Special instructions: Write your solutions out on paper and deliver them to SSO by 15:00 on Wednesday, 30th November, 2011. Clearly write your name, student ID number and the words "Comp36111 Sec. B Coursework" on the front (cover) sheet and staple all sheets together.

UNIVERSITY OF MANCHESTER
SCHOOL OF COMPUTER SCIENCE

Advanced Algorithms I: Coursework for Sec. B

Time: This should take you a few hours

Please answer the question.

Marks will be awarded for reasoning and method as well as being correct.

The use of electronic calculators is not recommended.

Section B

Answer the only question from this section

1. a) State Savitch's theorem, relating problem classes of the form SPACE(f) to their non-deterministic counterparts. Explain why Savitch's theorem shows that NPSPACE = Co-NPSPACE.

(3 marks)

b) State the Immerman-Szelepcsényi theorem, relating problem classes of the form NSPACE(f) to their complement classes.

(3 marks)

c) In the context of formal language theory, define the terms

i) *context-free grammar*,
ii) *context-sensitive grammar*;

explaining what it means for grammars of these kinds to accept a string.

(4 marks)

d) Suppose the language L is in NSPACE(n)—i.e. there is a nondeterministic Turing machine recognizing L, and running in linear space. Show that L is a context-sensitive language—i.e., there is a context-sensitive grammar which accepts exactly the strings in L.

(4 marks)

e) Show that any context-sensitive language can be recognized by a non-deterministic Turing machine using at most $O(n)$ squares on its worktape. (You may describe the algorithm informally, for example using pseudo-code; there is no need to write out the entire Turing Machine!)

(4 marks)

f) Hence, show that the complement of a context-sensitive language is another context-sensitive language. (This was an open problem in theoretical linguistics for some years.)

(2 marks)

END OF EXAMINATION