1. (a) Derive a Boolean algebra expression for the following binary truth table:

a	b	c	z
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

(b) Simplify your expression as much as possible.

(c) Draw a circuit diagram representing your (possibly simplified) expression.

(5+5+5)

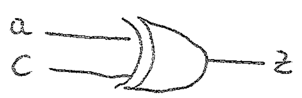
(a) $z = (a' \wedge b' \wedge c) \vee (a' \wedge b \wedge c) \vee (a \wedge b' \wedge c') \vee (a \wedge b \wedge c')$

(b) $z = (a' \wedge c) \wedge \underbrace{(b' \vee b)}_{=1} \vee (a \wedge c') \wedge \underbrace{(b' \vee b)}_{=1}$ (distr. law)

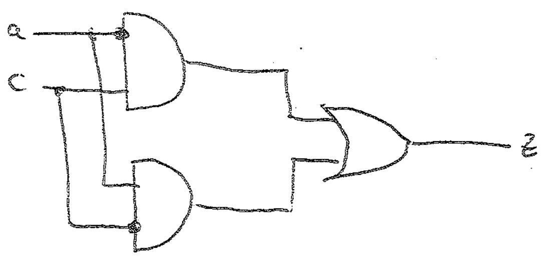
$= (a' \wedge c) \vee (a \wedge c')$

$= a \text{ XOR } c$

(c)



or



2. Show your work when answering the following questions.

   (a) Convert $(17.75)_{10}$ into binary.

   (b) Convert $(A1.C)_{16}$ into decimal.

   (c) Which integer is represented by the bit pattern 11110101 interpreted in 8-bit two's complement representation?

(5+5+5)

(a) $(17)_{10} = (10001)_2$

$(0.75)_{10} = \frac{1}{2} + \frac{1}{4} = (0.11)_2$

$\Rightarrow (17.75)_{10} = (10001.11)_2$

(b) $(A1.C)_{16} = \underbrace{10 \cdot 16^1}_{=160} + \underbrace{1 \cdot 16^0}_{=1} + \underbrace{12 \cdot 16^{-1}}_{=\frac{12}{16} = \frac{3}{4}}$

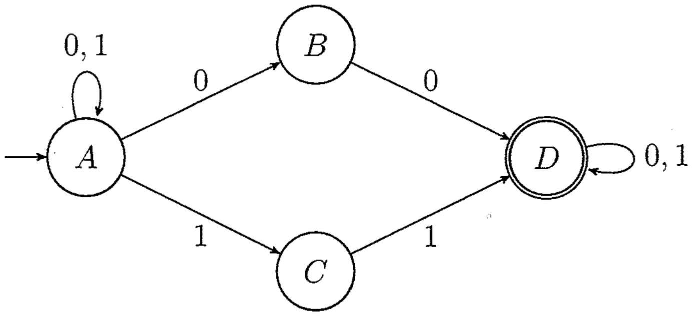
$= (161.75)_{10}$

(c) The integer is negative, to get the value, we need the two's complement:

$$\begin{array}{r} 0000\ 1010 \\ +\qquad\quad 1 \\ \hline 0000\ 1011 \end{array} = (11)_{10}$$

So the number is $(-11)_{10}$

3. Consider the following non-deterministic FSA:



(a) Is the input string 01001 accepted? Show the possible transitions of the FSA step-by-step.

(b) What strings does this FSA accept? Answer in words and state a corresponding regular expression.

(c) Convert this non-deterministic FSA into an equivalent deterministic FSA.

(5+5+5)

(a)

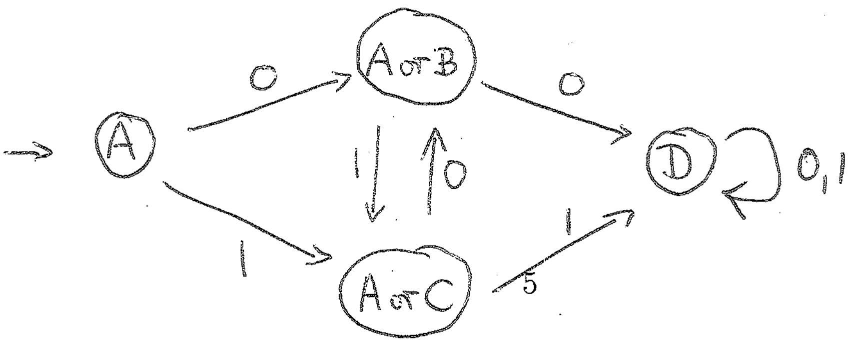
Input	Possible states
0	A, B
1	A, C
0	A, B
0	A, B, D
1	A, C, D

⇒ String is accepted

(b) All strings that contain the substring 00 or 11.

