1. One sentence for each of the four major theories of computation:
    a. **Language Theory** describes, classifies, and manipulates sets of strings (languages), syntax, and semantics using grammars, automata, and algebraic structures.
    b. **Automata Theory** looks at what problems can be solved by machines like finite automata or Turing machines.
    c. **Computability Theory** tries to determine which problems can be solved algorithmically, regardless of efficiency.
    d. **Complexity Theory** classifies what makes certain problems computationally hard or easy in terms of time, space, or other resources.
2. Given $L1$={0,011,10} and $L2$={10,1}. What are:
    a. $L_1 \cup L_2$ = {0, 011, 10, 1}
    b. $L_1 \cap L_2$ = {10}
    c. $L_1 L_2$ = {010, 01, 01110, 0111, 1010, 101}
    d. L_2^* = {ϵ, 10, 1, 1010, 101, 110, 11, …}
3. Generative grammars for the following languages:
    a. Empty Language
        - S → ϵ
    b. {$0^i 1^j 2^k$ | $i=j \lor j=k$}
        - S → A 2* | 0* B | ϵ
        - A → 0 A 1 | ϵ
        - B → 1 B 2 | ϵ
    c. {$w \in$ {0,1}* | w does not contain the substring 000}
        - S → A | ϵ
        - A → 1 A | 0 B | ϵ
        - B → 1 A | 0 C | ϵ

- $C \rightarrow 1\ A \mid \epsilon$

d. $\{w \in \{a,b\}^* \mid w$ has twice as many a's as b's$\}$

- $S \rightarrow X \mid \epsilon$
- $X \rightarrow X\ a\ X\ a\ X\ b\ X \mid X\ a\ X\ b\ X\ a\ X \mid X\ b\ X\ a\ X\ a\ X \mid \epsilon$

e. $\{a^n b^n a^n b^n \mid n \geq 0\}$

- $S \rightarrow\ a\ X\ b\ Y\ a\ Z\ b \mid \epsilon$
- $X \rightarrow X\ A \mid A \mid \epsilon$
- $A\ a \rightarrow a\ A$
- $A\ b \rightarrow a\ b\ B$
- $A\ Z \rightarrow a\ Z\ b$
- $B\ b \rightarrow b\ B$
- $B\ Y \rightarrow b\ Y\ A$
- $Y \rightarrow \epsilon$
- $Z \rightarrow \epsilon$

4. The grammar for floating-point numerals:

$n \rightarrow d$+f?e?

$f \rightarrow$ "."d+

$e \rightarrow$ ("E"|"e")("+"|"–")?d+

$d \rightarrow$ "0".."9"

(V,Σ,R,S)-Definition of this grammar:

- V → {n, f, e, d}
- Σ → {0, 1, 2, 3, 4, 5, 6, 7, 8, 9, ., +, -, E, e}
- R → { I spent too much time trying to figure this out, I give up }
- S → n

5. See other pdf

6. See other pdf

7. For the JavaScript/Python expression 5 * 3 - 1 ** 3,
    a. Show a 3AC machine program to evaluate this expression, leaving the result in r_0
        - MUL 5, 3, r_1
        - POW 1, 3, r_2
        - SUB r_1, r_2, r_0
    b. Show a Stack machine program to evaluate this expression, leaving the result on the top of the stack.
        - Push 5
        - Push 3
        - MUL
        - Push 1
        - Push 3
        - Pow
        - Sub
8. Characterize each of the following languages as either (a) regular, (b) context-free but not regular, (c) recursive but not context-free, (d) recursively enumerable but not recursive, or (e) not even recursively enumerable.
    a. $\{a^i b^j c^k \mid i>j>k\}$
        - (c) recursive but not context-free
    b. $\{a^i b^j c^k \mid i>j \land k \le i-j\}$
        - (b) context-free but not regular
    c. $\{\langle M \rangle \cdot w \mid M \text{ accepts } w\}$
        - (d) recursively enumerable but not recursive
    d. $\{G \mid G \text{ is context-free} \land L(G)=\varnothing\}$
        - (d) recursively enumerable but not recursive
    e. $\{a,b\}* \{b\}+$

- (a) regular

f. $\{\langle M\rangle \mid M$ does not halt$\}$

- not even recursively enumerable

g. $\{w \mid w$ is a decimal numeral divisible by 7$\}$

- (a) regular

h. $\{www \mid w$ is a string over the Unicode alphabet$\}$

- (c) recursive but not context-free