COSC 341 – Tutorial 11

1. Find regular expressions for following languages:
   (a) $L = \{a^n b^m c^l | n, m, l \in \mathbb{N}\}$ over $\Sigma = \{a, b, c\}$.
   (b) $L = \{a^n b^m c^l | n, m, l \in \mathbb{N}\} \setminus \{\lambda\}$ over $\Sigma = \{a, b, c\}$.
   (c) $L = \{w | w$ contains aa and bb as substring$\}$ over $\Sigma = \{a, b\}$
   (d) $L = \{w | w$ starts with a, contains two b's and ends with $cc\}$ over $\Sigma = \{a, b, c\}$
2. Is $L = \{a^n b^n c^m | m \geq n\}$ context free? Prove your answer.
3. In each of the following cases, give examples of languages L_1 and L_2 over $\{a, b\}$ such that:
   (a) L_1 is regular, L_2 is not, and $L_1 \cup L_2$ is regular.
   (b) L_1 is regular, L_2 is not, and $L_1 \cup L_2$ is not regular.
   (c) L_1 is regular, L_2 is not, and $L_1 \cap L_2$ is regular.
   (d) L_1 is not regular, L_2 is not regular, and $L_1 \cup L_2$ is regular.
   (e) L_1 is not regular and L_1^* is regular.