1. Using the Pumping Lemma, prove that the following language over $\Sigma = \{0, 1\}$ is not context-free:

$$\{0^n 1^n 0^{2n} : n \geq 0\}$$

2. Consider the following two languages:

$$A_{TM} = \{M, w : M \text{ is a Turing machine that accepts string } w\}$$
$$ALL_{TM} = \{M : M \text{ is a Turing machine and } L(M) = \Sigma^*\}$$

Show that $A_{TM} \leq ALL_{TM}$.

3. Answer each of the following questions with only **YES** or **NO** to indicate whether or not the first language class is a subset of the second. (Note: $A \subseteq B$ means that either $A = B$ or $A \subset B$.)
Do not guess if unsure, as wrong answers will lower your score!
Scoring: +2 points for correct answers; 0 points for no answers; -1 point for wrong answer

   a. regular $\subseteq$ co-acceptable?
   b. CFL $\subseteq$ NP?
   c. CFL $\subseteq$ acceptable?
   d. acceptable $\subseteq$ NP-hard?
   e. co-acceptable $\subseteq$ decidable?
   f. decidable $\subseteq$ NP-Complete?
   g. P $\subseteq$ NP?
   h. P $\subseteq$ NP-Complete?
   i. NP $\subseteq$ NP-hard?
   j. NP-Complete $\subseteq$ NP-hard?

1. $L = \{0^n 1^n 0^{2n} : n \geq 0\}$

Assume language L is context-free. Let P be the pumping length guaranteed to exist by the pumping lemma.

$S = 0^P 1^P 0^{2P}$

Since $S \in L$ and $|S| \geq P$, S can be divided into 5 pieces, UVXYZ, such that $UV^iXY^iZ \in L$ for all $i \geq 0$ and $|VXY| \leq P$.

Consider 3 possible cases:

1. VXY contains only one type of symbol.

   $UV^2XY^2Z \notin L$ because there would be too many 0's in the beginning, 1's in the middle, or 0's at the end of the string.

2. V contains some 0's and 1's or Y contains some 0's and 1's.

   $UV^2XY^2Z \notin L$ because the symbols in the middle of the string would be out of order.

3. V contains all 0's and Y contains all 1's, or V contains all 1's and Y contains all 0's.

   $UV^2XY^2Z \notin L$ because the resulting string would either have too few 0's at the beginning or at the end.

This contradicts the pumping lemma, so L is <u>not</u> context-free.

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Using pumping Lemma, prove that $\Sigma = \{0,1\}$ is not Content free.

$\{0^n 1^n 0^{2n} : n \geq 0\}$.

let P be pumping length.

let A be language $\{0^n 1^n 0^{2n}\}$.

let P = 2.

{00110000}.

divide into 5 parts uvxyz.

$\underbrace{00}_{u}\underbrace{11}_{y}\underbrace{00}_{x}\underbrace{0}_{y}\underbrace{0}_{z}$

u = 2	|u| = 2
v = 2	|v| = 2
x = 2	|x| = 2
y = 1	|y| = 1
z = 1	|z| = 1

Case i) :- $|vy| > 0$.

3 > 0 ✓.

Case ii) :- $uv^i xy^i z$. String length = 8.

let i = 2.

0011110000 not in A.

Case iii) $|xyz| \leq P$.

5 < 2 ✗ false.

So hence $\Sigma = \{0,1\}$ over $\{0^n 1^n 0^{2n}\}$ not a Content free gramma.

hello student,

ATM language can be undecidable or recognizable.

let's understand by a proof:

suppose there is another Turing machine that recognizes m Tusing machine, and M Turing machine will accept language when M Turing machine recognizes W string when M Turing machine recognizes and accept w string then H Turing machine accepts otherwise it will reject. therefore H Turing machine accepts w-string then it will be recognizable for one type string or we can say one type input otherwise it will be undecidable.

ALLTM is also an undecidable language because it includes all types of string and an infinite number of patterns. it can be all solution because ∑* means all string(all input).

there is only one main difference is ATM can be recognized over only one type string but ALLTM can be undecidable or recognizable over the n-type string. it can be equal at an infinite number of a string of same type(w-string), but there is another fact it can very difficult to define it because it's not fixed.

therefore ATM<=ALLTM

you have any problem to understand it then you can ask in comment section if you like my work then please rate it to give a thumbs up. Thanks you.

3)

a) Yes.

b) Yes (doubt).

c) yes.

d) acceptable $\subseteq$ NP-hard. (NO).

e) No.

f) NO.

g) Yes.

h) NO.

i) NO.

j) doubt