Show all your work to get any marks; no work = no marks!

Hand write with pen and paper, then upload images or a PDF file of the exam before 9:30 PM.

Print and fill out the attached exam, with pen and paper. If you do not have a printer, just hand-write your answers with pen and paper instead; please keep the answers in order (starting at #1). Upload a PDF file of your final exam submission; answer questions in order. Show ALL your work for every question. If you have questions, email Jason_Wilder@bcit.ca

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Student Number: A01354731

Score: ________ out of 21

1. a) Consider a multilevel computer in which all the levels are different. Each level has instructions that are 4 times as powerful as those of the level below it; that is, one level m instruction can do the work of 4 level m – 1 instructions. If a level-6 program requires 2 attoseconds to run, how long would equivalent programs take at levels 1 and 19, assuming 3 level m instructions are required to interpret a single m + 1 instruction? **(2 marks)**
   b) Also, what is wrong in that question? Explain. **(1 mark)**

a) $m=4$
$n=3$
$k=2as.$
$r=6$

In lvl 1:

$$2as \times \left(\frac{3}{4}\right)^{-6}$$
$$= 2 \times \frac{4096}{729}$$
$$= \frac{8192}{729} \approx 11.2373as.$$

In lvl 19.

$$2as \times \left(\frac{3}{4}\right)^{13}$$
$$= 2 \times \frac{1594323}{67108864}$$
$$= \frac{3188646}{67108864} \approx 0.0475 as.$$

b) This time might be too short to be realistic

2. Fill in the rows of this table: **(1 mark)**

	Frequency	Corresponding period
a	25kHz	40 microseconds
b	50MHz	20 nanoseconds
c	125Hz	8 milliseconds
d	30kHz.	33.3333 microseconds

3. Consider a pipeline whose stages take 14 nanoseconds, 16000 femtoseconds, 0.00003 milliseconds, and 0.15 microseconds. What are a) its latency and b) its bandwidth? **(2 marks)**

$14ns = 14ns$
$16000fs = 0.016ns$
$0.00003ms = 30ns$
$0.15\mu s = 150ns.$

a) Latency $= 14 + 0.016 + 30 + 150$
$= 194.016ns$

b) Bandwidth:
Slowest $= 150ns$
Bandwith $= \frac{1}{150}$ instruction/ns.

4. a) What is the Hamming Distance of a code whose words are 00000011, 10101010, 00001111, and 11110000?

d 00000011 | 10101010 = 4
d ↓ | 00001111 = 2
d ↓ | 11110000 = 6

d 10101010 | 00001111 = 4
d ↓ | 11110000 = 4
d 00001111 | 11110000 = 8

$d_{min} = 2$.

∴ Hamming distance = 2.

b) How many errors can it correct? c) What are the properties of a good error-correcting code? Why are these good properties? Explain clearly. **(2 marks)**

b) $\frac{2}{2} = 1$

It can correct less than 1 error which means 0 error can be corrected

c) The minimum Hamming Distant should be large so it will easier to detect errors. It's like two targets being far apart, the farther they are, the easier it is to tell which one a stray bullet was originally aimed at.

5. The following Hamming codeword was made using even parity, 1101101. a) Was there an error? b) Where? c) What was the original dataword supposed to have been? d) Explain the limitations of Hamming code in this question. Under what circumstances might Hamming code have failed here? **(2 marks)**

a)

No.	1	2	3	4	5	6	7
bin	0001	0010	0011	0100	0101	0110	0111
codeword	1	1	0	1	1	0	1
P	P_1	P_2		P_4			
check	1	2	1,2	4	1,4	2,4	1,2,4

$P_1: 1+1+0=2$, should be 0 but 1 ✗

$P_2: 1+0+0=1$, should be 1 ✓

$P_4: 1+0+1=2$, should be 0 but 1 ✗

∴ Yes there is.

b) P_1, P_4 wrong

Wrong bit $= 1+4=5$

∴ At bit 5.

c) original codeword:

1101001

original dataword:

0011

d) It can only detect at most one error. Otherwise it will fail.

