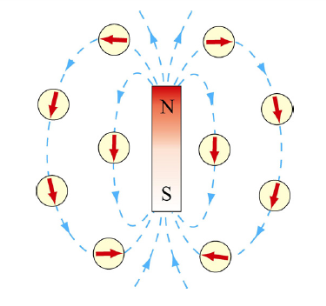
**Teaching the Concept of Magnetic Fields: A Summary**

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**Background Information: Magnetic Fields**

By the time this unit of Magnetic Fields is introduced, students have already learnt about Electric Fields. In a similar way to how Electric Fields  are produced by charged objects at all points in space, Magnetic Fields are produced by magnets. A magnetic field is defined as a change in energy within a volume of space that is produced by electric charges in motion. Electrons, a point charge, also produce magnetic fields that are dependent on the acceleration, velocity, and charge of the individual particles. The presence of a magnetic field at a point surrounding a magnet is represented by a vector field with a magnitude (specifying its strength) and a direction. To quickly demonstrate the presence of a field around a bar magnet, move a compass around all sides of a bar magnet.

The direction of the magnetic field at the point will dictate the direction of the compass needle. A bar magnet has two poles, labelled N and S. Like poles will repeal and unlike poles will attract. The strength of a magnetic field is highest at the poles and the field lines are always in the direction from North to South Pole. A Lorentz Force is exerted on an electrically charged particle in motion within a magnetic field at any given point. The magnitude of the Lorentz force is dependent the electric charge, q, and the velocity of the particle, v, within the magnetic field.

Current-carrying wires also experience magnetic fields as electric current is defined a collection of charged particles, each with its own magnetic field. This unit will address current inducing magnetic fields and its associated properties along straight conductors, current loops, solenoids (coil of wire in helical formation).

Magnetic fields are represented visually by magnetic field lines and are effective at qualitatively assessing the strength of the field at a given point. Field lines can be mapped by measuring the strength and direction at multiple locations around a magnet. By connecting these points, the lines of a magnetic field are created. Some properties of magnetic lines of force include: each have the same strength, an increase in distance from the poles of a magnet result in a lower density, they seek the path of least resistance, and they never intersect.

**Advanced Preparation / Teaching Ideas**

Before learning about magnetic field students need to be familiar with other concepts related to magnetism including: what is magnet, force attraction between magnets(rules), which attracted to magnet and so on. To prepare to teach about this new concept, teachers should begin with a Minds On Activity that actively and mentally engages students at the start of class. Educators can arrange to show an educational video on magnetic field from YouTube: Magnetic field(see below for website). This video will provide an explanation of the overall phases of the concept magnetic field. Teachers will need Internet access and a projector or Smart Board to show the video clip.

Once the video clip is shown, the teacher would engage students in an inquiry activity. Educators should set up bar magnet, compass and construction paper prior to the laboratory session. Also, students need to be familiar with safety procedures in the laboratory including: location of safety equipment, what to do in an emergency, and proper handling of laboratory equipment as well as proper laboratory apparel. Students should work in pairs for tracing out the magnetic field lines , will submit their own scientific drawings complete with labeled diagram/observation with different poles facing together. Educators can assist the students on each stage of the experiment by asking guiding questions such as “how does magnetic field of N-S, differ from N-N?”, “list two differences between them, and so on.

After the actual lab session is completed, the teacher can assist the students in a virtual laboratory. Prior to the lesson, teachers should post the desired website on the board as well as login access for the virtual lab in order to reduce student questions and confusion in the computer lab. The inquiry-based learning approach is best employed for this because it allows students to work independently while exploring the virtual laboratory. The purpose of this laboratory is to give students a virtual representation creation of magnetic field around current carrying wire ,earth magnetic field, right hand rule.The will measure the direction and strength of a magnetic field induced by a current in a wire, describe how Earth's magnetic field affects the strength of an induced field, describe how distance affects the strength of a magnetic field, explain how current affects the strength of a magnetic field, derive an equation for the strength of the magnetic field based on the current and distance.

It is easier for a student to understand the concept and derivation of formula through PowerPoint presentation. For that, teacher can use smart board or projector. If the educator ask some question in between it will more effective.

The next is a video lesson embedded with game to solve problem. It includes original video, animation demonstrating all the concept of electromagnetism. The game increase the enthusiasm of students learns thoroughly the topic electromagnetism.

Finally, there are several articles available to students and teachers regarding electromagnetic radiation, application of the concept in technology and space research (see below for link). A teacher led reading on the ethical issues, and support and opposition for this topic can be used as an assessment opportunity through which student’s debate about electromagnetic radiations. It is important to consider that not all students feel comfortable speaking, therefore, teachers should assign a reflection on the topic as a follow up activity.

