Team name : _____

University: _____

THEORETICAL COMPUTER SCIENCE

CS GAMES 2025

The Erudites of CS City need your help! They have determined that the secret of imagination lies within your brain, and they want to study you. To make this both useful and enjoyable, you will solve CS City problems during the study. Use your knowledge to uncover this secret and improve life in CS City!

Instructions :

1. Mobile phones, iPods, computers, smartwatches, and other electronic devices are not allowed. Only a non-programmable calculator is permitted.
2. Answer directly on the front of the questionnaire in the provided space. You may use the back as additional space if needed, but ensure that your answers are clearly visible.
3. Submit the questionnaire in its entirety and in order at the end of the exam.

For Grading			
1. Logical Sequence	/20	**9. Budding Automaton**	/15
2. I Know My Machine	/20	**10. What are the odds?**	/15
3. Algorithm Complexity	/15	**11. Let's Compile Together**	/10
4. Complex Construction	/10	**12. Theo, The Decidable Man**	/4
5. Turing the God machine	/20	**13. Crypto is Life**	/17
6. Grandma vs Grammar	/15	**14. Theo, The State Man**	/4
7. Deep Cleaning	/20	**15. Fun Little Puzzles**	/10
8. Polyglot 101	/25	**16. Quick Questions**	/30
TOTAL			/250

1. Logical Sequence

Let's first test your logical thinking to see if you can imagine what the next number will be.

20 points (2 points per correct answer)

Find the number that continues the following sequences:

1. 4, 7, 11, 18, _____
2. 1, 11, 21, 1211, 111221, _____
3. 4, 16, 37, 58, 89, _____
4. 89, 106, 113, 118, 128, _____
5. 11, 17, 23, 31, _____
6. 9, 61, 52, 63, _____
7. 1, 2, 6, 42, 1806, _____
8. 0, 1, 10, 11, 20, 101, 21, _____
9. 4, 6, 15, 105, _____
10. 1, 2, 3, 4, 5, 6, 7, _____

2. I Know My Machine

To properly analyze your brain, the Erudites need your help in operating their machine. Will you be able to understand and explain it to them?

20 points

1. Can you explain to a 5-year-old what assembly language is and what it is used for? (4 points)

2. One well-known assembly language is ARM. Below is a simple ARMv7 code snippet (line numbers are indicated on the left). Indicate the order in which the microprocessor executes the instructions using the associated line numbers. (4 points)

```
1       MOV LR , PC
2 test
3       BX LR
4       BL test
5       CMP LR , PC
6       BLT test
7       MOV R0 , #0x1
8       B test
```

3. Based on the following code, answer the questions below:

```
1      B main
2
3  table DC32 0xFA , 0x32 , 0x05 , 0x45 , 0x02 , 0x00
4
5  main
6      LDR SP , =myStack
7      ADD SP , SP , #64
8
9      LDR R0 , =table
10     BL mysteryFunction
11     MOV R5 , R0
12
13     B main
14
15 mysteryFunction
16     PUSH {R1, R2, LR}
17     LDR R1 , [R0], #4
18     MOV R2 , R1
19
20 start
21     CMP R1 , #0x00
22     BEQ end
23
24     CMP R1 , R2
25     MOVLT R2 , R1
26     LDR R1 , [R0], #4
27     B start
28
29 end
30     MOV R0 , R2
31     POP {R1 , R2 , LR}
32     BX LR
33
34 myStack DS32 16
```

a. Why are the PUSH and POP instructions used at lines 16 and 31? (2 points)

   b. What is the value of R5 after executing MOV R5, R0 at line 11? (2 points)

   c. Describe what mysteryFunction does. Be sure to understand its arguments and return value. (3 points)

4. Write an ARMv7 assembly code that places the sign (+ or -1) of R1 in R0. In other words, implement the following pseudo-code: (5 points)

```
if R1 < 0 then
  | R0 ← −1;
else
  | R0 ← 1;
end
```

3. Algorithm Complexity

The Erudites want to see how your imagination helps you understand an algorithm.

15 points

1. Determine the execution time of the following function as a function of n. Express your answer using the appropriate asymptotic notation. Justify your answer. (10 points)

```
void f(unsigned int n)
{
   for ( unsigned int i=1; i<=(n*n); i = 2*i)
         for ( unsigned int j=1; j<=n; j = 2*j)
               cout << ''bof" << endl;
}
```

2. For each situation described below, indicate which data container is preferable to use among <vector>, <list>, <stack>, <queue>, and <deque>. Your choice should be based on the execution time of the operations you will need to perform. (1 point per correct answer)

   a. After inserting elements into the container, the only operation performed is accessing the k-th stored element.

   b. You use the container to temporarily store elements and then retrieve them in the order they were stored.

   c. You need to store elements at either the beginning or end of the container and regularly access the k-th stored element.

   d. You will frequently traverse your container sequentially and remove elements satisfying a certain property (which is not always the same). You will also insert elements, but the insertion position does not matter.

   e. You use the container to temporarily store elements and then retrieve them in the reverse order they were stored.

4. Complex Construction

CS City needs your help in expanding the city. Of course, before building, they need to plan how the buildings will be constructed!

10 points

You need to create an algorithm that discovers and enumerates all possible ways to build a wall of dimensions $N \times M$.

The bricks must be placed so that the cracks of two consecutive rows are not aligned.

