Name: ..... 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:

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

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.

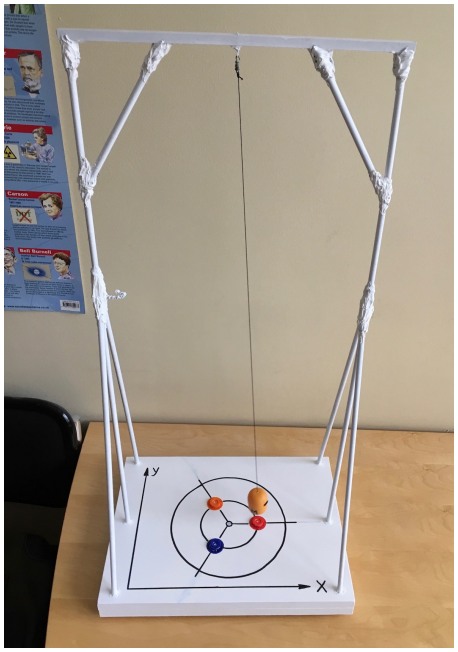

Figure 1: The magnetic pendulum in three magnetic potentials relevant to Questions 7 and 8. The magnets are marked with the red, orange and blue colours.