Q. The universal TM is unique.  T/F

Q. The language accepted by \( U \) is unique.  T/F

\[ L_u = \{ \langle M, x \rangle \mid M \text{ accepts } x \} \]

A universal TM has a bounded no. of states. There are only a finite number of TMs with a bounded no. of states. Thus a finite number of fns. account for all computation.

Q. There exists a bound \( k \) s.t.

(R) Any TM \( M \) can be converted to an equivalent TM \( M' \) with \( k \) states, simulated by.

(G) Any TM \( M \) can be converted to a TM with \( k \) states that is equivalent on some subset of inputs.

(2) Neither of the above

This row contains all other rows!

Q. There exists a rows s.t.

every other row is a subsequence of this row. Given \( M_i, j \) one can compute \( f(M_i, j) \) s.t. \( M_u (f(M_i, j)) = M_i (j) \).

Thm [Hennie & Stearns 66]: There exists a universal \( U \) s.t. if \( M_x \) halts on \( x \) in \( T \) steps, \( U(x, x) \) halts in \( C T \log T \) steps, where \( C \) only depends on \( M_x \).
Thus: If M halts on x in t steps U(<M>, x) halts in C t^2 steps (where C depends only on M's alphabet, number of states, and number of steps).

Pf: U determines no. of steps, alphabet, and number of states. U has work tapes.

Each move of <M> on x takes O(\log \Sigma) T, where T is runtime of <M> on x.

1. U reads current state and current symbol of <M>
2. U determines transition.
3. U implements this transition.

Reading assignments: undecidability, efficient simulation of TM
1.5, 1.7, 9.1 of HMU

Q. M is always faster than M' on all inputs. U(<M>, x) is always faster than U(<M'>, x).

Q. M's run time is exactly C|x| and M's is exactly C'x^2

(a) U(<M>, x) always halts faster than U(<M'>, x)
(b) U(<M>, x) always faster than U(<M'>, x) for sufficiently large |x|
(b) Run times of U(<M>, x) and U(<M'>, x) are incomparable.