To build this wall, three brick sizes are available: { 1X3 ; 1X2 : 1X1 }. You have an infinite number of bricks of each size.
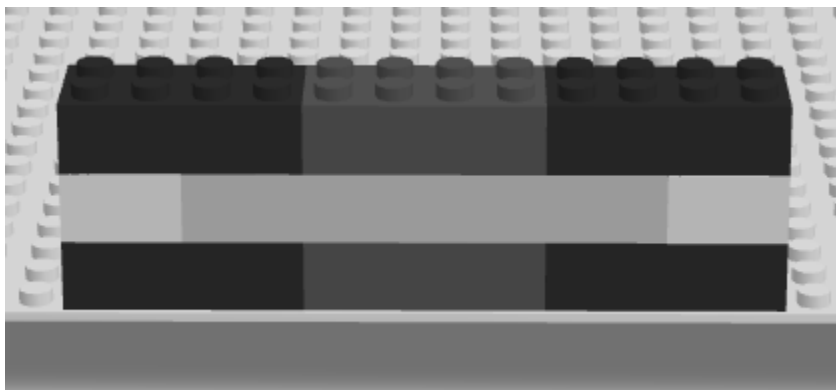
You must provide the algorithmic complexity of your solution and justify your answer.

Example 1:
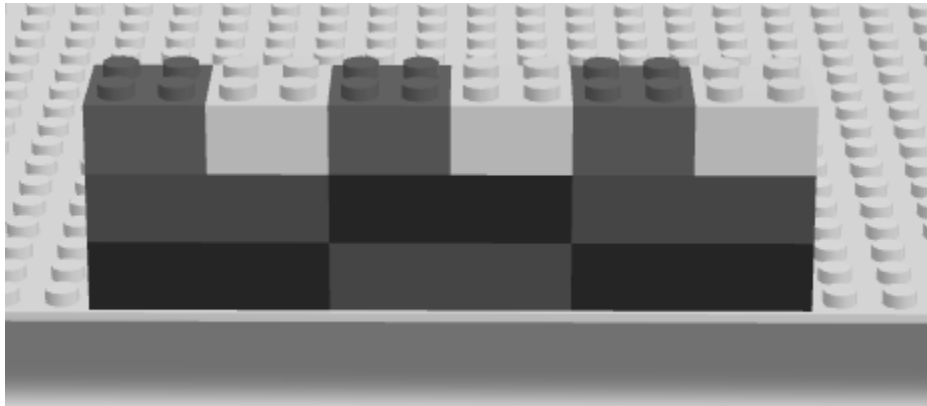
This arrangement is **NOT** valid because the cracks of two consecutive rows are aligned.

Example 2:

This arrangement is **valid**.

Note: The colors are used only to facilitate visualization.

5. Turing the God Machine

Can you imagine how automata work? I imagine so.

20 points

1. Our new computer does not understand how to validate words in the following language $\{a^n b^n c^n : n \in N\}$, we need you to construct a diagram representing a Turing Machine that can validate words from this language. (10 points)

2. What is the difference between a pushdown automaton and a Turing Machine? Be precise in outlining the differences. (4 points)

3. Construct a pushdown automaton recognizing the language $L = \{a^i b^j \mid i = 2j\}$. Clearly specify the mode of acceptance. Before providing the construction, briefly explain how your automaton works. (6 points)

6. Grandma vs. Grammar

Your grandmother wants help constructing her grammar. Your great-grandmother couldn't help her, and the Erudites say they're in a grand mess.

15 points

1. Consider the following grammar G1:

$$
\begin{aligned}
S &\rightarrow aAa \mid bBb \mid \varepsilon \\
A &\rightarrow C \mid a \\
B &\rightarrow C \mid b \\
C &\rightarrow CDE \mid \varepsilon \\
D &\rightarrow A \mid B \mid ab
\end{aligned}
$$

Convert grammar G into Chomsky Normal Form. (4 points)

2. Construct a context-free grammar G2 that generates the language: $L = \{a^i b^j c^k \mid i = j + k,\ i, j, k \geq 0\}$ and provide a derivation for the word "aaabcc". (4 points)

3. Consider the grammar G3 defined by the following rules (the terminal alphabet is {a, b, $}.)

$$
\begin{aligned}
S &\rightarrow W\,T\,ba \\
S &\rightarrow abUV \\
T &\rightarrow W\,T\,ba \\
T &\rightarrow \$ \\
U &\rightarrow abUV \\
U &\rightarrow \$ \\
V &\rightarrow V\,a \\
V &\rightarrow ba \\
W &\rightarrow W\,b \\
W &\rightarrow ab
\end{aligned}
$$

a. Describe the language generated by this grammar. Use a set notation or any other format that is clear and precise. Illustrate your explanation with well-chosen examples of sequences that belong to the language and those that do not. (4 points)

b. Show that G is ambiguous by providing two distinct derivation trees for the same word. (3 points)

7. Deep Cleaning

CS City is the cleanest city in the world, but not without effort! Keeping a city clean starts with cleaning your software!

