GMIT
INSTITIÚID TEICNEOLAÍOCHTA NA GAILLIMHE-MAIGH EO
GALWAY-MAYO INSTITUTE OF TECHNOLOGY

GALWAY-MAYO INSTITUTE OF TECHNOLOGY

SEMESTER 2 EXAMINATIONS 2015/2016

MODULE: COMP08015 – THEORY OF ALGORITHMS

PROGRAMME(S):
GA_KSOFG_H08 BACHELOR OF SCIENCE (HONOURS) IN SOFTWARE DEVELOPMENT

YEAR OF STUDY: 4

EXAMINERS:

Dr. Ian McLoughlin	(Internal)
Dr. Michael Schukat	(External)
Mr. Tom Davis	(External)

TIME ALLOWED: 2 Hours

INSTRUCTIONS: Attempt 3 questions. All questions carry equal marks.

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Programmable or text storing calculators, smart phones/watches or any other electronic devices are expressly forbidden in the Examination Hall.

Requirements for this paper (Please mark (X) as appropriate):

- ☐ Log Tables
- ☐ Graph Paper
- ☐ Dictionaries
- ☐ Statistical Tables
- ☐ Bible
- ☐ Thermodynamic Tables
- ☐ Actuarial Tables
- ☐ MCQ Only – Do not publish
- ☐ Attached Answer Sheet

Question 1

(a) Suppose we are to generate all permutations of the elements of the list $l = (1, 2, 3, 4)$. Explain how Heap's algorithm for generating permutations works, using it to generate the permutations of l. (40 marks)

(b) Explain the difference between Heap's algorithm and the Steinhaus–Johnson–Trotter (STJ) algorithm. Again, using l as an example. (40 marks)

(c) Compare and contrast the two algorithms in terms of time complexity. (20 marks)

Question 2

(a) Explain what a *side-effect* is in the context of functional programming. (40 marks)

(b) Explain what the following Scheme code does and how it works.

```
(define (binv l)
  (if (null? l)
    '()
    (if (not (or (= (car l) 0) (= (car l) 1)))
      '()
      (if (= (car l) 0)
        (cons 1 (binv (cdr l)))
        (cons 0 (binv (cdr l)))
      ))))
```

(40 marks)

(c) Explain the difference between the `list` and `quote` procedures in Scheme. (20 marks)

(PTO)

Question 3

(a) Give and explain the state table of a Turing Machine that inverts a sequence of zeroes and ones. That is, it should convert all zeroes to ones, and vice versa. (40 marks)

(b) Determine what the Turing Machine given by the following state table will do with an input of 111011. Show your workings.

State	Input	Write	Move	Next
	B	B	R	1
0	0	0	L	0
	1	1	L	0
	B	1	L	2
1	0	1	R	2
	1	0	R	1
	B	B	R	Stop
2	0	0	L	2
	1	1	L	2

Note the states and symbols are all given by the table. B is the blank symbol, state 0 is the initial state and Stop is the final state. (40 marks)

(c) Suggest what the Turing Machine above is designed to do in general, explaining your reasoning. (20 marks)

Question 4

(a) Explain what the Boolean satisfiability problem (SAT) is. (40 marks)

(b) Explain how to reduce the SAT problem to the 3-SAT problem. (40 marks)

(c) Show that the 3-SAT problem is NP-complete. You may assume that SAT is NP-complete. (20 marks)