Hand in your solutions electronically using CMS. Each solution should be submitted as a separate file. Collaboration is encouraged while solving the problems, but:

1. **list the names of those with whom you collaborated;**
2. **you must write up the solutions in your own words;**

Remember that when a problem asks you to design an algorithm, you must also prove the algorithm's correctness and analyze its running time. The running time must be bounded by a polynomial function of the input size.

The problem numbers below are from the **Exercise section in Chapter** 1 from the online version of the Arora-Barak textbook which can be found at `https://theory.cs.princeton.edu/complexity/book.pdf`.

(1) *(10 points)* Problem 12

(2) *(10 points)* Problem 13.

(3) *(10 points)* Define a two dimensional Turing machine to be a TM where each of its tapes is an infinite grid (and the machine can move not only Left and Right but also Up and Down). Show that for every (time-constructible) $T : \mathbb{N} \to \mathbb{N}$ and every Boolean function f, if f can be computed in time T(n) using a two-dimensional TM then $f \in \textbf{DTIME}(T(n)^2)$.