20 points

1. Based on the following diagram showing the different classes of a fictional application, place each of them in a layer of a hexagonal architecture model. (8 points)
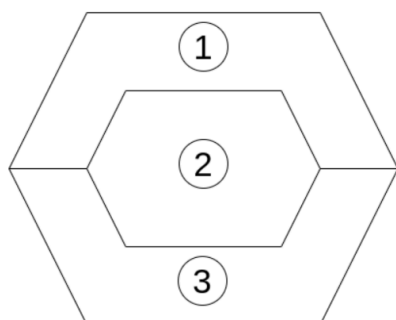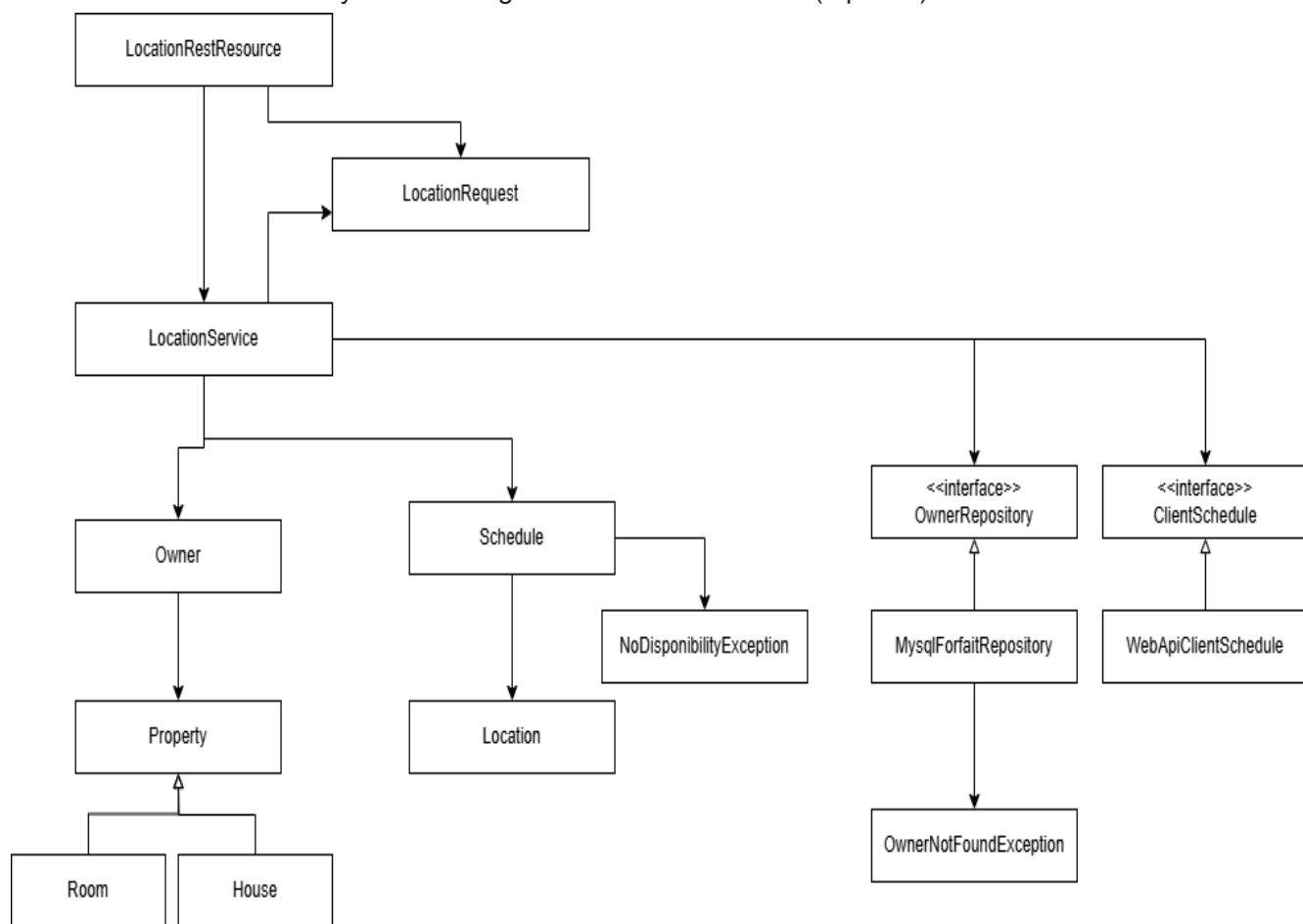
1: Interface 2: Domain 3: Infrastructure

LocationRestRessource	1	2	3
LocationRequest	1	2	3
LocationService	1	2	3
Owner	1	2	3
Property	1	2	3
Room	1	2	3
House	1	2	3
Schedule	1	2	3
NoDisponibilityException	1	2	3
Location	1	2	3
OwnerRepository	1	2	3
MysqlForfaitRepository	1	2	3
OwnerNotFoundException	1	2	3
ClientSchedule	1	2	3
WebApiClientSchedule	1	2	3

2. If you have a Repository with an interface like this:

```
public interface SuperRepository {
    User findByEmail(Email email);
    Order findByOrderNumber(OrderNumber orderNumber)
}
```

a. In what way does this interface not truly follow the spirit of a Repository? (3 points)

b. Which SOLID principle is most likely violated because of this? (2 points)

3. Consider the following Python code:

```
class ShoppingCart:
    def issue_new_invoice(self):
        items_to_invoice = []
        for item in self.items:
            if self.quantity[item] > 0:
                items_to_invoice.append(item)
        invoice = Facture(self.customer)
        invoice.add_items(items_to_invoice)
```

Which SOLID principle(s) are violated? (5 points)
Explain your reasoning based on the definition of the principle in the context of this specific case. Do not just provide the definition.

4. Who am I? (2 points)
I am actually composed of two parts: an interface and implementations.
The domain knows my interface but never my implementation.
My methods are designed to meet specific business domain needs.
I do not necessarily represent a database but rather an external data source.
My goal is to ensure that the decisions of this external source never affect the domain.

-   Active Record
-   DAO
-   Repository

8. Polyglot 101

The Erudites are impressed by your imagination, but they would like to see if it also enhances your ability to write in different programming languages.

