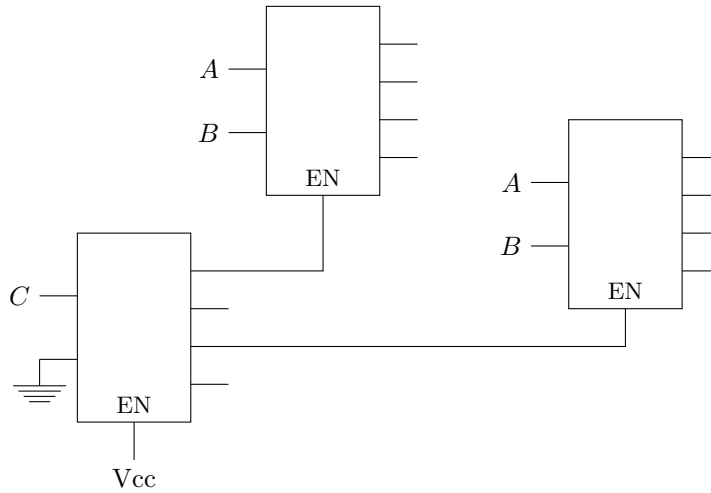
3. (25 points) A sensor on a car tire sends a 5-bit binary signal ($ABCDE$) that represents the tire pressure in PSI. The output $L$ (low pressure) should be 1 if the pressure is less than 19. The output $P$ (puncture) should be 1 if the pressure is less than 3. Use the following PAL diagram to implement outputs $L$ and $P$. You will **not** need to add any gates to the PAL diagram!
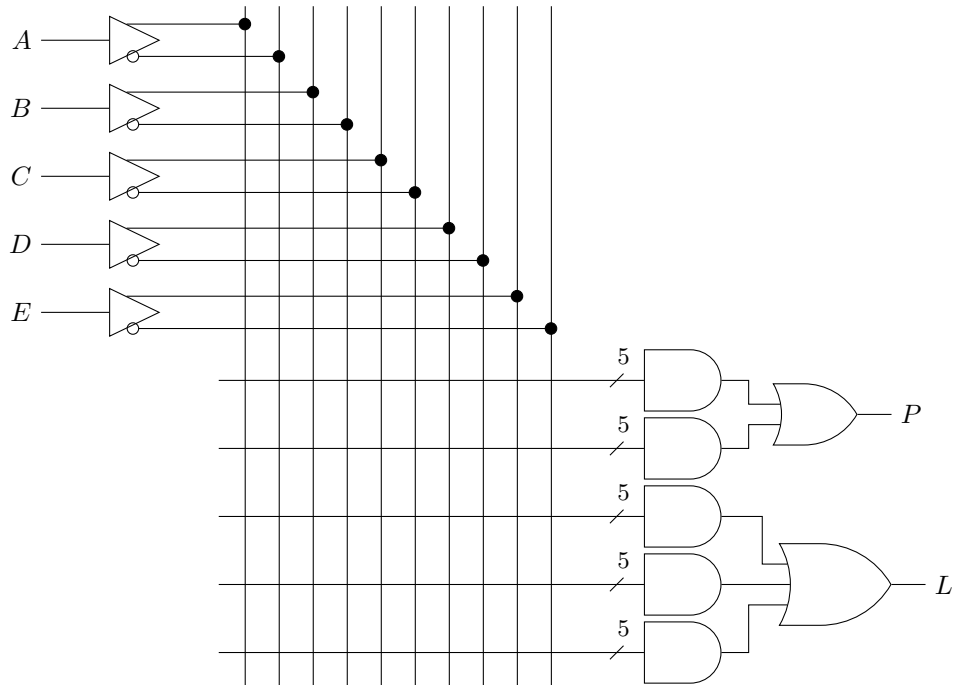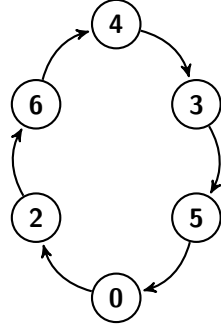
4. (10 points) Fill out the following timing diagram for a D latch with an active-low enable bit. Ignore all gate delays. Q(0) = 0.
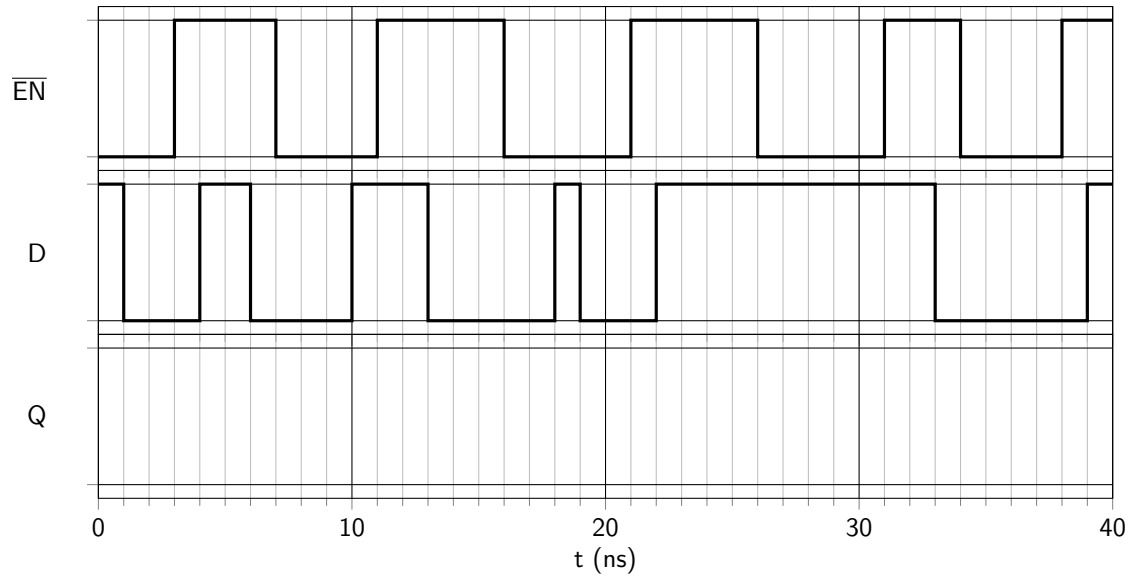