6. Create the odd-parity Hamming codeword for the dataword 010110111. Clearly identify parity bits. **(1 mark)**

No.	1	2	3	4	5	6	7	8	9	10	11	12	13
bin	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101
codeword	0	1	0	1	1	0	1	1	1	0	1	1	1
P	P_1	P_2		P_4				P_8					
check	1	2	1,2	4	1,4	2,4	1,2,4	8	1,8	2,8	1,2,8	4,8	1,4,8

$P_1: 1+1+1+1+1+0$
$= 5 \to P_1 = 0$

$P_2: 1+0+1+0+0=2$
$P_2 = 1$

$P_4: 1+1+1+0+1=4$
$P_4 = 1$

$P_8: 1+1+1+0+1=4$
$P_8 = 1$

Codeword = 01.0110111 0111

7. What is the mean memory access time for a system with four levels of cache and a main memory. The access times for these respectively are 2ns, 5ns, 10ns, 20ns, and 1 microsecond. 650 memory accesses were made. 400 hits were in level 1; 100 in level 2; 80 in level 3; 50 in level 4; the rest were in main memory. **(2 marks)**

$1\mu s = 1000ns.$

Total time $= 650 \times 2ns + 250 \times 5ns + 150 \times 10ns + 70 \times 20ns + 20 \times 1000ns$

$= 1300ns + 1250ns + 1500ns + 1400ns + 20000ns$

$= 25450ns$

$MAT = \frac{25450}{650} = \frac{509}{13} ns$

8. How long does it take to read a disk with 4000 cylinders, each containing seven tracks of 256 sectors? First, all the sectors of track 0 are to be read starting at sector 0, then all the sectors of track 1 starting at sector 0, and so on. The rotation rate is 1200 RPM, and a seek takes 4 msec between adjacent cylinders and 40 msec for the worst case. Switching between tracks of a cylinder can be done in 13 msec. **(2 marks)**

$1200 RPM = \frac{60}{1200} = 0.05s = 50ms$, 25ms average.

1. find track 0: 40 ms worst.
2. wait for sector 0: 25ms average
3. read that track on the 1st platter: 50ms.
   switch to next platter: 13ms
   wait sector 0: 37ms.
   read track: 50ms
   Repeat 7 times.
4. switch to 1st platter: 13ms
   move to next platter: 4ms
   wait sector 0: 50-13-4 = 33ms.
5. Repeat 3-4 4000 times.

Total: $40ms + 25ms + 4000 \times 7 \times (50+13+3$

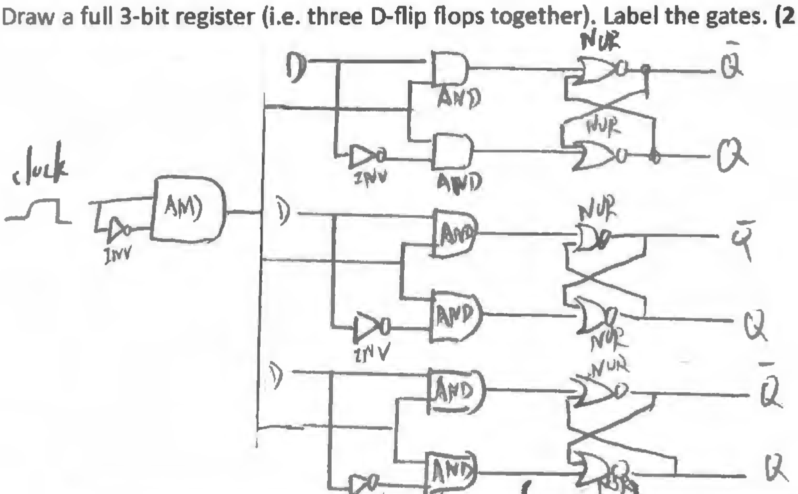
$= 2800065 ms$

$= 46.66775 min$

50+13+37

The scanner didn't capture the whole image.

9. Draw a full 3-bit register (i.e. three D-flip flops together). Label the gates. **(2 marks)**



10. Imagine you are tasked with designing a control system for the smart lighting in a home. The system has four lights (L1, L2, L3, L4) and is controlled by three inputs: Time of Day (T), Presence of People (P), and Special Mode (S).