15 points

For this challenge, you need to demonstrate your knowledge of multiple programming languages by writing a function called reverseString that takes a string as a parameter and returns the string with all its characters reversed. (e.g., Hello becomes olleH).

Attention: Your code must be clear and well-written. No partial points. If you use libraries, don't forget to import them.

(1 point per language, plus 1 bonus point if all 14 are correct.)

1. Python

2. Java

3. Rust

4. C++

5. Go

6. Ruby

7. Typescript

8. C

9. Elm

10. Fortran

11. Julia

12. R

13. Perl

14. VBScript

9. Budding Automaton

Even though the title suggests it, we are not asking you to build an automaton made of plants (although that would be impressive).
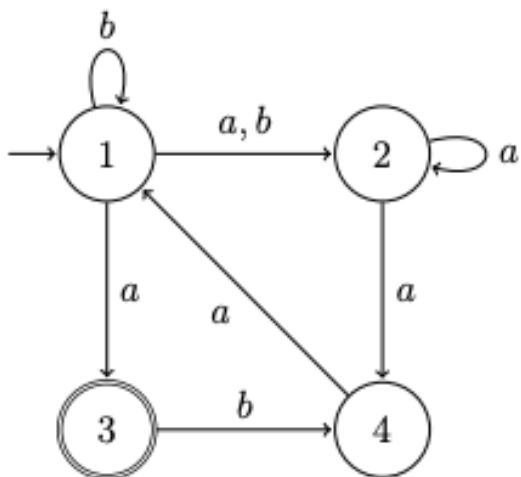
15 points

1. Construct finite automata that accept the following languages.
   The automata may be non-deterministic, and you may omit sink states if it simplifies your task. However, you cannot use transitions labeled with regular expressions or the empty word ϵ.

   a. Over the alphabet $\{0,1\}$, the set of non-empty words whose first letter appears at least two more times in the string. (4 points)

   b. Let L be the language over the alphabet $\{0,1\}$ defined by: $L = \{w \mid w \neq 00 \land w \neq 010\}$. (Which means L consists of all sequences except 00 and 010.) (5 points)

2. Construct a deterministic automaton that accepts the same language as the given non-deterministic automaton below. (6 points)

10. What Are the Odds?

The citizens of CS City know they are lucky to live in such a beautiful city, but they need your wisdom to understand the luck they have.

15 points

1. A box contains n red blocks and n + 1 black blocks. We randomly select 4 blocks without replacement. What is the value of n if the probability of drawing 1 red block and 3 black blocks is 156/575? (4 points)

2. During the last G8 Summit in Northern Ireland, in June, the seats of the 9 leaders present (including the European Union as an international entity) were assigned randomly. Two round tables were available, each with 6 seats (so some seats remained empty). Before seating, it was agreed that the U.S. representative and the Canadian representative must sit next to each other. No other constraints were imposed.
    a. How many different ways are there to seat the leaders? (3 points)

    b. What is the probability that the representatives of Italy and Germany sit at the same table, knowing that one of the two tables seats 6 people? (4 points)

3. Can you predict your position in the competition ranking after all the other questions (except this one) are graded? Provide a position from 1st to 25th. (1 point)

4. A blond hero dressed in green discovers a mountain village. To earn the villagers' trust, their chief assigns him a mission:

"The Yooks, our sworn enemies, have infiltrated our village by kidnapping one of our friends and taking his form. Find the spy, knowing that Yooks always lie, while the Anouki villagers always tell the truth."

- Chief of the Anoukis

The hero interrogates the villagers one by one and obtains the following statements:

Dobo: "Mazo is honest. This guy never lies!"
Kumu: "My intuition never fails. Mazo or Aroo is the liar you're looking for!"
Fofo: "Gumo and Zoma don't lie; they are definitely not Yooks!"
Zoma: "I swear I never lie!"
Mazo: "Believe it or not, but I swear that Dobo and I never lie!"
Aroo: "Between you and me, Kumu is a liar…"
Gumo: "Fofo, Mazo, or Aroo constantly lie."

Which villager is the disguised Yook? Specify your reasoning and the logical predicates you used to arrive at your answer. (3 points)
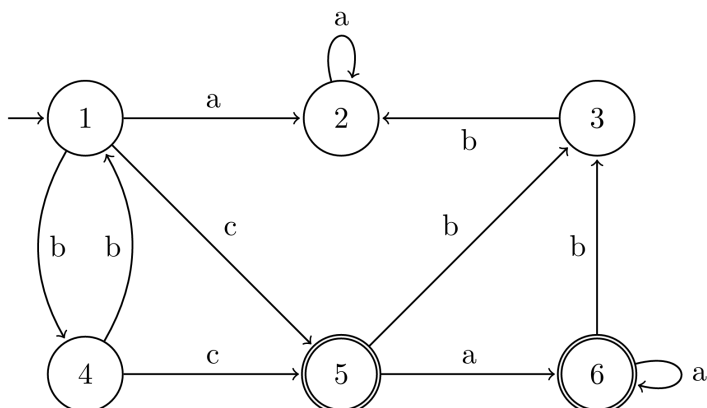
11. Let's Compile Together

