*Name:*_____
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ECS 17: Data, Logic, and Computing
Midterm 1: solutions
February 5, 2025

Notes:

1) The midterm is open book, open notes.
2) You have 50 minutes, no more: I will strictly enforce this.
3) The midterm is graded over 70 points
4) You can answer directly on these sheets (preferred), or on loose paper.
5) Please write your name at the top right of each page you turn in!
6) Please, check your work! **Also, do show your work**

Part I (6 questions, each 5 points; total 30 points)
(These questions are multiple choices; in each case, find the most **plausible** answer)

1) ***The sum of the ASCII codes for the letters of a 3-letter word is #D8. Which of the following words could it be?***

    a. DOG
    b. CAT
    c. ZOO
    d. ANT

*#D8 = 13*16 + 8 = 216 (decimal).*
Using decimal only:
DOG: 68 + 79 + 71 = 218 ≠ 216
CAT: 67 + 65 + 84 = 216
ZOO: 90+79+79 = 248 ≠ 216
ANT: 65 + 78+84 = 227 ≠ 216

2) ***A biomedical engineer is designing a device to monitor human heart activity. The device must accurately capture an ECG signal containing frequency components up to 150 Hz. However, to account for potential noise and ensure proper filtering, the engineer decides to include a safety margin of 20% above the maximum signal frequency. Which of these sampling frequencies could the engineer use (circle all that apply)?***

    a. 150 Hz
    b. 180 Hz
    c. 300 Hz
    d. 360 Hz
    e. 380 Hz

*The highest possible frequency in the signal is 150 Hz + 20% of 150 Hz = 180 Hz, when we account for noise. Nyquist theorem says that the sampling frequency should be > 2*180, i.e. > 360 Hz. The only option strictly above 360 is 380 Hz.*

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3) ***Let x be a hexadecimal digit (i.e. a number in {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F}. We know that #x0 + #1x = #Ax (where # means that the numbers are given in hexadecimal format; for example, if x = 1, #x0 = #10 = $(16)_{10}$). Solve for x:***

   a. 7
   b. 8
   c. 9
   d. A

The equation is: #x0 + #1x = #Ax
Rewiring it in decimal format:
16x + 0 + 16 + x = 160 + x
16 x = 160-16 = 144
i.e. x = 9.

4) ***On a quiz for ECS17, you are asked to do a simple addition. Unfortunately, the printout of the question failed and instead of writing the characters, it wrote the ASCII code for those characters:***
#23 #33 #41 #20 #2B #20 #23 #32 # 46 #20 #3D
What is the result of the addition (in decimal format)?

   a. 68,
   b. 70,
   c. 104,
   d. 105.

The expression
#23 #33 #41 #20 #2B #20 #23 #32 # 46 #20 #3D
Means
#3A + #2F =
#3A = 3x16 + 10 = 58 (decimal)
#2F = 2x16 + 15 = 47 (decimal)
Therefore
#3A + #2F = 105 (decimal)

5) ***A marine biologist is conducting two simultaneous studies on a fish species:***
   - ***Recording their tail movement which occurs at 12 Hz***
   - ***Recording their gill movement which occurs at 15 Hz***

   If the biologist wants to use a single recording system to capture both movements accurately, what sampling rate could they use? (circle all that are correct)?

   a. 12 Hz,
   b. 15 Hz,
   c. 24 Hz,
   d. 30 Hz,
   e. 32 Hz.

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*As we want to record both tail movement and gill movement, the highest frequency in the signal is 15 Hz. Therefore, we need to record with a sampling frequency > 2*15 =30. The only choice is 32 Hz.*

6) ***A home security system has three sensors:***
   - ***A window sensor (W): outputs 1 if the window is open***
   - ***A motion detector (M): outputs 1 if motion is detected***
   - ***A door sensor (D): outputs 1 if the door is open***

   An alarm connected to those sensors should trigger EITHER when the window is open AND motion is detected, OR if the door is open, BUT NOT when both those 2 conditions are met (i.e. the OR is exclusive). Which Boolean expression correctly represents when the alarm should trigger?