**Curriculum Expectations**

**Overall Expectations**

**D1.** analyse the operation of technologies that use gravitational, electric, or magnetic fields, and assess

the technologies’ social and environmental impact;

**D2.** investigate, in qualitative and quantitative terms, gravitational, electric, and magnetic fields, and

solve related problems;

**D3.** demonstrate an understanding of the concepts, properties, principles, and laws related to

gravitational, electric, and magnetic fields and their interactions with matter.

**Specific Expectations**

**D1.2** assess the impact of an electromagnetic technology that is used for the benefit of society or the environment (e.g., devices for diagnosing and treating diseases, technologies for treating seeds to increase the rate of germination) [AI, C]

**D2.1** use appropriate terminology related to electricity and magnetism, including, but not limited to: *direct current, alternating current, electrical potential difference, resistance, power, energy, permanent magnet, electromagnet, magnetic field, motor principle,* and *electric motor.* [C]

**D2.4** conduct an inquiry to determine the magnetic fields produced by a permanent magnet, a straight current-carrying conductor, and a solenoid, and illustrate their findings [PR, AI, C]

**D2.5** conduct an inquiry to determine the direction of the magnetic field of a straight current-carrying conductor or solenoid [PR, AI]

**D2.6** conduct an inquiry to determine the direction of the forces on a straight current-carrying conductor that is placed in a uniform magnetic field [PR, AI]

**D3.4** describe, with the aid of an illustration, the magnetic field produced by permanent magnets (bar and U-shaped) and electromagnets (straight conductor and solenoid)

**D3.7** state Oersted’s principle, and apply the right-hand rule to explain the direction of the magnetic field produced when electric current flows through a long, straight conductor and through a solenoid

**Lesson Sequence**

**Lesson 1: Introduction to Magnetic Fields**

* *Magnetic Force Fields*
  + *Earth’s Magnetic Field*
* *Domain Theory of Magnetism*
* *Principle of Electromagnetism*

**Lesson 2: Magnetic Fields II**

* *Magnetic Field of a Straight Conductor*
* *Magnetic Field of a Current Loop*
* *Magnetic Field of a Solenoid*

**Lesson 3: Magnetic Forces on Moving Charges**

* *Measuring Magnetic Fields*
* *Right Hand Rule for the Direction of Magnetic Force*
* *Charge-to-Mass Ratios*

**Lesson 3: Magnetic Force on a Current Carrying Conductor**

* *Right Hand Rule For The Motor Principle*
* *Application: Maglev Trains*

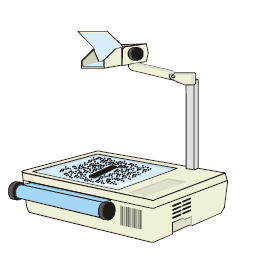
**Lesson 4: Ampere’s Law**

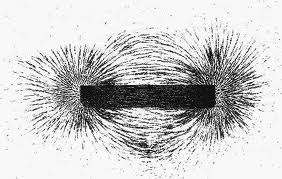
* *The Ampere as a Unit of Electrical Current*
* *Application: Coaxial Cables*

**Lesson 5: Electromagnetic Induction**

* *Lenz’ Law*

**Potential Student Difficulties / Possible Solutions**

Some students may have initial difficulty in visualizing the lines of a magnetic field. To assist in the visualization of a magnetic field, we can use magnets and iron filings to map a magnetic field. This visualization will assist students in understanding and reinforcing the concept of field lines which were introduced in the unit of electric fields. It is vital to carry out this demonstration during one of the first lessons. This demonstration can easily be carried out by placing a magnet underneath a sheet of Acrylic and drop some iron filings around all the edges of the magnet. To project the image at a large scale, the teacher should use an overhead projector. A streaming video of the experiment is also an effective method.

An effective exercise to further assist in the visualization of magnetic fields for the students is by having the students mapping a magnetic field in a laboratory. The task would be to map the magnetic field at intervals of one-center along all sides of a bar magnet. This exercise will first allow students to hypothesize the relationship between the strength of the magnetic field and the distance from a magnetic field. By finding this information, students will discover the changes a magnetic field undergoes from pole to pole and the shape of the field.