The Erudites' homework folder is taking up too much space, and they need your help reducing its size.
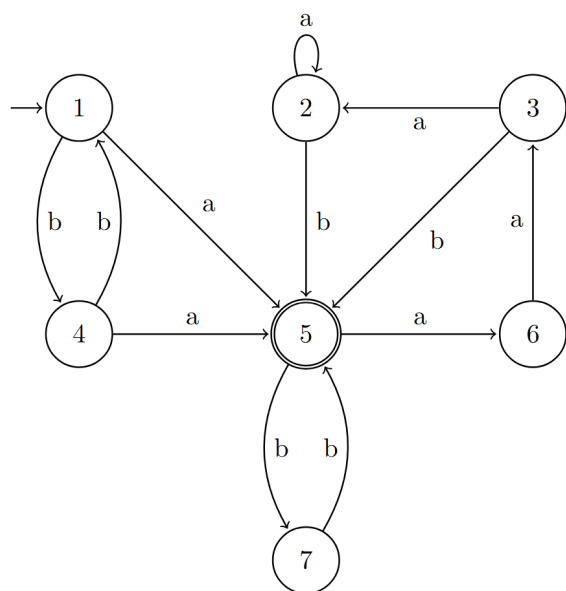
10 points

1. Minimize the following automata by transforming them into their minimal equivalent automaton. (4 points)

   a.

   b.

2. Provide the regular expressions corresponding to the languages of the previous automata. (2 points)

12. Theo, the Decidable Man

In Divergent, Tris cannot decide on a faction because she belongs to none. Theo, on the other hand, is decidable.

4 points

Prove that the following language is decidable:

K = {⟨N ⟩ : is a deterministic finite automaton over the alphabet {0, 1, 2, 3, 4} and L(N) contains at least one palindromic substring of length at least 3}

13. Crypto is Life

Thanks to science, imagination has been encrypted into these messages. Nobody is quite sure what it's for, but the Erudites would like you to recover it.

17 points

1. Decode the following words, each encoded differently:
   a. 506f72747567616c (1 points)

   b. Noitceles (1 points)

   c. Ubpxrl (1 points)

   d. 07810111610210810512 0 (1 points)

   e. PfGrqdog (1 points)

2. Using the Vigenère cipher with the key "GAUSS":
   a. Encrypt the plaintext "DISQUISITIONESARITHMETICAE" (2 points)

   b. Decrypt the ciphertext "VAOUS YEX ESZULS" (2 points)

3. Using the XOR cipher with the key "11001100"
   a. Encrypt the binary message"10110101" (1 points)

   b. Decrypt the message "1011110101011101" (1 points)

4. Find the 2025th pseudo-random number generated by the following linear congruential generator, and explain the impact of poor parameter selection on this type of generator. (4 points)

$$X_n = (3X_{n-1} + 7)\%11 \; with \; X_0 = 5$$

5. Most store items are associated with a Universal Product Code (UPC), whose representation as a barcode should be familiar to you.

The previous code is in the UPC-A system. In this system, the last digit is a check digit, which is calculated as follows:
- The position of the digits starts from the left: 1st = 7, 2nd = 8, etc.
- Sum all the digits in odd positions (1st, 3rd, 5th, etc.) and multiply the sum by 3.
- Then, add the sum of the even-positioned digits (2nd, 4th, 6th, etc.) to this total.
- If the result is congruent to 0 modulo 10 (i.e., divisible by 10), then the UPC number is valid, so 780672318862 is valid.

Is the following UPC-A code valid? (1 point)

6. Write a Regex that matches all strings except those starting with LEGO. Your regex must not use lookaheads (?= et ?!) or lookbehind (?<= et ?<!). (2 points)

14. Theo, the State Man

Since you proved he is decidable, Theo is now in all his states!

4 points

For this problem, the alphabet is {0,1}. Let x be a non-empty word over this alphabet, and define n_x as the binary representation of the word x. Prove that it is possible to represent the following language using a deterministic finite automaton (DFA):

$$K = \{x : x \mathrel{!=} epsilon \mathbin{\&\&} (n_x) \bmod 42 = 5\}$$

Of course, you do not need to list all transitions (though that would be a valid answer). Instead, you can explain how to generate them.

15. Fun Little Puzzles

The Erudites would really love to see if you can solve these puzzles. For science.

10 points

1. Kakuro (4 points)

The objective is to fill in the empty cells (white) with numbers between 1 and 9. The sum of all numbers in a row must match the number at the left end of that row. The sum of all numbers in a column must match the number at the top of that column. No row or column can contain duplicate numbers.
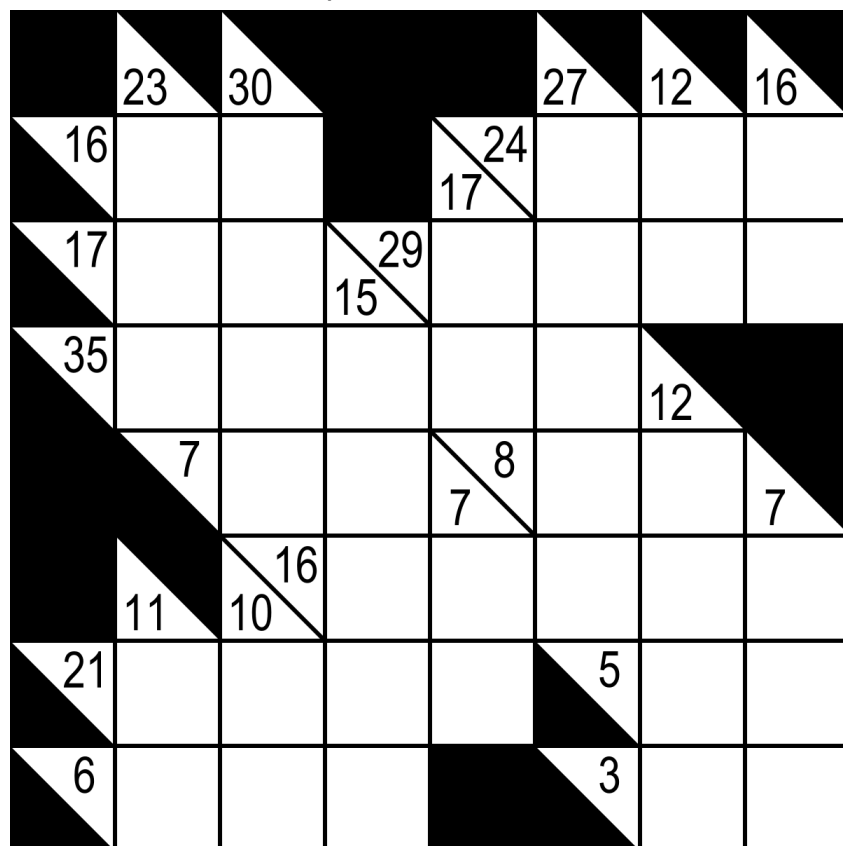
2. Sudoku (3 points)