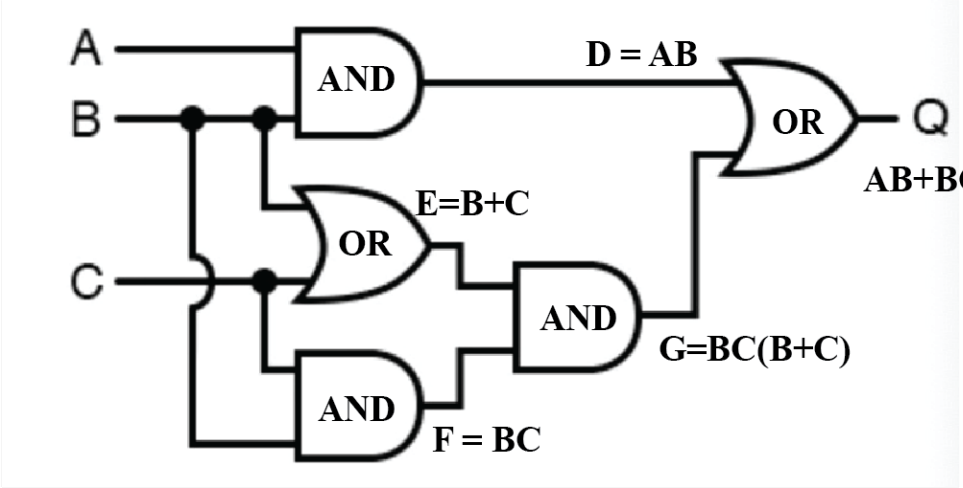
   a. $(W \oplus M) \cdot D$,
   b. $W \cdot M \cdot D$,
   c. $W \cdot M + D$,
   d. $(W \cdot M) \oplus D$.

The window is open AND motion is detected: $W \cdot M$
The door is open: D
As we want exclusive OR ("but not when both…"), the answer is $(W \cdot M) \oplus D$

Part II (One problem with 2 questions, each 10 points; total 20 points)

Consider the Boolean expression $A \cdot B + B \cdot C \cdot (B + C)$

a. Draw the logic circuit using basic gates



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b. Build its truth table

A	B	C	D=AB	E=B+C	F=BC	G=EF	$A \cdot B + B \cdot C \cdot (B + C)$
1	1	1	1	1	1	1	1
1	1	0	1	1	0	0	1
1	0	1	0	1	0	0	0
1	0	0	0	0	0	0	0
0	1	1	0	1	1	1	1
0	1	0	0	1	0	0	0
0	0	1	0	1	0	0	0
0	0	0	0	0	0	0	0

Part III (two problems, each 10 points; total 20 points)

1) You arrive on an island inhabited by **Knights (who always tell the truth)** and **Knaves (who always lie)**. You meet **three islanders**: **Alex, Blake, and Casey**. You know that at least one of them is a Knight and at least one is a Knave, but you do not know how many of each there are. You ask each of them, **"How many of you are Knights?"**

- **Alex** says, *"At least one of us is a Knave."*
- **Blake** says, *"Alex would say that exactly one of us is a Knight."*
- **Casey** surprisingly says, "*I really like peanut butter*".

Can you determine who are the Knights and who are the Knaves? Does Casey really like peanut butter? Explain your reasoning. (***10 points***)

We build a truth table. Note that while usually there are 8 options when we consider 3 people, there are only six options in this case, as there must be at least one knight and at least one knave, meaning that we cannot have all 3 being knights or all 3 being knaves. We only consider the statements of Alex and Blake, as what Casey says in not informative. Note that Alex's statement is always true.

Line #	Alex	Blake	Casey	Alex says	Blake says
1	Knight	Knight	Knave	True	False
2	Knight	Knave	Knight	True	False
3	Knight	Knave	Knave	True	True
4	Knave	Knight	Knight	True	True
5	Knave	Knight	Knave	True	False
6	Knave	Knave	Knight	True	False

Line 1 is incompatible: Blake would be a knight that lies
Line 2 is compatible
Line 3 is incompatible: Blake would be a knave that tells the truth
Lines 4-6 are incompatible: Alex would be a knave that is telling the truth.

Therefore, Alex and Casey are knights and Blake is a knave. Since Carey is a knight, they are telling the truth and therefore like peanut butter!

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2) On an island, there are three tribes:

- Day-Tribers, who always tell the truth during the day and lie at night.
- Night-Tribers, who always lie during the day and tell the truth at night.
- Spy-Tribers, who may lie or tell the truth at any time.

You arrive on the island and meet three people, Alice and Bob, and Cathy. You know that one is a day-Triber, one is a night-Triber, and one is a spy-Triber.

