Project 2: Optimisation

Important: Part 1 and Part 2 must be done individually and must be your own work. Part 3 can be done individually or in a group of 2. (Groups of more than 2 are not permitted.)

See "Project 2" Canvas page for full details on expectations and marking criteria.

PART 1: MAXIMISING A FUNCTION

Objective: Find the maximum value of $f(x, y, z)$, where

$$\begin{aligned} f(x,y,z) &= e^{\sin(40z)} + \sin(60\cos(z)) + e^{\sin(50x)} \\ &\quad + \sin(60e^y) + \sin(70\sin(x)) + \sin(\sin(80y)) \\ &\quad - \sin(10(x+y)) + \frac{x^2+y^2+z^2}{100} \end{aligned}$$

Constraints: The solution must be subject to the (hard) constraints:

$$0 \leq x, y, z \leq 5 \qquad \text{and} \qquad x, y, z \in \mathbb{R}$$

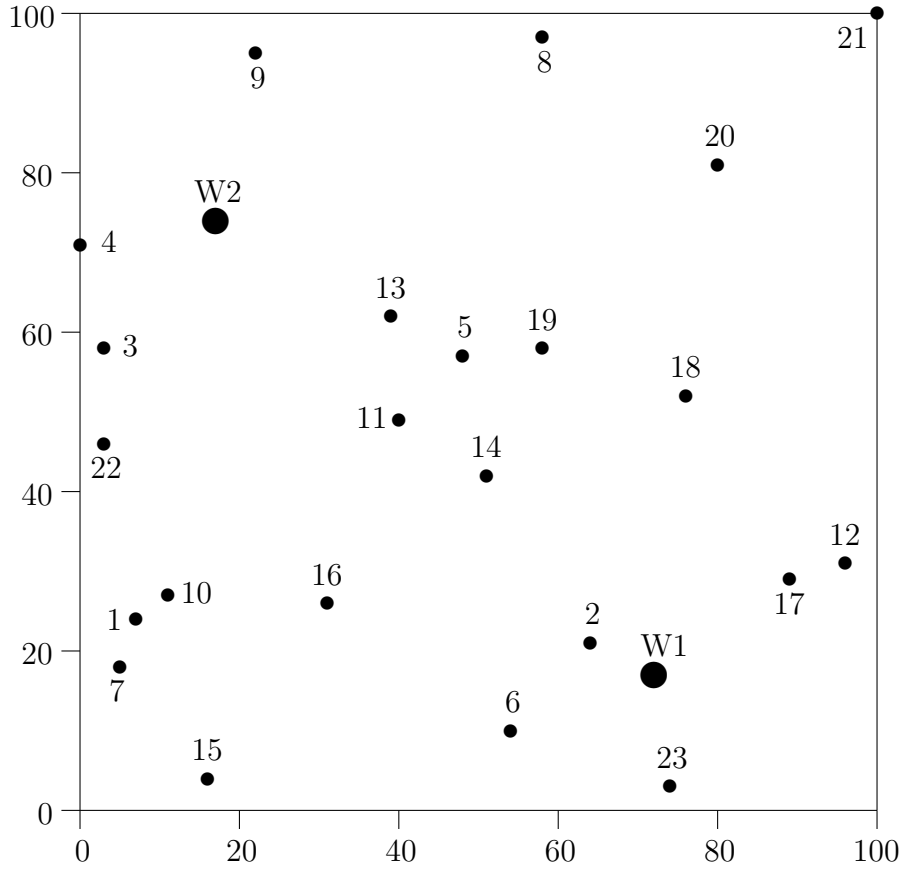
You should explain the approach taken, submitting all programming code that is used - provide comments to code, or a description of the code, where appropriate to demonstrate you understand the code used.

Equation in Python:

```
math.exp(math.sin(40*z)) + math.sin(60*math.cos(z)) + math.exp(math.sin(50*x))
+ math.sin(60*math.exp(y)) + math.sin(70*math.sin(x)) + math.sin(math.sin(80*y))
- math.sin(10*(x+y)) +(x**2+y**2+z**2)/100
```

PART 2: DISTRIBUTION NETWORK

A major supermarket is updating its delivery network. They have 2 main warehouses (W1 and W2) and 23 stores at locations (1-23). Each day they must carry out a daily delivery from their two warehouses to all 23 stores, with the vehicles returning to the warehouses at the end of the day. The geographical locations of the sites are shown below:



(The location coordinates and distance matrix is available on Canvas - in an Excel file.)

There are two types of vehicle that the supermarket can use:

	Cost per mile	Maximum stores it can supply
Van	£1	4
Lorry	£2	16

Given the aim is to **minimise the total daily costs**, find the best strategy such that every store receives its delivery and the warehouses have the correct number of vehicles at the end of the day to carry out the deliveries the following day.

Questions: Which stores should each warehouse supply? How many vans or lorries does each warehouse require? What routes should each vehicle take? What is the total cost?

PART 3: YOUR OWN REAL-LIFE EXAMPLE

Important: maximum 4 pages if done individually, maximum of 6 pages if done in a group of two.

Create your own example of a real-life optimisation problem. This can be any example from business, government, leisure or sport. It may involve using existing data, or simply approximating behaviour with simulated data and your own model. However, it must be your own example you create, and you cannot simply replicate an existing example.

The key points you must include in your report are:

(*i*) **Background:** Introduce the situation, including any relevant information that is needed to understand the problem (including references);

(*ii*) **Aim:** Specify what is to be optimised. What is the main objective? What constraints will there be?

(*iii*) **Model:** Convert your problem into a mathematical or statistical problem - what is the form of your solutions? What is your objective function? What will the mathematical or statistical model be to get from your solutions to your objective? What constraints exist on your possible solutions?

(*iv*) **Optimisation Method:** Explain how you solved the problem - for example, what algorithm(s) did you use etc. Submit your code/program so your results can be verified. Comment or explain how your code works - this can be done in a separate file, e.g. a Python file, or in an Appendix which will not count towards your page limit.

(*v*) **Results:** Give the results to your problem. Is there just one optima, or multiple optima? Explain how you know you have got the optimal solution, or at least a solution close to the optimal, and that you are not at a local optima?

(*vi*) **Conclusion:** Relate your results back in terms of the original problem. Carry out a critical analysis of your results - what are the strengths and weaknesses of your work? (Weaknesses in your model, for example due to the assumptions you make to simplify it, are not a bad thing, as long as you are aware of them. Remember, no model is perfect!)

For Groups only: *If you are a group of 2, you must also submit a short summary (max 100 words) of what each member contributed to the work, the "added value" gained by working in a group, as opposed to on your own, and any problems faced working as group.*