The objective is to fill in the grid so that each row, each column, and each 3×3 sub-grid contains all digits from 1 to 9, without repetition.

5	3			7				
6			1	9	5			
	9	8					6	
8				6				3
4			8		3			1
7				2				6
	6					2	8	
			4	1	9			5
				8			7	9

3. Puzzle loop (3 points)

Create a continuous line that never crosses itself and forms a loop while respecting the number of lines passing through squares with numbers.
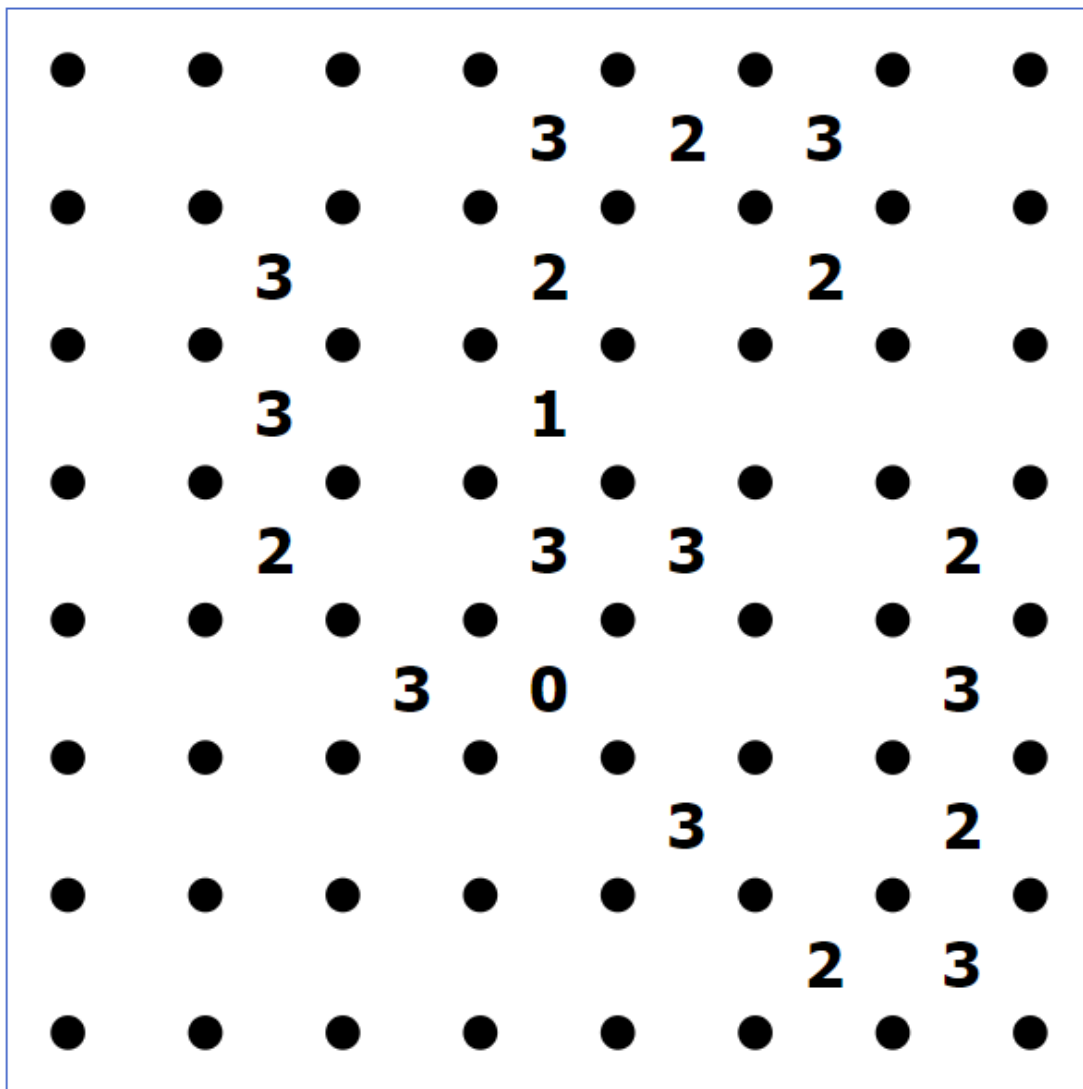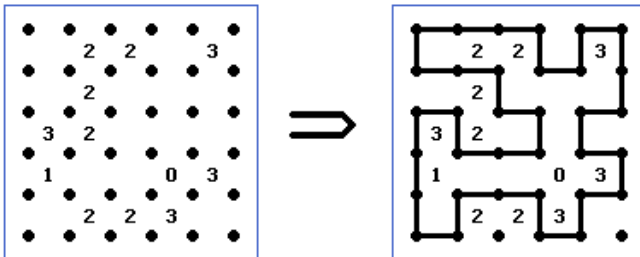
16. Quick Questions

Since the citizens of CS City never lie, the Erudites are fascinated by your ability to distinguish true from false. Could it be a product of your imagination?

