- **You shall receive feedback on the problems *only if*:**
  1. You submit **to Ekanshdeep** by **2359 hrs on Thursday, November 7**, 2019, and
  2. **Submit each problem in a separate sheet** with your name on each sheet. This is essential because the TAs divide correction duties by problem.
- This problem set should take you approximately an hour to solve. This is the pace that will be expected in the quizzes.

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1. Show that neither the set

$$\text{TOTAL} = \{M \mid M \text{ halts on all inputs}\}$$

nor its complement is r.e.

2. A *linear bounded automaton* (LBA) is exactly like a one-tape Turing machine, except that the input string $x \in \Sigma^*$ is enclosed in left and right endmarkers $\vdash$ and $\dashv$ which may not be overwritten, and the machine is constrained never to move left of the $\vdash$ nor right of the $\dashv$. It may read and write all it wants between the endmarkers.

   (a) Give rigorous formal definition of deterministic linearly bounded automata including a definition of configurations and acceptance. Your definition should begin as follows: " A *deterministic linearly bounded automaton (LBA)* is a 9-tuple

   $$M = (Q, \Sigma, \Gamma, \vdash, \dashv, \delta, s, t, r),$$

   where Q is a finite set of *states, ...* "

   (b) Let M be a linear bounded automaton with state set Q of size k and tape alphabet Γ of size m. How many possible configurations are there on input x, $|x| = n$?

   (c) Argue that the halting problem for deterministic linear bounded automata is decidable.

   (d) Prove by diagonalization that there exists a recursive set that is not accepted by any LBA.