[01]* (00|11) [01]*

(c)



4. Are the following statements true or false? If true, give a *brief* explanation. If false, correct or amend the statement so that it is true.

   (a) Starvation implies deadlock.

   (b) Deadlock can only occur if processes are in circular waiting.

   (c) Deadlock may occur when several processes compete for a single mutually exclusive resource.

   (d) Imposing a total ordering on resource acquisition can prevent deadlocks.

   (e) Using a smaller page size increases the size of the page tables.

(2+2+2+2+2)

(a) No, deadlock implies starvation!

(b) True, this is one of the four necessary conditions for deadlock.

(c) No, deadlock can only occur when several processes compete for two or more mutually exclusive resources. (A circular waiting pattern cannot be established if there is only one mutually exclusive resource.)

(d) True, this is one of the simple strategies for deadlock avoidance, but it is usually not fair and might be difficult if resources are ephemeral. Breaks circular waiting.

(e) True, if memory is a given requirement, smaller pages imply more pages are necessary, so the page tables grow.

5. You are asked to set up a RAID array with four 2 TB disks. Usable capacity of the entire array must be at least 4 TB. You ponder the options RAID 5, RAID 6 and RAID 10.

   (a) Compare the three options in the categories usable capacity, speed of small random writes, and data integrity in case of a drive failure.

   (b) Make a recommendation. If no option is superior in all respects, state a use case that would favor each.

(5+5)

(a) RAID 5:
- Usable capacity 6TB (one disk for redundancy)
- Writing a single block requires first reading (possibly in parallel) two blocks, then writing (possibly in parallel) three blocks. So at best double the time of a single write, usually worse.
- Probability of single-bit-error is high during rebuild.

RAID 6:
- Usable capacity 4 TB (two disks for redundancy)
- Write speed in the best case like RAID 5, but involves one more disk, so more parallelism to maintain speed.
- During rebuild, acts like RAID 5, so orders of magnitude safer

RAID 10
- Like RAID 6 (two disks for redundancy)
- Write speed optimal, two single-disk writes easily in parallel

- Risk during rebuild only on half of array, so safer but not much safer than RAID 5.

(b) recommendation:

- If data integrity is critical, RAID 5 and RAID 10 are not suitable as they have too high a chance of bit errors during rebuild. (See lecture/homework for concrete numbers.) So RAID 6 is prefered.

- If speed of random writes is critical and data integrity can be addressed by independent measures, RAID 10 is preferred

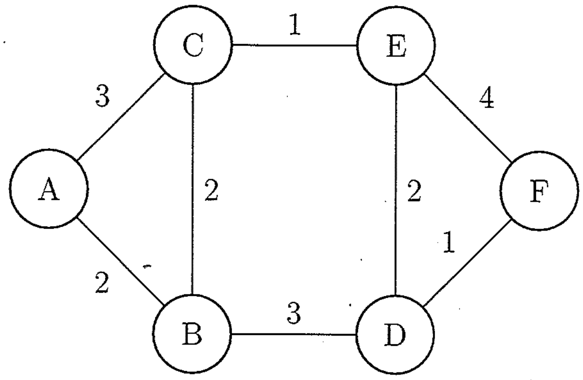
- RAID 5 wins on capacity, but this is not required in the problem specification. With disks of TB-size, it is almost never a good idea.

6. (a) Encode the data word 1110 as a Hamming (7,4) encoded message. Use the bit ordering convention from class.

   (b) You want to encode a stream of data bytes (1 byte = 8 bits) such that each byte to be encoded corresponds to exactly two bytes in the encoded message stream. What are your options within the Hamming (n, k)-family of codes? Explain your preferred choice.

(5+5)

7. Consider the following router network:



Use Dijkstra's algorithm to compute the shortest path from router A to every other router in the network. (10)

6. (a)

p_1	p_2	d_1	p_4	d_2	d_3	d_4
$\boxed{0}$	$\boxed{0}$	1	$\boxed{0}$	1	1	0

(b) To encode 8 bits, need 4 bits parity, so Hamming (12,8) would work, wasting 4 bits or Hamming (13,8) with additional parity to detect but not correct 2-bit errors, wasting 3 bits.

More symmetrical, use two Hamming (8,4) code words, wasting no bits and 8 making the message more robust, as each of the two code word bytes can be corrected/checked independently

7.

Step	M	D(A)	D(B)	D(C)	D(D)	D(E)	D(F)
0	A, B, C, D, E, F	0(A)	∞	∞	∞	∞	∞
1	B, C, D, E, F	0	2(B)	3(C)	∞	∞	∞
2	C, D, E, F	0	2	3	5(B)	∞	∞
3	D, E, F	0	2	3	5	4(C)	∞
4	D, F	0	2	3	5	4	8(C)
5	F	0	2	3	5	4	6(B)
Routing table for A:		A	B	C	B	C	B