- Alice says: *"Bob is a night-Triber."*
- Bob says: *"Cathy is the spy-Triber."*
- Cathy says: *"Alice is the day-Triber and it is day."*

Can you determine whether it is currently day or night, and which tribe(s) Alice, Bob and Cathy belong to? Explain your reasoning. ***(10 points)***

We build a truth table. We use: DT: day-Triber, NT: night-Triber, ST: spy-Triber

Line #	Day / Night	Alice	Bob	Cathy	Alice Says	Bob says	Cathy says
1	Day	DT	NT	ST	True	True	True
2	Day	DT	ST	NT	False	False	True
3	Day	NT	DT	ST	False	True	False
4	Day	NT	ST	DT	False	False	False
5	Day	ST	DT	NT	False	False	False
6	Day	ST	NT	DT	True	False	False
7	Night	DT	NT	ST	True	True	False
8	Night	DT	ST	NT	False	False	False
9	Night	NT	DT	ST	False	True	False
10	Night	NT	ST	DT	False	False	False
11	Night	ST	DT	NT	False	False	False
12	Night	ST	NT	DT	True	False	False

Compatibility:
Line 1 is incompatible: Bob is a night-triber, it is day, he should lie.
Line 2 is incompatible: Alice is a day-triber, it is day, she should tell the truth.
Line 3 is compatible.
Line 4 is incompatible: Cathy is a day-triber, it is day, she should tell the truth.
Line 5 is incompatible: Bob is a day-triber, it is day, he should tell the truth.
Line 6 is incompatible: Cathy is a day-triber, it is day, she should tell the truth.
Line 7 is incompatible: Alice is a day-triber, it is night, she should lie.
Line 8 is incompatible: Bob is a night-triber, it is night, he should tell the truth.
Line 9 is incompatible: Bob is a day-triber, it is night, he should lie.
Line 10 is incompatible: Alice is a night-triber, it is night, she should tell the truth.
Line 11 is incompatible: Cathy is a night-triber, it is night, she should tell the truth.
Line 12 is incompatible: Bob is a night-triber, it is night, he should tell the truth.

The only compatibility is line 3: it is day, Alice is a night-triber (she lies), Bob is a day-Triber (he tells the truth) and Cathy is a spy-Triber.

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Appendix A: ASCII table

Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char	Dec	Hex	Char
0	00	Null	32	20	Space	64	40	@	96	60	`
1	01	Start of heading	33	21	!	65	41	A	97	61	a
2	02	Start of text	34	22	"	66	42	B	98	62	b
3	03	End of text	35	23	#	67	43	C	99	63	c
4	04	End of transmit	36	24	$	68	44	D	100	64	d
5	05	Enquiry	37	25	%	69	45	E	101	65	e
6	06	Acknowledge	38	26	&	70	46	F	102	66	f
7	07	Audible bell	39	27	'	71	47	G	103	67	g
8	08	Backspace	40	28	(	72	48	H	104	68	h
9	09	Horizontal tab	41	29	)	73	49	I	105	69	i
10	0A	Line feed	42	2A	*	74	4A	J	106	6A	j
11	0B	Vertical tab	43	2B	+	75	4B	K	107	6B	k
12	0C	Form feed	44	2C	,	76	4C	L	108	6C	l
13	0D	Carriage return	45	2D	-	77	4D	M	109	6D	m
14	0E	Shift out	46	2E	.	78	4E	N	110	6E	n
15	0F	Shift in	47	2F	/	79	4F	O	111	6F	o
16	10	Data link escape	48	30	0	80	50	P	112	70	p
17	11	Device control 1	49	31	1	81	51	Q	113	71	q
18	12	Device control 2	50	32	2	82	52	R	114	72	r
19	13	Device control 3	51	33	3	83	53	S	115	73	s
20	14	Device control 4	52	34	4	84	54	T	116	74	t
21	15	Neg. acknowledge	53	35	5	85	55	U	117	75	u
22	16	Synchronous idle	54	36	6	86	56	V	118	76	v
23	17	End trans. block	55	37	7	87	57	W	119	77	w
24	18	Cancel	56	38	8	88	58	X	120	78	x
25	19	End of medium	57	39	9	89	59	Y	121	79	y
26	1A	Substitution	58	3A	:	90	5A	Z	122	7A	z
27	1B	Escape	59	3B	;	91	5B	[	123	7B	{
28	1C	File separator	60	3C	<	92	5C	\	124	7C	|
29	1D	Group separator	61	3D	=	93	5D	]	125	7D	}
30	1E	Record separator	62	3E	>	94	5E	^	126	7E	~
31	1F	Unit separator	63	3F	?	95	5F	_	127	7F	□

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Appendix B: Decimal / Binary / Hexadecimal

Base 10	Base 2	Base 16
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

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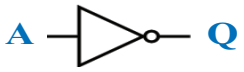
<td> 
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<td>OR</td>
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<td>A+B or A∨B</td>
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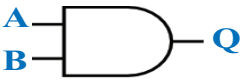
<td> 
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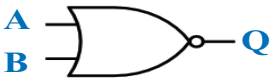
<td> 
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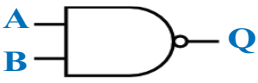
<td> 
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