30 points (1 point per correct answer)

True or False

1. A stack is a FIFO (First In, First Out) data structure.
   a. True
   b. False
2. Assembly language makes it easier to write a program for a microprocessor compared to machine code.
   a. True
   b. False
3. If $f(n)$ is in $\Omega(n)$ and $f(n)$ is in $O(n^{3/2})$, then it is impossible for $f(n)$ to be in $\Theta(n \log n)$.
   a. True
   b. False
4. If $f(n)$ is in $\Theta(n \ln(n))$, then $f(n)$ is in $\Omega(n)$.
   a. True
   b. False
5. If $f(n)$ is in $O(n)$, then it is impossible for $f(n)$ to be in $\Omega(n \log n)$.
   a. True
   b. False
6. A Megabyte contains 1,048,576 bytes.
   a. True
   b. False
7. Redis is a distributed caching technology.
   a. True
   b. False
8. In the context of databases, an ACID transaction guarantees that all updates are visible to all users at the same time.
   a. True
   b. False
9. A binary search tree (BST) is always balanced.
   a. True
   b. False
10. In C++, std::move transfers ownership of a resource but does not physically move data in memory.
    a. True
    b. False

Error Codes
11. What does HTTP error 404 mean?
    a. *Unauthorized*
    b. *Forbidden*
    c. *Bad Request*
    d. *Not Found*
12. What does HTTP error 200 mean?
    a. *OK*
    b. *Forbidden*
    c. *Accepted*
    d. *Created*
13. What does HTTP error 303 mean?
    a. *Moved Permanently*
    b. *Multiple Choices*
    c. *See Other*
    d. *Not Modified*
14. What does HTTP error 451 mean?
    a. *Precondition Required*
    b. *Blocked by Windows Parental Controls*
    c. *Retry With*
    d. *Unavailable For Legal Reasons*
15. What does HTTP error 501 mean?
    a. *Unauthorized*
    b. *Not Implemented*
    c. *Bad Gateway*
    d. *Service Unavailable*

Programming Language Knowledge

16. Who is known as the creator of Java?
    a. Thomas Sowell
    b. James Gosling
    c. Bill Joy
    d. Emmett Brickowski
17. Who is known as the creator of Python?
    a. Guido van Rossum
    b. Linus Torvalds
    c. Dennis Ritchie
    d. Tim Wozniak
18. Who is known as the creator of Ruby?
    a. Jack Druggens
    b. Simon Peyton Jones
    c. Yukihiro Matsumoto
    d. David Flanagan

19. What does PHP stand for?
    a. elePHant Program
    b. Process for Hyper-Programming
    c. PHP: Hypertext Pre-Processor
    d. PHP (The letters have no meaning)
20. In which decade was the QWERTY keyboard layout invented?
    a. 1870-1879
    b. 1910-1919
    c. 1950-1959
    d. 1980-1989

Miscellaneous Questions
21. Which innovations led to memory management in modern operating systems?
    a. Automatic paging and memory segmentation
    b. Paged memory, virtual memory, and memory segmentation
    c. Virtual memory and DDR3
    d. Micro-segmentation, dynamic management, and cache memory
22. What is the role of the pivot in a QuickSort algorithm?
    a. It is randomly selected and placed at its final position.
    b. It is used to divide the array into smaller subarrays for recursive sorting.
    c. It sorts the subarrays itself.
    d. It creates an array of average values to assist sorting.
23. What happens if you use an invalid index in a raw array in C++?
    a. A runtime exception occurs.
    b. Undefined behavior may occur, including segmentation faults.
    c. The program returns a default value like null or 0.
    d. The index is ignored, and memory is allocated dynamically.
24. Which algorithm is used for asymmetric encryption?
    a. AES
    b. RSA
    c. SHA-256
    d. MD5

We are giving you the answer
1. $\neg(\neg a \land \neg b) = a \lor \neg b$
    a. True
    b. False
2. $(\neg\neg\neg\neg\neg\neg\neg b) \lor (a \land b)$ *si a est Vrai et b est Faux*
    a. True
    b. False
3. $(\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg\neg b \lor (a \land b)) \oplus ((\neg b \lor a) \land b)$ if
   a is False and b is True
    a. True
    b. False

Tools

ASCII TABLE

Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char	Decimal	Hex	Char
0	0	[NULL]	32	20	[SPACE]	64	40	@	96	60	`
1	1	[START OF HEADING]	33	21	!	65	41	A	97	61	a
2	2	[START OF TEXT]	34	22	"	66	42	B	98	62	b
3	3	[END OF TEXT]	35	23	#	67	43	C	99	63	c
4	4	[END OF TRANSMISSION]	36	24	$	68	44	D	100	64	d
5	5	[ENQUIRY]	37	25	%	69	45	E	101	65	e
6	6	[ACKNOWLEDGE]	38	26	&	70	46	F	102	66	f
7	7	[BELL]	39	27	'	71	47	G	103	67	g
8	8	[BACKSPACE]	40	28	(	72	48	H	104	68	h
9	9	[HORIZONTAL TAB]	41	29	)	73	49	I	105	69	i
10	A	[LINE FEED]	42	2A	*	74	4A	J	106	6A	j
11	B	[VERTICAL TAB]	43	2B	+	75	4B	K	107	6B	k
12	C	[FORM FEED]	44	2C	,	76	4C	L	108	6C	l
13	D	[CARRIAGE RETURN]	45	2D	-	77	4D	M	109	6D	m
14	E	[SHIFT OUT]	46	2E	.	78	4E	N	110	6E	n
15	F	[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	[NEGATIVE 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 OF 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	[SUBSTITUTE]	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	[DEL]

