

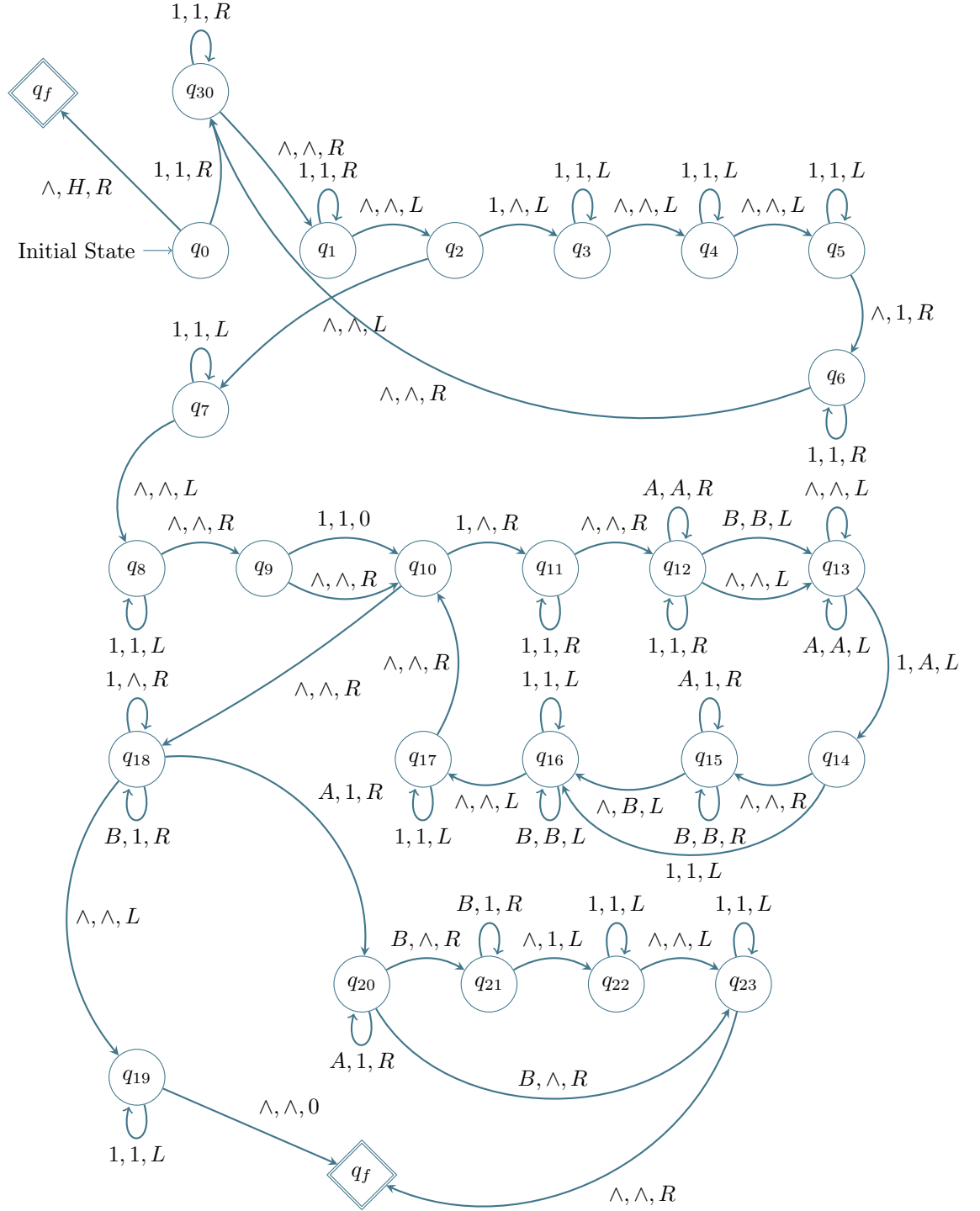
Mod/Div Turing Machine

INDIVIDUAL COURSEWORK
F29FB, SPRING 2022

SUBMITTED BY

H00347035

1 Graph



2 Mathematical Notation

$$s_0 \equiv \wedge, s_1 \equiv 1, s_2 \equiv A, s_3 \equiv B, s_4 \equiv H$$

$$M_g = \{ \begin{array}{l} ((q_0, s_0) \rightarrow (q_f, s_4, 0)), \\ ((q_0, s_1) \rightarrow (q_{30}, s_1, R)), \\ ((q_1, s_1) \rightarrow (q_1, s_1, R)), \\ ((q_1, s_0) \rightarrow (q_2, s_0, L)), \\ ((q_{30}, s_1) \rightarrow (q_{30}, s_1, R)), \\ ((q_{30}, s_0) \rightarrow (q_1, s_0, R)), \\ ((q_2, s_0) \rightarrow (q_7, s_0, L)), \\ ((q_2, s_1) \rightarrow (q_3, s_0, L)), \\ ((q_3, s_1) \rightarrow (q_3, s_1, L)), \\ ((q_3, s_0) \rightarrow (q_4, s_0, L)), \\ ((q_4, s_1) \rightarrow (q_4, s_1, L)), \\ ((q_4, s_0) \rightarrow (q_5, s_0, L)), \\ ((q_5, s_1) \rightarrow (q_5, s_1, L)), \\ ((q_5, s_0) \rightarrow (q_6, s_1, R)), \\ ((q_6, s_1) \rightarrow (q_6, s_1, R)), \\ ((q_6, s_0) \rightarrow (q_{30}, s_0, R)), \\ ((q_7, s_1) \rightarrow (q_7, s_1, L)), \\ ((q_7, s_0) \rightarrow (q_8, s_0, L)), \\ ((q_8, s_1) \rightarrow (q_8, s_1, L)), \\ ((q_8, s_0) \rightarrow (q_9, s_0, R)), \\ ((q_9, s_1) \rightarrow (q_{10}, s_1, 0)), \\ ((q_9, s_0) \rightarrow (q_{10}, s_0, R)), \\ ((q_{10}, s_1) \rightarrow (q_{11}, s_0, R)), \\ ((q_{10}, s_0) \rightarrow (q_{18}, s_0, R)), \\ ((q_{11}, s_1) \rightarrow (q_{11}, s_1, R)), \\ ((q_{11}, s_0) \rightarrow (q_{12}, s_0, R)), \\ ((q_{12}, s_1) \rightarrow (q_{12}, s_1, R)), \\ ((q_{12}, s_2) \rightarrow (q_{12}, s_2, R)), \\ ((q_{12}, s_3) \rightarrow (q_{13}, s_3, L)), \\ ((q_{12}, s_0) \rightarrow (q_{13}, s_0, L)), \\ ((q_{13}, s_0) \rightarrow (q_{13}, s_0, L)), \\ ((q_{13}, s_2) \rightarrow (q_{13}, s_2, L)), \\ ((q_{13}, s_1) \rightarrow (q_{14}, s_2, L)), \\ ((q_{14}, s_0) \rightarrow (q_{15}, s_0, R)), \\ ((q_{14}, s_1) \rightarrow (q_{16}, s_1, L)), \\ ((q_{15}, s_2) \rightarrow (q_{15}, s_1, R)), \\ ((q_{15}, s_3) \rightarrow (q_{15}, s_3, R)), \\ ((q_{15}, s_0) \rightarrow (q_{16}, s_3, L)), \end{array} \begin{array}{l} ((q_{16}, s_1) \rightarrow (q_{16}, s_1, L)), \\ ((q_{16}, s_3) \rightarrow (q_{16}, s_3, L)), \\ ((q_{16}, s_0) \rightarrow (q_{17}, s_0, L)), \\ ((q_{17}, s_1) \rightarrow (q_{17}, s_1, L)), \\ ((q_{17}, s_0) \rightarrow (q_{10}, s_0, R)), \\ ((q_{18}, s_1) \rightarrow (q_{18}, s_0, R)), \\ ((q_{18}, s_3) \rightarrow (q_{18}, s_1, R)), \\ ((q_{18}, s_2) \rightarrow (q_{20}, s_1, R)), \\ ((q_{18}, s_0) \rightarrow (q_{19}, s_0, L)), \\ ((q_{19}, s_1) \rightarrow (q_{19}, s_1, L)), \\ ((q_{19}, s_0) \rightarrow (q_f, s_0, 0)), \\ ((q_{20}, s_2) \rightarrow (q_{20}, s_1, R)), \\ ((q_{20}, s_3) \rightarrow (q_{21}, s_0, R)), \\ ((q_{20}, s_0) \rightarrow (q_{23}, s_0, L)), \\ ((q_{21}, s_3) \rightarrow (q_{21}, s_1, R)), \\ ((q_{21}, s_0) \rightarrow (q_{22}, s_1, L)), \\ ((q_{22}, s_1) \rightarrow (q_{22}, s_1, L)), \\ ((q_{22}, s_0) \rightarrow (q_{23}, s_0, L)), \\ ((q_{23}, s_1) \rightarrow (q_{23}, s_1, L)), \\ ((q_{23}, s_0) \rightarrow (q_f, s_0, R)), \end{array} \}$$

3 Input (3, 5)

- (i) The TM starts by checking if the head starts at a \wedge (blank) then the divisor is 0 and the ticket is invalidated and the TM halts. Otherwise the divisor is a natural number and goes to the next state.
- (ii) Go to the rightmost of the unary until we reach a blank.