5. (10 points) Fill out the following timing diagram for a rising-edge triggered JK flip-flop. Ignore all gate delays. Q(0) = 1.
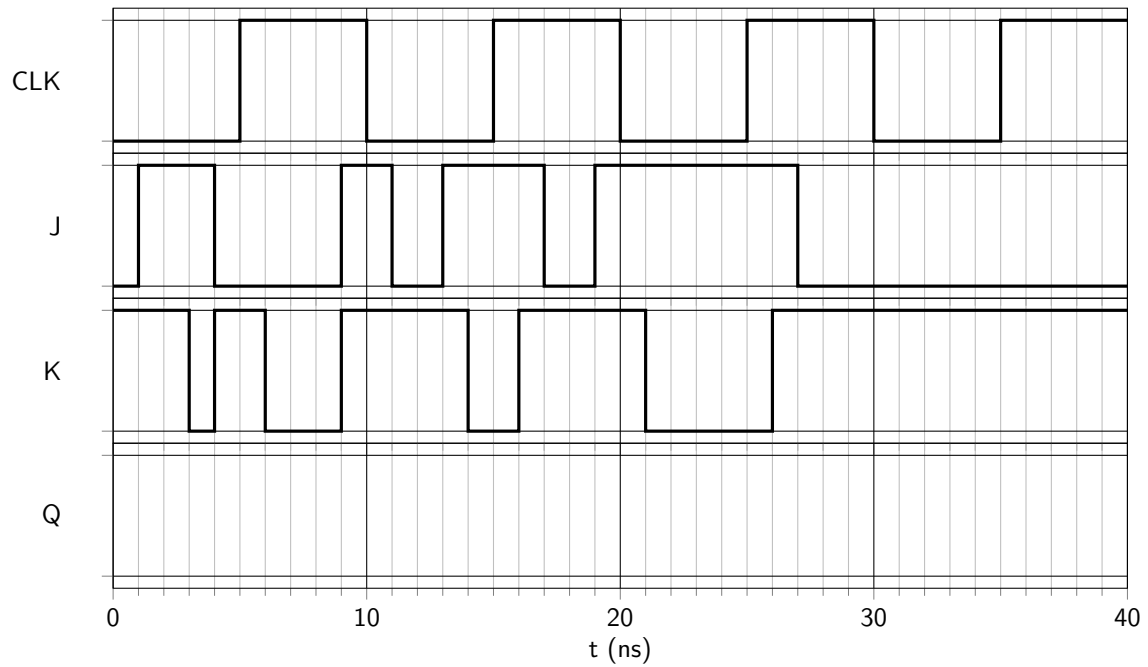
6. (25 points) Design a 3-bit counter that counts in the sequence given in the state diagram below. Use D flip-flops and a minimum number of external gates. Write each flip-flop equation, then draw the circuit diagram using the template below. K-maps are provided on the next page.
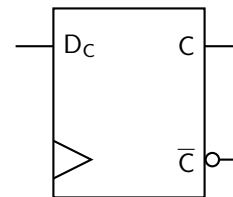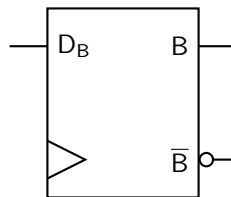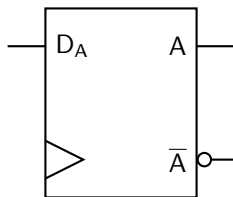
$T_A = \underline{\hspace{6cm}}$

$T_B = \underline{\hspace{6cm}}$

$T_C = \underline{\hspace{6cm}}$

| $A$ | $B$ | $C$ | $A^+$ | $B^+$ | $C^+$ |
|-----|-----|-----|-------|-------|-------|
| 0 | 0 | 0 | | | |
| 0 | 0 | 1 | | | |
| 0 | 1 | 1 | | | |
| 0 | 1 | 0 | | | |
| 1 | 0 | 0 | | | |
| 1 | 0 | 1 | | | |
| 1 | 1 | 1 | | | |
| 1 | 1 | 0 | | | |

| BC | A 0 | 1 |
|----|-----|---|
| 00 | | |
| 01 | | |
| 11 | | |
| 10 | | |

| BC | A 0 | 1 |
|----|-----|---|
| 00 | | |
| 01 | | |
| 11 | | |
| 10 | | |

| BC | A 0 | 1 |
|----|-----|---|
| 00 | | |
| 01 | | |
| 11 | | |
| 10 | | |