ANSWER QUESTIONS 1 AND 2

1. Let $ABC$ be the language
\[ ABC = \{ (abc)^n \mid n \geq 0 \}. \]
Give well-grounded answers to the following questions.

(a) Is $ABC$ a regular language?
(b) Can language $ABC$ be recognized with a pushdown automaton?
(c) Can language $ABC$ be generated by a context-free grammar?

2. Show that the halting problem of Turing machines
\[ \text{HALT}_{TM} = \{ (M, w) \mid M \text{ is a TM and halts on input } w \} \]
is undecidable. You may assume that the universal language $U$ over the binary alphabet is not decidable. Is $\text{HALT}_{TM}$ semi-decidable? Justify your answer.
3. Give a state diagram for the nondeterministic finite automaton corresponding to the regular expression \( \{0, 1\}^* 1(0 \mid \varepsilon)1 \{0, 1\}^* \). Use the algorithm given in the lectures to come up with an equivalent deterministic finite automaton. Give also the equivalent minimum automaton.

4. Convert the following language into Chomsky Normal Form using the systematic technique given in the lectures.

\[
S \rightarrow A \mid B \\
A \rightarrow aBa \mid \varepsilon \\
B \rightarrow bAb \mid \varepsilon
\]

5. What do the following mean exactly?

(a) \( A \in \mathbb{P} \);
(b) \( A \preceq_m B \);
(c) \( \text{PSPACE} = \text{NPSPACE} \).

6. Space complexity classes. How do they relate to time complexity classes? Explain the reasons for those containments that you recognize.