Time of Day (T): This input has two states, Day (0) and Night (1).

Presence of People (P): This input detects if people are present (1) or not (0).

Special Mode (S): This input indicates whether a special mode is activated (1) or not (0). Special mode could be anything like a party mode or an energy-saving mode.

The lights in the home must operate under the following conditions:

During the Day (T=0): Only L2 should be on if people are present (P=1), regardless of the Special Mode (S).

During the Night (T=1) and No Special Mode (S=0): L1 and L3 should be on if people are present (P=1); otherwise, all lights should be off.

During the Night (T=1) and Special Mode (S=1): L4 should be on, and L1 should also be on if people are present (P=1), regardless of their presence for L4.

Your task is to:

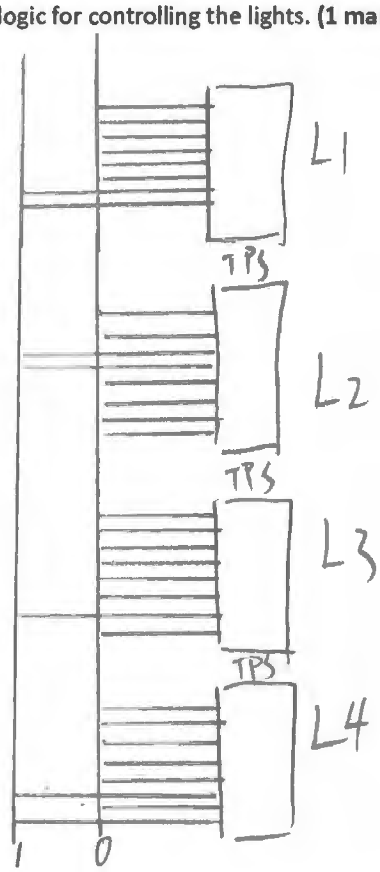
a) Develop a truth table that for the logic to turn each light on or off based on the inputs T, P, and S. **(1 mark)**

b) Design a set of multiplexers that implement this logic for controlling the lights. **(1 mark)**

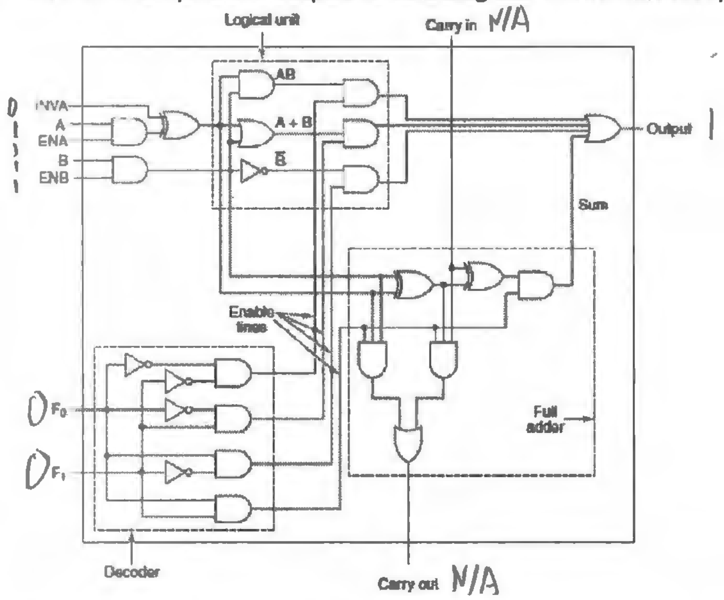
a)

T	P	S	L1	L2	L3	L4
0	0	0	0	0	0	0
0	0	1	0	0	0	0
0	1	0	0	1	0	0
0	1	1	0	1	0	0
1	0	0	0	0	0	0
1	0	1	0	0	0	1
1	1	0	1	0	1	0
1	1	1	1	0	0	1

b)



11. Fill in all the inputs and outputs for this diagram. The circuit must perform the operation "1 and 1": **(1 mark)**



12. Fill in all the inputs and outputs for this diagram to perform the operation "write 000 to word 2": **(1 mark)**