Module Code: COMP 5920M

Module Title: Scheduling **© UNIVERSITY OF LEEDS**

School of Computing

Semester Two 2018/2019
May 2019

Calculator instructions:

- You are not allowed to use a calculator in this exam.

Dictionary instructions:

- You are not allowed to use your own dictionary in this exam. A basic English dictionary is available to use: raise your hand and ask an invigilator, if you need it.

Exam information:

- This is a **closed book** examination, no material is permitted.
- There are **4 pages** to this exam.
- There will be **2 hours** to complete this exam.
- **Answer all 3 questions**.
- The number in brackets [ ] indicates the marks available for each question or part question.
- You are reminded of the need for clear presentation in your answers.
- The total number of marks for this examination paper is **60**.

Question 1

Under the Generate and Select approach for train crew scheduling, the Select Phase can be solved as a set covering integer linear programming (ILP) problem.

(a) Explain the principle constraints in the ILP. [2 marks]

(b) One of the tasks in your coursework was to implement a greedy heuristic to reduce the given dataset DS2 from 73,517 down to a target of 200 candidate shifts before applying the ILP.

(i) Briefly describe the greedy heuristic used. [3 marks]

(ii) Suppose a feasible solution schedule for DS2 requires at least 80 shifts. What would be the effect of setting a target for the greedy heuristic to reduce DS2 down to 70 candidate shifts? [2 marks]

(iii) Suggest how some candidate shifts could be prioritised for deletion thereby improving the greedy heuristic. [3 marks]

(c) The ILP can be solved in two stages as discussed in this module.

(i) Outline the two stages. [5 marks]

(ii) Briefly explain how crew scheduling problem specific characteristics can be exploited in the second stage and give one example to illustrate. [5 marks]

Question 2

(a) How far ahead actual operations are scheduled has very significant implications on the scheduling process. Discuss the above statement in the context of public transport. [8 marks]

(b) The table below shows a timetable for 40 university courses. For example Course 11 (highlighted) has been assigned to Room 4 in Timeslot 5, but this might not be feasible if there are more students enrolled for Course 11 than Room 4 can accommodate.

Timeslot	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*
Room	Course								
1		19		12	36	39	6	24	29
2	7	25	26	27	2	16		14	
3	13		30	1		4	33		35
4		3	40	34	**11**		5	32	8
5	18	20	31	17		28	15		
6	38	21	10		22		37	9	23

Many simple 'low level heuristics' (LLH) could be designed to try to improve the timetable. For example, the assignments in the timetable could be swapped individually or in rows or in columns.

(i) Discuss how the goodness of a potential solution timetable could be evaluated by an LLH. [3 marks]

(ii) Outline a performance based hyper-heuristic algorithm utilising a group of LLHs, which may be applied for the above timetabling problem. [4 marks]

(c) Telescopes used in astronomy, e.g. the Hubble Space Telescope, are very expensive scarce resources. Suppose a scheduling algorithm for such telescopes is classified as
1 | clv, prec, pmtn | $\sum \boldsymbol{w_j U_j}$.
Explain the meaning of this classification [5 marks]

Question 3

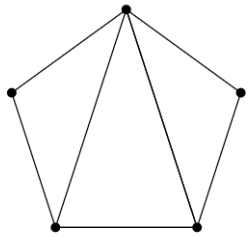
(a) Utilising limited resources is commonly required in scheduling. For rail transport scheduling, train units and crews are resources readily available at their arrival stations. Discuss the role of shortest path algorithms in optimising re-deployment of train units and crews at the end of the timetabled trips they have served.

[5 marks]

(b) Discuss how a graph can be set up for a bus timetable with the intention of using the graph's chromatic number as an estimate of the fleet size required to cover the timetable

[3 marks]

(c) The graph below represents a graph colouring problem, which can be solved by the 'saturation degree ordering heuristic'. Outline the heuristic and illustrate its steps by applying it to the graph below. [5 marks]



(d) Outline the modelling of train unit scheduling as a multi-commodity network flow problem (a mathematical formulation of the associated ILP is not required)

[7 marks]