Name: ..... Student ID:

- Student ID: ....
- 1. [12 p.] What is chaos in the context of nonlinear dynamics?
- 2. [12 p.] What are the Feigenbaum constants?
- 3. [12 p.] Explain the idea behind construction of a fractal.
- 4. [12 p.] Sketch a 1-D phase portrait corresponding to the following system:

$$\dot{x} = \sin x. \tag{1}$$

5. [13 p.] Determine if the following system is linear or nonlinear:

$$\ddot{x} + \dot{x} + \sin x = 0. \tag{2}$$

6. [13 p.] Linearise the following system:

$$\begin{cases} \dot{x} = -y, \\ \dot{y} = y \left( x^3 + y^3 \right) + x. \end{cases}$$
(3)

- 7. [13 p.] Video: (Link: https://www.youtube.com/watch?v=TYXVgJdcX\_Q) Is the magnetic pendulum shown in the video and in Fig.1 a chaotic system? If you believe the pendulum to be chaotic, then what is the source or sources of the chaos?
- 8. [13 p.] Video: Does the pendulum have an unstable fixed point (unstable pendulum position)? If so, can we position the pendulum at that point for a prolonged period of time? Explain your answers.



Figure 1: The magnetic pendulum in three magnetic potentials relevant to Questions 7 and 8. The magnets are marked with the red, orange and blue colours.