Math

$$P(n,r) = \frac{n!}{(n-r)!}$$

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

$$C(n,r) = \frac{P(n,r)}{r!} = \frac{n!}{r!(n-r)!}$$

$$\sum_{k=1}^{n} k = \frac{1}{2}n(n+1)$$

$$\sum_{k=1}^{n} k^2 = \frac{1}{6}n(n+1)(2n+1)$$

$$\sum_{k=1}^{n} k^3 = \frac{1}{4}n^2(n+1)^2$$

$$(a+x)^n = a^n + na^{n-1}x + \frac{n(n-1)}{2!}a^{n-2}x^2 + \frac{n(n-1)(n-2)}{3!}a^{n-3}x^3 + \dots$$

$$= a^n + \binom{n}{1}a^{n-1}x + \binom{n}{2}a^{n-2}x^2 + \binom{n}{3}a^{n-3}x^3 + \dots$$

Team Name: _____

ARMv7 Table

Instruction	Description		
ADD Rd, Rs	Rd	<--	Rs + Rd
ADD Rd, Const	Rd	<--	Rd + Const
ADD Rd, Rs, Op1	Rd	<--	Rs + Op1
AND Rd, Rs, Op1	Rd	<--	Rs AND Op1
B etiquette	PC	<--	adresse(etiquette)
BL etiquette	LR	<--	PC - 4, PC <-- adresse(etiquette)
BX Rs	PC	<--	Rs
CMP Rs, Op1	drapeaux = Rs -Op1		
LDR Rd, etiquette	Rd	<--	valeur(etiquette)
LDR Rd, =etiquette	Rd	<--	adresse(etiquette)
LDR Rd, [Rb, Op1]	Rd	<--	Mem[Rb+Op1]
LDR Rd, [Rb], Opt1	Rd	<--	Mem[Rb], Rb <-- Rb + Op1
LDR Rd, [Rb, Op1]!	Rb	<--	Rb +Op1, Rd <-- Mem[Rb]
MUL Rd, Rn, Rs	Rd	<--	Rb x Rs
MVN Rd, Op1	Rd	<--	!Op1 (inverse the bits)
POP {Liste Reg}	SP	<--	SP - 4 x (nb registre)
PUSH {Liste Reg}	SP	<--	SP + 4 x (nb registre)
STR Rs, etiquette	valeur(etiquette)	<--	Rd
STR Rs, [Rb, Op1]	Mem[Rb+Op1]	<--	Rs
STR Rs, [Rb], Op1	Mem[Rb]	<--	Rs, Rb <-- Rb + Op1
STR Rs, [Rb, Op1]!	Rb	<--	Rb + Op1, Mem[Rb] <-- Rs
SUB Rd, Rs	Rd	<--	Rd - Rs
SUB Rd, Const	Rd	<--	Rd - Const
SUB Rd, Rs, Op1	Rd	<--	Rs - Op1
MOV Rd, Rs	Write register value (Rs) in register value (Rd)		
MOV Rd, Const	Write constant in Rd		

Condition	Code	Condition	Code
Equals	EQ	Not equals	NE
Greater than	GT	Less than	LT
Greater or equals	GE	Less or equals	LE

Theoretical Computer Science

A context-free grammar is in **Chomsky Normal Form** (CNF) if and only if all its production rules follow one of three forms: $X \rightarrow YZ$, $X \rightarrow a$, or $S \rightarrow \varepsilon$. In this notation, $X, Y,$ and Z are non-terminal symbols, a is a terminal symbol, S represents the start symbol of the grammar, and ε denotes the empty word. This form ensures that each production either replaces a non-terminal with exactly two non-terminals, replaces a non-terminal with a single terminal, or allows the start symbol to derive the empty word.

Example of a Turing Machine
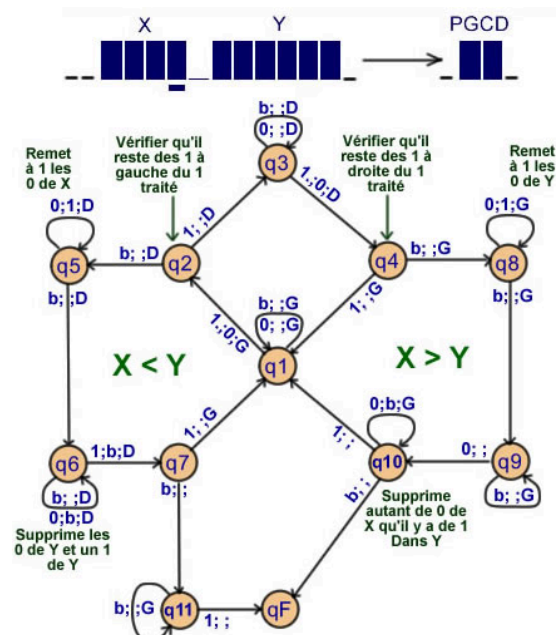
Extra pages

(Don't forget to write the question you are finishing here)