UNIVERSITI UTARA MALAYSIA

FINAL EXAM
FIRST SEMESTER SESSION 2008/2009

CODE/SUBJECT NAME : QQP 3043/ TEKNIK-TEKNIK HEURISTIK
DATE : 23 NOVEMBER 2008
TIME : 9.00-11.30 AM (2½ HOURS)
VENUE : TE, DSB K.TM

INSTRUCTIONS:
1. This book script contains SIX (6) questions in NINE (9) printed pages, excluding the cover page and appendix.
2. An appendix is given on page 10.
3. Answer ALL questions in the space provided.

MATRIC NO :  
(in words )  
(in numbers)
IC. NO :
LECTURER :
GROUP :  
TABLE NO:

PLEASE DO NOT OPEN THIS SCRIPT UNTIL YOU ARE TOLD TO DO SO

CONFIDENTIAL
QUESTION 1 (12 MARKS)

The United Group Co. is a major investor in commercial real-estate development projects. It currently has the opportunity to share in three large construction projects: (i) Construct a high-rise office building, (ii) Construct a hotel, and (iii) Construct a shopping centre. Each project requires each partner to make investments at four different points in time: a down payment now, and additional capital after one, two and three years. Table below shows for each project the total amount of investment capital required from all the partners at these four points in time. All three projects are expected to be very profitable in the long run. So the management wants to invest as much as possible in some or all of them. The objective is to determine the investment mix that will be most profitable, based on current estimate of the profitability. The company currently has $25 million available for capital investment. It is assumed that another $20 million will become available after one year, $20 million more after two years, and another $15 million after three years.

<table>
<thead>
<tr>
<th>Year</th>
<th>Office Building (million)</th>
<th>Hotel (million)</th>
<th>Shopping Centre (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>$40</td>
<td>$80</td>
<td>$90</td>
</tr>
<tr>
<td>1</td>
<td>60</td>
<td>80</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>90</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>Net Present Value</td>
<td>45</td>
<td>70</td>
<td>50</td>
</tr>
</tbody>
</table>

a) Formulate an integer programming (IP) model for this problem such that the total net present value of these investments is maximized. (10 marks)
b) State the type of problem (with respect to the decision science area) that this investment situation belongs to. 

(2 marks)

QUESTION 2 (10 MARKS)

Utara is a subsidiary of an LTL (less-than-truck-load) transportation company. Clients bring their shipments to the Utara terminal to be loaded into delivery trucks and they can rent the space up to 36 ft in length, which is the maximum capacity of a truck. The client pays for the exact linear space the shipment occupies. Partial shipment is strongly avoided since Utara wants to minimize the number of trucks used, so that cost is also minimized as much as possible. The following table provides the outstanding orders Utara needs to process.

<table>
<thead>
<tr>
<th>Order</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size (ft)</td>
<td>5</td>
<td>11</td>
<td>22</td>
<td>15</td>
<td>7</td>
<td>9</td>
<td>18</td>
<td>14</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Item value (RM)</td>
<td>120</td>
<td>93</td>
<td>70</td>
<td>85</td>
<td>125</td>
<td>104</td>
<td>98</td>
<td>130</td>
<td>140</td>
<td>65</td>
</tr>
</tbody>
</table>

Solve the above bin-packing problem for Utara using Non-increasing Best Fit greedy heuristics. How many trucks does Utara need to provide for these shipments? 

(10 marks)
QUESTION 3 (28 MARKS)

Given below is a table illustrating merit values ranging from 1 - 10 for each pair of student to project work in a course.

<table>
<thead>
<tr>
<th>Student</th>
<th>Project Work</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>J</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
</tr>
</tbody>
</table>

Use Genetic Algorithm (GA) to solve this problem with potential solution represented in the permutation form. Five initial solutions are given as follows:

S1 1 2 3 4 5
S2 1 2 5 4 3
S3 2 1 3 4 5
S4 1 2 4 3 5
S5 5 2 3 4 1

a) Determine the objective function value for each of the initial solution above, if the objective is to maximize total merit values obtained.