$q_{30}: \wedge \wedge \wedge 1 @ 11 \wedge 11111 \wedge \wedge \wedge$
 $q_{30}: \wedge \wedge \wedge 11 @ 1 \wedge 11111 \wedge \wedge \wedge$
 $q_{30}: \wedge \wedge \wedge 111 @ \wedge 11111 \wedge \wedge \wedge$

$q_0: \wedge \wedge \wedge @ 111 \wedge 11111 \wedge \wedge \wedge$

- (iii) Check if there is a unary and go to the rightmost of the said unary. Otherwise (if blank, \wedge) then go to DIV/MOD part of TM.
- (iv) Once at the rightmost of the unary and check if there is a unary number, move it to the leftmost of the divisor and go back to (ii). Otherwise (if blank) copying is done and go to the leftmost of the divisor then starts the mod/div operation.

$q_1: \wedge \wedge \wedge 111 \wedge @ 11111 \wedge \wedge \wedge$
 $q_1: \wedge \wedge \wedge 111 \wedge 1 @ 1111 \wedge \wedge \wedge$
 $q_1: \wedge \wedge \wedge 111 \wedge 11 @ 111 \wedge \wedge \wedge$
 $q_1: \wedge \wedge \wedge 111 \wedge 111 @ 11 \wedge \wedge \wedge$
 $q_1: \wedge \wedge \wedge 111 \wedge 1111 @ 1 \wedge \wedge \wedge$
 $q_1: \wedge \wedge \wedge 111 \wedge 11111 @ \wedge \wedge \wedge$

$q_2: \wedge \wedge \wedge 111 \wedge 1111 @ 1 \wedge \wedge \wedge$
 $q_3: \wedge \wedge \wedge 111 \wedge 111 @ 1 \wedge \wedge \wedge$
 $q_3: \wedge \wedge \wedge 111 \wedge 11 @ 11 \wedge \wedge \wedge$
 $q_3: \wedge \wedge \wedge 111 \wedge 1 @ 111 \wedge \wedge \wedge$
 $q_3: \wedge \wedge \wedge 111 \wedge @ 1111 \wedge \wedge \wedge$
 $q_3: \wedge \wedge \wedge 111 @ \wedge 1111 \wedge \wedge \wedge$
 $q_4: \wedge \wedge \wedge 11 @ 1 \wedge 1111 \wedge \wedge \wedge$
 $q_4: \wedge \wedge \wedge 1 @ 11 \wedge 1111 \wedge \wedge \wedge$
 $q_4: \wedge \wedge \wedge @ 111 \wedge 1111 \wedge \wedge \wedge$
 $q_4: \wedge \wedge @ \wedge 111 \wedge 1111 \wedge \wedge \wedge$
 $q_5: \wedge @ \wedge 111 \wedge 1111 \wedge \wedge \wedge$
 $q_6: \wedge 1 @ \wedge 111 \wedge 1111 \wedge \wedge \wedge$

- (v) Once copying is done(determined by iv.), then go to the leftmost of the divisor and start mod/div operation.

$q_2: \wedge \wedge 11111 \wedge 111 @ \wedge \wedge \wedge$
 $q_7: \wedge \wedge 11111 \wedge 11 @ 1 \wedge \wedge \wedge$
 $q_7: \wedge \wedge 11111 \wedge 1 @ 11 \wedge \wedge \wedge$
 $q_7: \wedge \wedge 11111 \wedge @ 111 \wedge \wedge \wedge$
 $q_7: \wedge \wedge 11111 @ \wedge 111 \wedge \wedge \wedge$
 $q_8: \wedge \wedge 1111 @ 1 \wedge 111 \wedge \wedge \wedge$
 $q_8: \wedge \wedge 111 @ 11 \wedge 111 \wedge \wedge \wedge$
 $q_8: \wedge \wedge 11 @ 111 \wedge 111 \wedge \wedge \wedge$
 $q_8: \wedge \wedge 1 @ 1111 \wedge 111 \wedge \wedge \wedge$
 $q_8: \wedge \wedge @ 11111 \wedge 111 \wedge \wedge \wedge$
 $q_8: \wedge @ \wedge 11111 \wedge 111 \wedge \wedge \wedge$
 $q_9: \wedge \wedge @ 11111 \wedge 111 \wedge \wedge \wedge$