1. Provide an algebraic expression in terms of n for the size of the phenotypic search space (the number of possible sets of vertices). [1 mark]

The number of subsets of a set of size n is 2^n

Excluding the empty set, 2^n - 1

2. Describe how to use a binary representation of length n for the genotype. [1 mark]

To use a binary representation of length n for the genotype, we can represent each vertex in the graph as a binary digit in the genotype. Specifically, we can use a binary digit of 1 to indicate the presence of the corresponding vertex in the phenotype, and 0 to indicate the absence of the vertex in the phenotype. Using this binary representation, we can apply genetic operators such as mutation and crossover to create new candidate solutions, evaluate the fitness of each solution by counting the number of 1's in the binary string (which corresponds to the number of vertices in the phenotype), and select the best solutions for the next generation.

3. For the graph G above, provide the genotype that represents the phenotype with vertices 2, 3, 5 and 7. [1 mark]

Given phenotype {2, 3, 5, 7}

The binary genotype can be represented as follows:

Vertex 1: Absent (0) Vertex 2: Present (1) Vertex 3: Present (1)

Vertex 4: Absent (0) Vertex 5: Present (1) Vertex 6: Absent (0)

Vertex 7: Present (1) Vertex 8: Absent (0)

The binary genotype is "01101010" = { 2, 3, 5, 7 }

4. Design a fitness function F(p) for a phenotype p, in terms of the number of edges covered and the number of vertices used. The function must provide the fitness of p as a single value (it can't return a vector of values) That value can be integer or real. There is no single correct answer to this question. Designing the function is entirely for you to solve! [2 marks]

F(p) can be defined as:

F(p) = (number of edges in phenotype p) - (number of vertices covered by p)

5. Calculate the fitness of the phenotype {2, 3, 5, 7} in graph G above using your fitness function. Show working. [1 mark]

F(p) = 8 – 4 = 4

6. Calculate the fitness of the phenotype {2, 4, 6, 3, 8} in graph G above using your fitness function. Show working. Note that this is an optimal solution, so the fitness value here should be higher than that for question 5 (or any other suboptimal phenotype). If it isn't, revise your fitness function! [1 mark]

F(p) = 11 – 5 = 6

7. Suppose we decided to use swap mutation. Explain why that would be either a good or bad idea. [1 mark]

Swap mutation may not be as effective when the solution space is highly constrained and there are limited possibilities for improvement. In this case, it may be better to use mutation operators. Also, the effectiveness of swap mutation depends on the size of the population and the number of iterations.

8. Give two reasons why a termination criterion that only halts when a valid solution (read: minimum vertex cover) is found is insufficient. [1 mark]

Large search space: The search space can be enormous, and searching the entire space for a valid solution may take an unacceptably long time. If the algorithm is allowed to run indefinitely until a valid solution is found, it may never terminate.

Local optima: Even if a valid solution is found, it may not be the optimal solution. In many optimization problems, there may be many local optima, which are solutions that are better than most nearby solutions, but not as good as the global optimum.

9. Suggest an additional termination criterion to fix the problem in question 8 above. [1 mark]

Max number of iterations that the algorithm can run: This would ensure that the algorithm does not run indefinitely and allows for comparison between different runs of the algorithm with the same maximum number of iterations.