Name: _____

CSCI 380: Activity 7

Turing Machines

Team Roles	Team Member
Facilitator: reads the questions aloud, keeps track of time and makes sure everyone contributes appropriately.	
Spokesperson: talks to the instructor and other teams.	
Quality Control: records all answers & questions, and provides team reflection to team & instructor.	
Process Analyst: considers how the team could work and learn more effectively.	

> **Note**
>
> If you have 3 people, combine Facilitator & Process Analyst.

Learning Objectives

1. Create accepter Turing Machines
2. Extrapolate to transducer Turing Machines
3. Practicing Problem Solving skills

In this Activity, you will find two Modules and one Reflection section.

start time:

Model I. Turing Machines Accepters (15 min)

A Turing machine is an automata with read-write memory on a tape that extends infinitely in both directions.

$$M = (Q, \Sigma, \Gamma, \delta, q_0, \square, F)$$

We want the input to be separate from other usage of the tape, so we require that the space ($\square$) is not an element of the input alphabet: $\Sigma \subseteq \Gamma - \{\square\}$

The transition function δ does not need to be complete. After each read, we write to the tape in the same location, then move Left or Right.

$$\delta : Q \times \Gamma \to Q \times \Gamma \times \{L, R\}$$

We again use instantaneous descriptions to model the automata, describing the tape changes, state changes, and position of the read head, with a **computation** showing movement from one to the next. For example:

$abq_1cd \vdash abeq_2d$ because of $\delta(q_1, c) \to (q_2, e, R)$.

The language defined by the Turing Machine is

$$L(M) = \left\{ w \in \Sigma^+ : q_0 w \overset{*}{\vdash} x_1 q_f x_2 \text{ for some } q_f \in F, x_1, x_2 \in \Gamma^* \right\}$$

♣

Explore the Model Questions

1. What does $\square$ represent?
2. What directions can the head move?
3. Apply the following transition to the instantaneous description.

$$\delta(q_3, a) \to (q_6, b, L)$$

$$aaq_3ad$$

4. Make a Turing Machine that accepts the regular expression $b(a + bb)^*(ba^* + \lambda)$
5. Make a Turing Machine that accepts $L = \{a^n b^n : n \geq 1\}$

Critical Thinking Questions

3 Make a Turing Machine that accepts $L = \{a^n b^n c^n : n \geq 1\}$

STOP

Wait for all teams to complete this model. The spokesperson will be reporting out to the rest of the class.

start
time:

Model II. Turing Machine Transducers (20 min)

Turing Machines can do more than accept and reject. Because they can write to the tape, they can transform input into output, or *transduce*.

Whenever the machine halts, the output of the function is whatever is on the tape.

$$\hat{w} = f(w) \text{ where } q_0 w \overset{*}{\vdash} q_f \hat{w} \text{ for } w \in \Sigma, \hat{w} \in \Gamma$$

♣

Explore the Model Questions

1. What is a transducer?
2. Where is the output found?
3. Write a transducer Turing Machine to add two numbers. Numbers will be expressed in unary, so 5 = 11111. Input will be two numbers separated by a 0. 111011 represents 3 + 2.
4. Write a transducer Turing Machine to duplicate words. For simplicity, let $\Sigma = \{1\}$. An example computation for this machine would be $q_0 1111 \overset{*}{\vdash} q_f 11111111$.

Critical Thinking Questions

5. Write an accepter Turing Machine to determine $x \geq y$, where $x, y \in 1^*$. Input will be two unary numbers separated by a 0. 111011 represents the question $3 \geq 2$.

Looking Back - Group Reflection

Review the job descriptions on your role card. Evaluate privately on how well you performed in your role. Provide the following using the **SII framework**:

S – *Strength* (Also what specifically did you do that would indicate that it was a strength)

I – *Improvement* Area

I – *Insight* concerning either the process or the content of the activity

Facilitator

List below how long each Model took your group:

- Model I:
- Model II:

Process Analyst

Give feedback to each of your other team members with a **strength** that you observed, either in their role or their process skills.

Quality Control

Summarize the activity for your group members, by answering the following question.

1. How similar was your solution to Model II.5 to Model II.3?

Spokesperson

Gather up the name cards and any other materials and give them to Dr. Goadrich.