Questions 1-4 should be completed on the Udacity site. The graders will download and evaluate your answers. The others should be typed and uploaded to T-Square.

1. Complete the exercise of tracing through the configuration sequence for the given Turing machine .

<https://www.udacity.com/course/viewer#!/c-ud557/l-1740638623/e-1740278552/m-1740278553>

1. Program a Turing machine the shifts its input one square to the right and places a $ sign at the beginning of the tape. See

<https://www.udacity.com/course/viewer#!/c-ud557/l-1740638623/e-1732309017/m-1740278556>

1. Program a Turing machine that tests if the input string has an equal number of zeros and ones. See

[https://www.udacity.com/course/viewer#!/c-ud557/l-1740638623/e-1740278557/m-174027855](https://www.udacity.com/course/viewer#!/c-ud557/l-1740638623/e-1740278557/m-1740278558)

4. Program a two-tape Turing machine to perform substring search. See <https://www.udacity.com/course/viewer#!/c-ud557/l-1728138752/e-1718598811/m-1751158600>

5. Another alternative Turing machine model has a single, one-way infinite tape, but two read-write heads. The transition function has the form , the same as a multi-tape machine. Describe how you would program such a machine to decide the language .

Hint: You can use the S (stay put) movement to achieve the effect of having one head move faster than the other.

(Writing down the transition function is not required, but you should go into enough detail to convince the reader that you could do so if asked.)

6. Suppose we have a one-tape Turing machine whose head instead of having to move just left or right in each computation step, can move left or right or stay put. We called these “stay-put machine” in the lesson. Prove that it is possible to create a new Turing machine that recognizes the same language as by changing only the transition function , keeping the same and .

7. Suppose that we constrained the standard 1-tape Turing machine to only be able to write to each square on the tape two times. Prove that this model can decide every language that a standard Turing machine can.

Hint: Use lots of tape and do a lot of copying.

Bonus (hard): Describe how you would modify your machine so that it only writes to each square once.

8. Consider a Turing machine with a two-dimensional tape where the head can move up and down as well as right and left. Assume that the paper is infinite in the right and downward directions. Give a formal definition of this machine.