Another difficulty students may encounter is confusion between the direction of a force on a charged particle within electric fields or magnetic fields, as they are usually covered within the same unit. This situation documented in the journal *Physical Review Special Topics – Physics Education* in an article entitled “Interference between electric and magnetic fields concepts in introductory physics” To recall, a positive charge moving through an electric force experiences a force in the same direction as the field. A negative charge experiences a force in the opposite direction as the field. However, the forces on charged particles travelling through magnetic fields experience forces perpendicular to the field lines. The theory behind the confusion with magnetic fields is that students learn electric fields first and apply those principles to the magnetic field section. To distinguish properties of electric fields to magnetic fields, it is critical that the teacher consistently re-emphasizes the distinctions between the two throughout the unit. Another strategy is frequently using visual representations for each type of field. If the students have grasped the concept of forces on electric fields, it may also be helpful for them to remember the directions of forces in a magnetic field via the right hand rule.

**Differentiated Assessment**

Students would have a choice for their culminating task assessment on the concept of magnetic field. The following tasks are targeted to students’ multiple intelligences:

○ A Cartoon as shown in the introduction of magnetic field ,They can convey any idea about magnetic field(Visual)

○ A song about the earth’s magnetic field, examples are in YouTube(Musical) ○ A model showing the magnetic lines using iron fillings(Kinesthetic)

○ A audiotaped conversation about any concept included in the magnetic field(Linguistic group work)

○ A hand written magazine about the concept of magnetic field(Intrapersonal, Group activity)

○ Design an experiment to investigate the magnetic field around two long parallel conductors with equal currents in opposite directions. Assume the wires are very close together and the measurements are taken from at least 5.0 cm away. (Logical)

○ A debate can be conducted about after effect of electromagnetic radiation

○ Students’ understanding of the concepts of magnetic field would also be evaluated on a unit test

○ Formative assessment would be completed based students contribution in assessment tool in Gismo lesson plan and participation in the online lab. In addition to these, the achievement chart will also be used to assess students’ oral and written communication for the debate.

**Applications and Social Issues / Implications**

Students will be introduced to the technologies of Particle Accelerators and Antennas that incorporate electromagnetics. Particle accelerators are devices that accelerate charged particles to high speeds within beams through the use of electromagnetic fields. Antennas are devices which incorporate electromagnetic waves in the conversion from electrical current to radio waves. A radio signal is a form of electromagnetic wave that carries signals at the speed of light through the air.

The unit will also briefly cover the topic of the presence of electromagnetic fields (EMF) and the relationship to our health. Electromagnetic fields can be produced by cellular phones, computers, appliances, transformers, power lines, home wiring, etc. The main concern with regard to electromagnetic fields is the radiation produced. There have been links between the radiation and increased levels of leukemia and certain cancers. However, the safety of being in the vicinity of electromagnetic fields for long periods of time is still up for public debate and studies have often been contradictory.

**Safety Considerations**

* Considering the nature of adolescents, they should be well monitored while they are in the virtual lab activity in order to make sure that they are doing the job as intended
* Unsafe websites should be blocked either by appropriate settings on browser or through school’s server
* Students demonstrate that they have the knowledge, skills, and habits of mind required for safe participation in science activities and laboratories when they (Ontario Science Curriculum, 2008):

• maintain a well-organized and uncluttered work space;

• follow established safety procedures;

• identify possible safety concerns;

• suggest and implement appropriate safety procedures;

• carefully follow the instructions and example of the teacher;

; • consistently show care and concern for their own safety and that of others

**Annotated Bibliography**

Hirsch, Alan J. (2003), Nelson Physics 12. Nelson Canada, Toronto. Print.

Guisasola, J., Almudí, J. M. and Zubimendi, J. L. (2004), Difficulties in learning the introductory magnetic field theory in the first years of university. Sci. Ed., 88: 443–464. doi: 10.1002/sce.10119

[URL: http://onlinelibrary.wiley.com/doi/10.1002/sce.10119/pdf]. Accessed: July 7, 2012.

Volz, D., & Sapatka, S. (2000). Middle School Science with Calculators. Beaverton, OR: Vernier Software & Technology [URL:http://21ctl.fi.ncsu.edu/msms/magnetic\_lab.html#magnetic\_field]. Accessed: July 7, 2012.

<http://www.youtube.com/watch?v=zbTrHWW3xvU> ,vedio demonstration on concept of magnetic field

<http://www.explorelearning.com/index.cfm?method=cResource.dspView&ResourceID=611> ,

Gismos lesson plan

<http://ia700204.us.archive.org/12/items/AP_Physics_B_Lesson_41/Container.html>

Electromagnetic induction ,video and game

Ontario curriculum guide

<http://www.skepdic.com/emf.html> , online journal discussing electromagnetic field, electromagnetic radiation, cancer due to electromagnetic radiation.