Workshop Tutorials for Introductory Physics
EI7: **Magnetism**

A. Review of Basic Ideas:

Use the following words to fill in the blanks:
repel, mono-poles, magnetic, electric, two, decreases, positive, attract, currents, electricity, force, velocity, tesla, direction

Magnets and magnetism

In the same way that electrically charged objects produce an _____field, magnets produce a _____ field. The force between two magnetic poles is similar to the force between electrically charged particles, the force _____ with the square of the distance between them, and like poles _____ while opposite poles _____. However there is a difference - we can isolate negative charge, for example an electron, away from positive charges, but an isolated magnetic pole has never been observed. If you start with a bar magnet and cut it in half you will have _____ magnets, each with a north pole and a south pole. Each time you cut it in half you will still have pieces with a north and a south pole.

There is a relationship between _____ and magnetism, which was discovered by Hans Oersted in 1819. During a lecture demonstration he noticed that a wire carrying an electric current deflected the needle in a nearby compass. Not only are magnetic fields produced by permanent magnets, but they are also produced by moving charges, or _____.

We define an electric field at a point as the electric _____ per unit charge on an appropriate test object at that point. The appropriate object is a small _____ charge. We can define a magnetic field in the same way. The only difficulty is that magnetic _____ (a north pole without a south pole, or a south pole without a north pole) don't exist. So what we use as our test object is a current, in particular a moving positive test charge. Experiments have shown that the force on a moving charged particle in a magnetic field depends on the size of the charge and also on the _____ of the charge. Note that we use velocity and not speed, as _____ is important. If the particle is moving parallel to the field it experiences no force, and it experiences the biggest force when it moves at right angles to the field. We can write this as $\mathbf{F} = q\mathbf{v}\mathbf{B}\sin\theta$, where $\mathbf{F}$ is the force on the particle with charge, q, moving with velocity $\mathbf{v}$ through a magnetic field of strength $\mathbf{B}$, and θ is the angle between the vectors $\mathbf{v}$ and $\mathbf{B}$. This is the equation that defines magnetic field strength. The SI unit for i is the _____, T, which is equivalent to $N.A^{-1}.m^{-1}$.

B. Activity Questions:

1. Magnets and magnetic fields
Use the iron filings to investigate the field lines of the magnets.
How do these compare with the field lines of the Earth?
Many animals such as pigeons and some fish 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
What happens when you turn the current on?
What happens when you change the direction of the current?
Draw a diagram showing the field produced by the current.

3. Torque on a current carrying coil in a magnetic field

Draw the magnetic force at the points marked by dots on the diagrams below.
If held stationary prior to release, in which of the above cases is the loop more likely to start turning on its own.
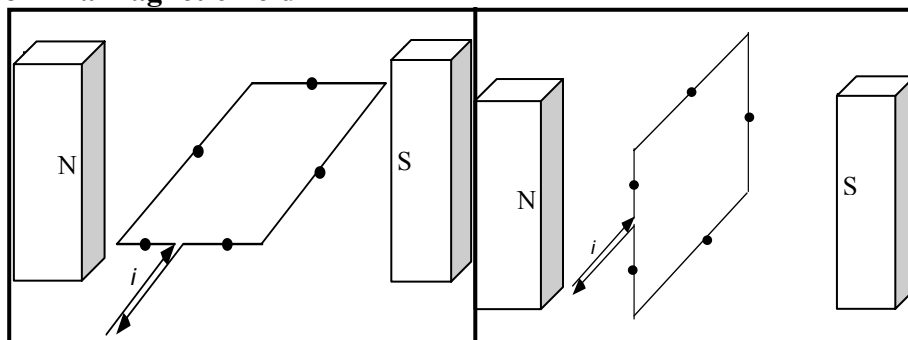
C. Qualitative Questions:

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.
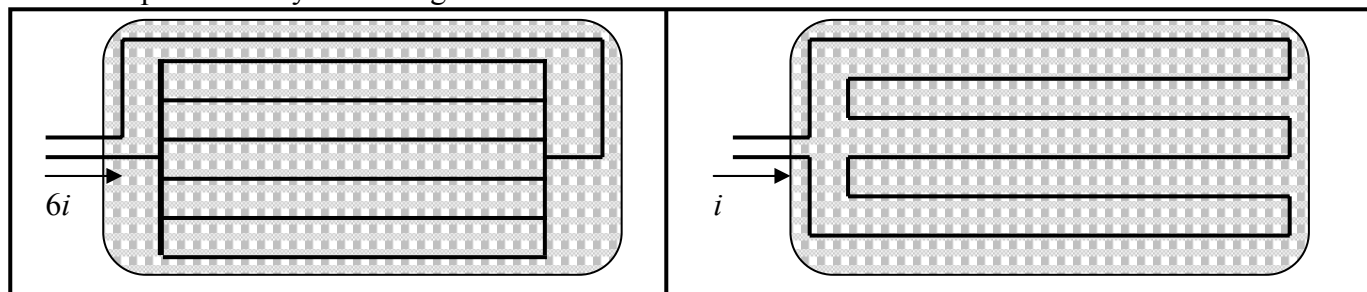**a.** Sketch the magnetic field lines for the Earth's magnetic field.
b. Sketch the path of a charged particle which has become trapped in the Earth's magnetic field.
c. Would the aurora australis (southern lights) or the aurora borealis (northern lights) be possible if the earth had no magnetic field? 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 lower magnetic field above the wires in the blanket?

D. Quantitative Question:

An electron is accelerated by a potential difference of 20 kV in the evacuated tube of a television set.
a. How much kinetic energy has the electron gained in the tube?
b. What is the speed of the electron?
It then passes through a uniform magnetic field of 300 mT.
c. If the electron is travelling from left to right in the tube, and the field is directed down, which way will the electron be deflected?
d. What is the magnetic force experienced by the electron?

$m_{electron} = 9.11 \times 10^{-31}$ kg