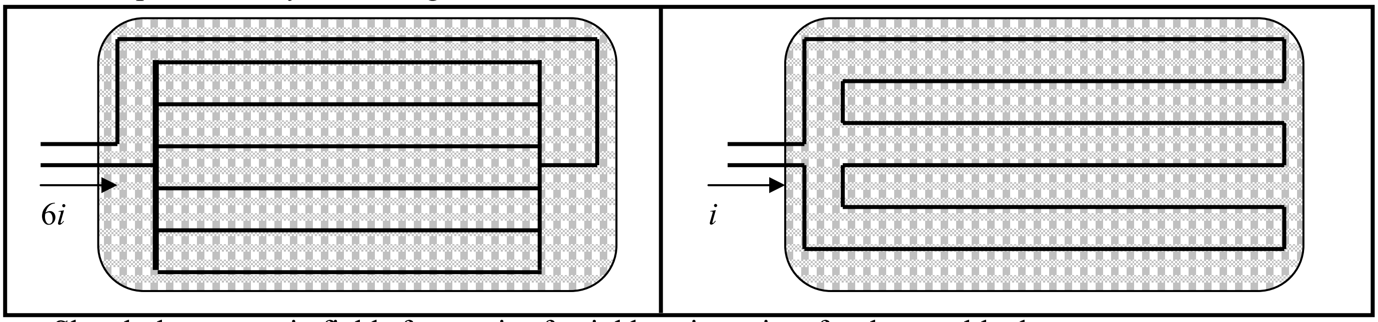
Workshop Tutorials for Biological and Environmental Physics

ER7B: **Magnetic Fields**

A. Qualitative Questions:

1. The Earth's magnetic field is important because it protects us from charged particles radiated by the sun. It also provides a means of navigating for humans and for many animals as well.
a. Sketch the magnetic field lines for the Earth's magnetic field.
b. Sketch the path of a charged particle which has become trapped in the Earth's magnetic field.
c. Would the aurora australis (southern lights) or the aurora borealis (northern lights) be possible if the earth had no magnetic field? Explain your answer,
The aurora australis is occasionally visible from southern Victoria and Tasmania in winter, and from further north when there is a lot of sunspot activity. However, due to light pollution, the aurora is impossible to see from large cities such as Sydney and Melbourne.
d. Why are these light shows normally seen only near the poles?

2. Electric blankets work by passing currents along wires embedded in the blankets. The resistance of the wires and the current flowing through them causes them to heat up, thus keeping you cosy and warm. However apart from heat, the current carrying wires also produce a magnetic field. The figures below show two possible ways of wiring an electric blanket.



a. Sketch the magnetic fields for a pair of neighbouring wires for the two blankets.
b. Which wiring pattern would give you a smaller average magnetic field above the wires in the blanket?

B. Activity Questions:

1. Magnets and magnetic fields
Use the iron filings to investigate the field lines of the magnets.
How do these field lines compare to the magnetic field lines of the Earth?
Many animals such as pigeons and some fsish have a magnetic sense which allows them to use the Earth's magnetic field to navigate.

2. Magnetic field around a current carrying wire – Oersted's experiment
Use the compasses to find the direction of the magnetic field at different points around the wire.
Draw a diagram showing the field around the wire.
What happens when you swap the connections and change the direction of the current?

3. Solenoid
Draw a diagram showing the magnetic field in and around the solenoid.
Are there any points where the magnetic field is zero?
How does the magnetic field vary inside the solenoid?

4. The magnetic force - pinch effect
Turn on the power supply and observe what happens to the wires.
How can you make them repel instead of attracting?
Draw a diagram showing the field, current and forces on the wires.

D. Quantitative Questions:

1. The heart produces an electric field due to the movement of charges required to trigger the heart muscles to contract. Measuring the changes in potential is a common way of investigating heart function and is called an electrocardiogram or ECG measurement. The heart also produces a magnetic field of around 5.5×10^{-11} T, and measuring changes in this magnetic field, called a magnetocardiogram (MCG), can also give valuable information about the condition of the heart.
Consider a carbonate ion, HCO_3^-, moving in the blood at $0.52\ m.s^{-1}$.
a. What will be the maximum possible acceleration of this ion as it moves past the heart?
b. What will be the minimum acceleration of this ion as it moves past the heart?

Data HCO_3 has a mass of 61 amu, and 1 amu = 1.67×10^{-27} kg.

2. Magnetic field therapy is used to treat all sorts of ailments in humans and in horses and even dogs and cats, in particular soft tissue and bone damage.
A magnetic field generator which consists of a coil of wire is placed around the person to be treated as shown below. The generator can produce a field inside the coil of 100 G = 0.015 T when a current of 1.5 A runs through the coil. The coil has a diameter of 510mm and has a total length of 230 mm.
If the coil is a simple solenoid, what length of wire is used to make the coil?