

**Start Time:**

**Your name:**

**Stop Time:**

**Integrity signature:**

Suggested time limit 15 minutes, not counting download and upload. Please add explanation if over 20 minutes.

1. Let  $n \in \mathbb{N}$ . Give the definition of a numeral  $\underline{n}$ .
2. Let  $S$  be a  $k$ -ary relation on the integers. Give the definition of “ $S$  is representable in  $\mathbb{Q}$ ”.
3. Let  $f$  be a  $k$ -ary function on the integers. Give the definition of “ $f$  is representable in  $\mathbb{Q}$ ”.
4. Let  $\text{Halt}_0^{\text{TM}}$  be the halting problem for Turing machines (with Gödel number of Turing machines interpreted as integers). Explain why  $\text{Halt}_0$  is not representable in  $\mathbb{Q}$ .