(5 marks)
b) Compute the mating probability for each initial solution. (6 marks)

c) Next, obtain a new solution population through the processes of parent selection, a one-point crossover, and mutation with crossover and mutation rates being 0.80 and 0.40 respectively. Use rank selection for parent crossover. Explain how you choose the parents based on rank. Define your mutation procedure and highlight the mutated cell(s). (15 marks)

d) What is the best solution so far? (2 marks)
QUESTION 4 (25 MARKS)

Given in the table below are the processing times and due dates for a single machine scheduling problem with 10 outstanding jobs to be processed. All times are in days and due time is measured from time 0. The objective is to minimize total tardiness with a tardiness penalty value of 3 for each day a job is off schedule.

<table>
<thead>
<tr>
<th>Job</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing time</td>
<td>10</td>
<td>3</td>
<td>13</td>
<td>15</td>
<td>9</td>
<td>22</td>
<td>17</td>
<td>30</td>
<td>12</td>
<td>16</td>
</tr>
<tr>
<td>Due time</td>
<td>20</td>
<td>98</td>
<td>100</td>
<td>34</td>
<td>50</td>
<td>44</td>
<td>32</td>
<td>60</td>
<td>80</td>
<td>150</td>
</tr>
</tbody>
</table>

a) Solve this problem using Simulated Annealing technique with the initial solution $x^0$ as given below and for two temperature levels, whereby $T_0 = 10$; $T_1 = 0.8T_0$; $N_t = 2$.
(Neighbour: Exchanging a pair of jobs)

A B C D I G B J E H F

(15 marks)
b) Suppose that this problem is to be solved using the Tabu Search (TS) technique. Use the same initial solution and the same neighbour generation heuristics to create three neighbours. Evaluate each of them and conclude which neighbour to be chosen as the current solution [end of first iteration]. Describe how you set your tabu list and tabu tenure for the whole TS process.

(8 marks)

c) What is the function of tabu list in the TS technique?

(2 marks)
QUESTION 5 (6 MARKS)

A distribution company has four sales territories, each of which will be assigned a sale representative. Based on past experience, the company's sales manager has estimated the annual sales volume (in thousands) for each sales representative in each territory to be as illustrated in the table below.

<table>
<thead>
<tr>
<th>Sales Rep.</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>80</td>
<td>54</td>
<td>60</td>
</tr>
<tr>
<td>2</td>
<td>60</td>
<td>52</td>
<td>40</td>
<td>72</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>60</td>
<td>44</td>
<td>48</td>
</tr>
<tr>
<td>4</td>
<td>52</td>
<td>74</td>
<td>36</td>
<td>40</td>
</tr>
</tbody>
</table>

Use any assignment heuristic technique to determine the assignment of representatives to territories and the total amount of sales that could be achieved through the assignment.

(6 marks)
QUESTION 6 (19 MARKS)

a) State two reasons (or situations) where it is suitable to use a heuristic technique to solve a problem. (4 marks)

b) State two disadvantages of heuristic techniques. (2 marks)

c) Explain two of the important features of a Greedy method. (4 marks)

d) Describe the procedure of LP Relaxation that one needs to do when solving an optimization problem using Branch and Bound method. (3 marks)
e) For each type of the problem below, describe one suitable application problem/situation.

i) A set covering problem

(3 marks)

ii) A knapsack problem

(3 marks)
A General Algorithm for SA

Let

\[ X = \text{the set of feasible solutions} \]
\[ z(x) = \text{the objective function to be minimized over } X. \]
\[ T_t = \text{the decreasing sequence of values of temperature to be used; } t = 0, 1, \ldots. \]
\[ N_i = \text{the number of iterations to be performed at each temperature } T_i. \]

Then, the algorithm proceeds as follows:

**Step 1: initialization**

Let \( x^0 \) = the initial solution and \( t^0 \) = the initial temperature.

**Step 2: general step**

When the temperature is \( T_t \), do the following.
Set iteration counter \( n \) to 0.

If \( x' \) is the current solution, find a solution \( y \) in the neighbourhood of \( x' \) at random. Then

If

\[ z(y) \leq z(x') \text{ then } x^{i+1} = y \]

Else If

\[ z(y) > z(x') \text{ then } x^{i+1} = y \text{ with probability } \exp[-(z(y)-z(x'))/T_t] \]

and

\[ x^{i+1} = x' \text{ with probability } (1-\exp[-(z(y)-z(x'))/T_t] \]

Next, increase the iteration count by 1 and continue with \( x^{i+1} \) as the current solution.

When \( n = N_i \), change \( T \) to \( T_{i+1} \) and start the next step.

Continue until the stopping criterion is met.