MIND TREKKERS
Copper Block Lesson Plan

Amount of time needed:
Set up takes: 35 min.
Demo takes: 1-3 min

Materials:
1. Liquid nitrogen (LN\textsubscript{2})
2. Copper block with flexible metal strip
3. 2” cylinder magnet
4. LN\textsubscript{2} Styrofoam bath container

Set up instructions:
1. This demonstration involves the use of LN\textsubscript{2}. Please refer to the LN\textsubscript{2} Safety Instructions for proper handling.
2. Put the copper block in the styrofoam container, making sure to place the flexible metal strip underneath it so it will help you get the block out.
   Note: this is done before LN\textsubscript{2} is added, but if there’s excess left over from the last cooling cycle, it is still permissible with caution not to spill/splash the LN\textsubscript{2}.
3. Once the block is situated in the container, slowly pour LN\textsubscript{2} over the block and fill the container. Cover the container. After about 5 minutes, open the lid and refill the container and replace the lid. The entire cooling process, with the block starting from room temperature, should take no more than about 20-30 minutes, however while it is still cooling, the LN\textsubscript{2} will be boiling profusely. This is a key way to figure out if the block is still being cooled.
4. Once the boiling becomes less intense and it appears as though the copper block is merely sitting in the container of calm liquid, Use a pliers to grab the metallic strip underneath the block and pull it up to elevate the block in the container. Once the block is far enough out of the LN\textsubscript{2} to grab, do so with gloves! Place the block on top of the styrofoam lid and move the LN\textsubscript{2} bath somewhere behind-the-scenes where it will not be disturbed.

SAFETY!
1. Follow all safety precautions for liquid nitrogen safety, attached to the lesson plan.
2. Once the block is properly cooled, it will be extremely cold to the touch. Prolonged exposure of the block to skin at this temperature will cause the oils on the skin (or the skin itself) to freeze to the block. This frostbite is painful and should be avoided.
3. The magnet used in this experiment is extremely strong and should never be allowed in direct contact with a ferromagnetic material and especially not another magnet.
4. Do not leave the magnet on the cooled copper block. It will cause the protective coating on the magnet to peel off. It will also cause the magnet to become too cold to handle comfortably.

Lesson’s Big Idea bullet points
Lenz’s law and induced magnetic fields play key roles in this demonstration. When the magnetic field changes (using the 2” magnet) in the localized area of a conductor (the copper block) induces an electric current in that conductor.

The direction of this current is governed by Lenz’s Law: “An induced current is always in such a direction as to oppose the motion or change causing it.” This means that the induced electric current from the localized change in magnetic field will always oppose that change by creating its own magnetic field. This induced magnetic field will hinder all motion of the large magnet as it moves in the area of the copper block.

**Instructional Procedure**

1. Once the copper block is cooled and setup, use the neodymium magnet to show that the magnet does not move freely when in the near vicinity of the copper block. Suggested actions to try: dropping the magnet from about 10-15 cm above the block, holding the magnet about 1 cm off of the surface and trying to move it laterally across the block, and setting the magnet on its rolling edge and giving it a “kick” to try to roll it.

2. After the onlookers have seen you do it, let them try similar activities with the magnet. Instruct them to attempt to move the magnet in the vicinity of the copper block and feel the opposing magnetic force.

3. Key concepts: Lenz’s Law, electromagnetic induction, opposing magnetic forces, magnetic fields.

**Assessment**

Q: “What would happen if we moved a non-magnet in the area of the block?”
A: “Nothing. The non-magnet produces no change in the magnetic field in the area of the block, hence there is no induced current and no induced magnetic field.”

Q: “Would the effect be different for a smaller/weaker magnet?”
A: “Yes. The weaker magnet would not change the field in the area of the conductor as much as the big magnet did.”

Q: “Does the effect work the same if the block is un-cooled?”
A: “No. When the block is super-cooled, the resistivity of the block is far less than it is at room temperature, hence the induced current may flow more freely to create a stronger induced magnetic field to oppose the motion of the magnet.

**References**

Lenz’s Law, Ferromagnetism, Electromagnetic Induction

**National Standards**

K-4 Content Standard B: Physical Science, Light, heat, electricity and magnetism
5-8 Content Standard B: Physical Science, Transfer of energy, Motions and forces
9-12 Content Standard B: Physical Science, Motions and forces, Interactions of energy and matter