1. Give an example of (or state that does not exist):
   
   (a) a language that is recursive but not r.e.  
   By definition does not exist
   
   (b) a language that is regular but whose complement is recursive  
   Any regular language
   
   (c) a language accepted by a TM that does not have a context-free grammar  
   \(0^n1^n2^n\)
   
   (d) a language accepted by a nondeterministic TM but not by a deterministic TM.  
   Does not exist

2. Consider the following TM with input alphabet \{0, 1\}:

   (a) Give two strings of length 3 accepted by the TM.
   
   (b) Give two strings of length 3 NOT accepted by the TM.
   
   (c) Describe in succinct-ish English the language of this TM. Be precise.

   All binary strings where the number of 0’s and the number of 1’s differ by exactly one.
3. Consider the following transducer.

(a) What is the output if the input is 11?

(b) What is the output if the input is 1000?

This transducer computes an arithmetic function treating the input (and output) as the binary of a positive integer. What function does it compute?

4. Consider a TM that is not allowed to write the same character to a cell that it just read. (For example, 00R would not be allowed.) Show that this version has the same power as a standard TM.

E.g. For each offending transition, such as 00R, add extra state and replace with a move that writes a special character and keeps head stationary while going to the extra state; then add transition that writes 0 and moves right.

5. State Church’s thesis.

There is a TM for problem if and only if there is an effective procedure (algorithm) for it.