| University of Cape Town | Department of Physics |
|---|---|

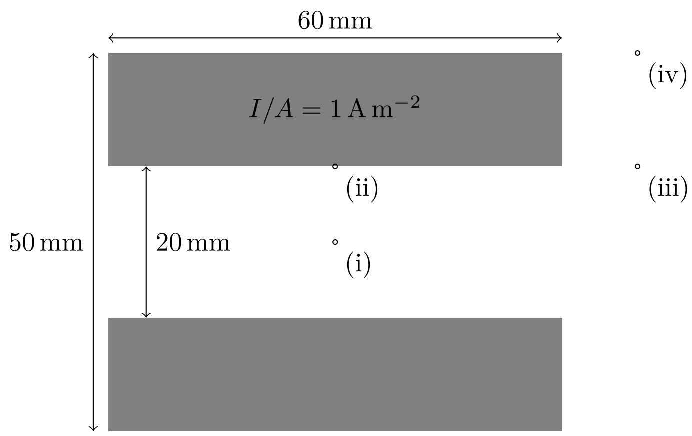
**Computational Physics**
Honours Module

**PHY4000W-CP**

# Tutorial 3

**Due Wed, 26 April 2023, 12pm** **T Dietel**

1. Calculate the magnetic field of a solenoid with an inner diameter of 20 mm, an outer diameter of 50 mm and a length of 60 mm. The current density in the solenoid is $1\,\mathrm{A\,m^{-2}}$.




   (a) Calculate the magnetic field (i) at the center of the solenoid, (ii) at the inner boundary in the middle of the solenoid and at two points outside outside of the solenoid, 10 mm from its end, at (iii) the inner and (iv) outer radius of the solenoid. The points are marked in the sketch above.

   (b) Calculate and visualize the magnetic field at all positions.

2. In this problem, you will study the influence of Mars on the period of the Earth, using the Runge-Kutta method to calculate the orbits of Mars and Earth around the Sun.

   You may use a simplified model of the solar system, involving only Sun, Earth and Mars. All orbits are assumed to be in one plane, and the major axes for Earth and Mars coincide. Start the simulation with Earth and Mars both at their perihelion, i.e. the closest points to the centre-of-mass.

   (a) Implement the Runge-Kutta algorithm for the simulation of these three bodies and calculate the orbits of Earth and Mars, using the perihelion and the maximum orbital velocity as well as the masses as inputs, and neglecting the gravitational force between the two planets.

   Verify your calculation by comparing the orbital eccentricities with the literature values.

   (b) Determine the periods of Earth and Mars assuming no force between the planets. Compare with the literature values.

   (c) Include the gravitational force between Earth and Mars in your calculation. Simulate several orbits and determine the duration of each orbit. Visualise your results in an intuitive way. How does the presence of Mars change the period of the Earth?

| | **Sun** | **Earth** | **Mars** |
|---|---|---|---|
| Mass ($10^{24}$kg) | 1 988 500 | 5.9724 | 0.64171 |
| Perihelion (AU) | | 0.9832899 | 1.3813334 |
| Max. orbital velocity (km/s) | | 30.2874 | 26.4998 |