Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2021/2022

COURSE NAME	:	METAHEURISTICS TECHNIQUE IN MATHEMATICS
COURSE CODE	:	BWA 41103
PROGRAMME CODE	:	BWA
EXAMINATION DATE	:	JANUARY / FEBRUARY 2022
DURATION	:	3 HOURS
INSTRUCTION	:	1. ANSWER **ALL** QUESTIONS. 2. THIS FINAL EXAMINATION IS **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK**

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1

(a) Categorize four type of metaheuristic techniques into their five different classifications. Fill your answer in the **Table Q1(a)** given.

Table Q1(a)

Classification		Simulated Annealing	Tabu Search	Genetic Algorithm	Ant Colony Optimization
C1	Nature				
	Non-nature				
C2	Static Objective				
	Dynamic Objective				
C3	Using Memory				
	Memory-less				
C4	One Neighborhood				
	Multiple Neighborhoods				
C5	Trajectory Method				
	Population-based Methods				

(20 marks)

(b) Based on **Figure Q1(b)** below, explain the issue of each situation regarding their searching process of metaheuristic techniques using your own words.

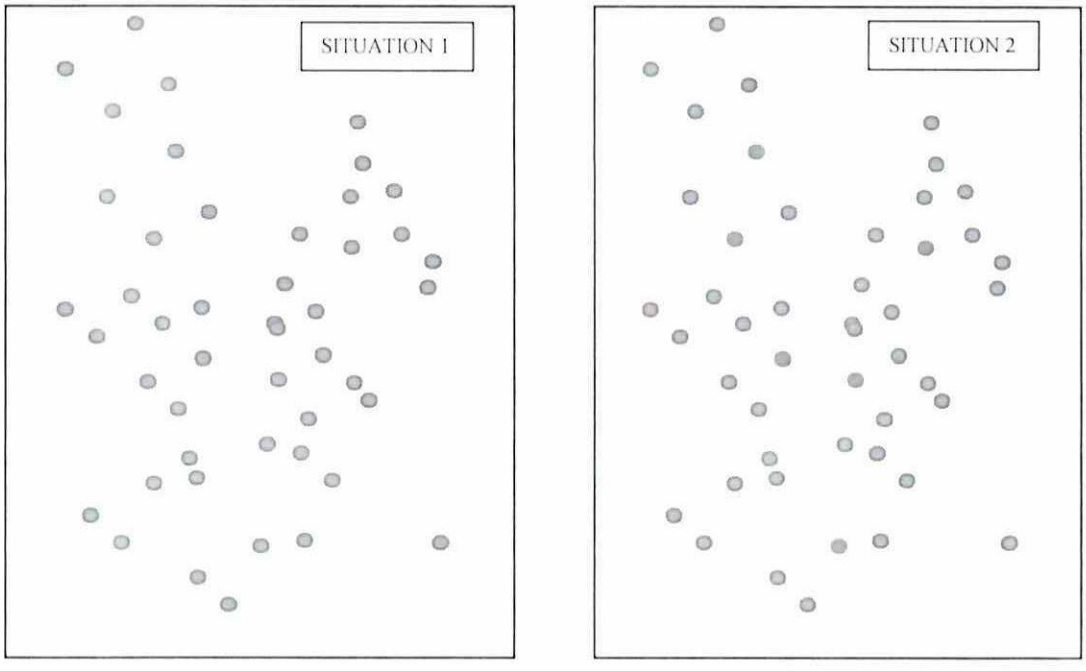

Figure Q1(b)

(5 marks)

Q2 (a) The algorithm below is a simple procedure that easy to be implemented and quick to be executed, but it has main disadvantage.

```
Procedure
Begin
        Initialize (k, i)
        Repeat
                Generate configuration (i → j);
                Calculate ΔCij = C(i) - C(j)
                if ΔCij ≤ 0 then i = j;
        until ΔCij ≥ 0 for all j in the neighbourhood of i;
End;
```

(i) State the name of the above algorithm.

(2 marks)

(ii) Discuss **FOUR (4)** main disadvantage of this algorithm.

(4 marks)

(iii) Explain **TWO (2)** strategies on how to overcome the weakness of this algorithm.

(2 marks)

(b) The classroom scheduling problem is solved using Simulated Annealing, where the aim of study is to maximize the preference of teachers and students. The **Table Q2(b)** shows the iteration of moves.

Table Q2(b)

Current Evaluation	Neighborhood Evaluation	Current Temperature
75	65	25
75	65	50
65	55	25
65	55	50
75	65	90
55	45	25
65	55	90
55	45	50
55	45	90

(i) Determine the number of iterations involved at each temperature.

(2 marks)

(ii) Calculate the probability of acceptance for each temperature.

(11 marks)

(iii) Based on the obtained result in **Q2(b)(ii),** explain **TWO (2)** conclusions regarding the acceptance criteria of the worse moves.

(2 marks)

(iv) In order to improve the performance of Simulated Annealing, determine **TWO (2)** changes that could be made regarding the number of iteration at each temperature.

(2 marks)

Q3 (a) Ant Colony Optimization is one of the population-based approaches. Discuss **FIVE (5)** inspiration of Ant Colony Optimization in terms of the natural behaviour of ant searching for food.

(5 marks)

(b) Assume four cities $\{A, B, C, D\}$, which are represented by a fully connected graph. The **Table Q3(b)** represents the pheromone levels on each edge of the graph and the distances between each city. Assume that the pheromone levels and distances are symmetric and an ant started its journey at city A and has travelled to city C.

Table Q3 (b)

	Pheromone Levels			
	A	B	C	D
A				
B	0.23			
C	0.12	0.97		
D	0.33	0.53	0.65	

	Distances			
	A	B	C	D
A				
B	11			
C	10	7		
D	9	14	4	

(i) Estimate the probability that the ant will travel to city B.

(3 marks)

(ii) Estimate the probability that the ant will travel to city D.

(3 marks)

(iii) Assume the ant completes its tour using the route $ABCD$. Estimate the pheromone levels on each edge once they have been updated. Assume $Q = 100$, the evaporation parameter is set to 0.4 and the value of alpha and beta are set to 1.

(14 marks)

Q4 Suppose a Genetic Algorithm uses chromosomes of the form $x = qrstuvwx$ with a fixed length of eight genes. Each gene can be any digit between 0 and 9. Let the fitness of individual x be calculated as:

$$f(x) = (q + r) - (s + t) + (u + v) - (w + x)$$

and let the initial population consists of four individuals with the following chromosomes:

$x_1 = 6\ 5\ 4\ 1\ 3\ 5\ 3\ 2$
$x_2 = 8\ 7\ 1\ 2\ 6\ 6\ 0\ 1$
$x_3 = 2\ 3\ 9\ 2\ 1\ 2\ 8\ 5$
$x_4 = 4\ 1\ 8\ 5\ 2\ 0\ 9\ 4$

(a) Estimate the fitness of each individual, showing all your calculation steps, and arrange them in order to begin the most fit to the least fit last.

(10 marks)

(b) Apply the following crossover operation to the chromosomes of four individuals:

(i) Cross the two most fit individuals using a one-point crossover at the middle point (points t and u).

(ii) Cross the second and third most fit individuals using a two-point crossover at the middle point (points r and v).

(8 marks)

(c) Suppose a new population consists of four offspring individuals received by the crossover operations in **Q4(b)**. Point out the fitness of the new population and show all your calculation steps. Has the overall fitness improved? Give your own conclusions.

(7 marks)

– **END OF QUESTIONS** –