- **You shall receive feedback on the problems *only if* :**

  1. You submit **to Ekanshdeep** by **2359 hrs on Thursday, October 31**, 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 2.5 hours to solve. This is the pace that will be expected in the quizzes.

"Don't stop me now." – Freddie Mercury

1. Look up the term *enumerator* from Section 3.2 of Sipser's book. Show that a language is decidable iff some enumerator enumerates the language in the standard order of strings, i.e. lengthwise followed by lexicographic.

2. Consider the following version of the membership problem : we are given a Turing Machine M, a word w and a constant c. Does M accept w without exceeding $c\,|w|$ space on its tape? Show that this problem is decidable.

3. Prove that the halting problem is not co-recursively enumerable via diagonalisation.

4. We know that CFLs are a strict subset of recursive languages. Now, extend the model of PDAs by adding one additional stack. On reading a word we can push and pop both stacks independently of each other. Thus the transition function now looks like:

$$\delta : Q \times \Sigma \times \Gamma \times \Gamma \to Q \times \Gamma^* \times \Gamma^*$$

Give such a machine that accepts $\{ww \mid w \in \{a,b\}^*\}$. Show that these machines are as powerful as Turing machines.