

OLLSCOIL NA hÉIREANN, MÁ NUAD

NATIONAL UNIVERSITY OF IRELAND, MAYNOOTH

THIRD COMPUTER SCIENCE AND SOFTWARE ENGINEERING EXAMINATION

SAMPLE 2002

PAPER SE307

COMPUTATION AND COMPLEXITY THEORY

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Answer ALL QUESTIONS from Section A and any TWO questions from Section B.

Use a MCQ Answer Sheet for Section A – enter your name, student ID, and module code. Negative marking will be applied for Section A (2 marks for a correct answer, -0.5 for an incorrect answer, 0 for no attempt).

Time Allowed: 2 hours.

**SECTION A (40 marks)**

1. Consider Turing machine  $T$  of the form  $(Q, \Sigma, I, q_0, F)$ , where  $I$  is a set of tuples [2 marks] of the form  $(q, s, q', s', m)$ , and where all symbols have their usual meaning. Which of the following conditions must be true for  $T$  to be a valid Turing machine?
  - (a)  $I$  is finite
  - (b) if  $I$  is finite then  $T$  will halt
  - (c)  $F$  is nonempty
  - (d) if  $F$  is nonempty then  $T$  will halt
  - (e) if  $F$  is nonempty then  $T$  will halt on at least one input
2. Consider  $T$  from Question A.1. Which of the following conditions can be true for [2 marks]  $T$  to be a valid Turing machine?
  - (a)  $\Sigma$  is finite
  - (b)  $2^\Sigma$  is finite
  - (c)  $s = s'$  for each tuple in  $I$
  - (d) all of the above
  - (e) none of the above
3. through 20. Eighteen other questions similar to those from previous SE307 and CS403 exam papers.

## SECTION B (30 marks)

1. (a) Consider a set  $X$  of all tuples of the form  $(a, b)$ , where for each tuple the following two conditions hold:  $a, b \in \mathbb{N}$  and  $a < b$ . Prove that  $X$  is countable. [7 marks]  
(b) Explain in your own words, and as concisely as possible, the differences between the following three classes of problem:  $\mathcal{NP}$  problems,  $\mathcal{NP}$ -hard problems, and  $\mathcal{NP}$ -complete problems. [8 marks]
2. (a) Explain the difference between the terms *intractable* and *unsolvable*. Give examples of three intractable problems and three unsolvable problems. [7 marks]  
(b) Prove that the halting problem is unsolvable. [8 marks]
3. One more question similar in content to Sect. B from previous SE307 and CS403 exam papers.