



- Magnets have areas that attract more strongly than other areas.
- These areas are called the poles of a magnet.
- A magnetic pole is the part of a magnet that exerts the strongest force on other magnets or magnetic material, such as iron.



- If a bar magnet is suspended so that it rotates freely, one pole of the magnet will always turn toward the north, with the opposite pole facing south.
- The pole of the magnet that orients northward is called the north pole, and the opposite pole of the magnet is called the south pole.











- The magnetic poles are not in the same location as the geographic poles
- **Magnetic declination** is the angle between true north and magnetic north
- The angle depends on where you are:
 - Victoria, BC (15.66° East)
 - St. John's, NF (17.59° West)
 - Winnipeg, MB (2.72° East)
- This angle changes due to changes in Earth's magnetic field
 - Current change in Winnipeg is 0.085°/y West

• **Magnetic inclination** or magnetic dip is the angle between the horizontal plane and the magnetic field vector.



- This value depends on your location since the Earth and the magnetic field is curved.
 - At the equator, 0°
 - At the poles, 90°
 - Winnipeg, 74.5°
- What happens if you cut a bar magnet in half?
- Each half of the bar magnet has a north pole and a south pole.
- Even the smallest particles that behave as magnets have two opposite poles.
 - No experiment has ever found any object with a single magnetic pole.
- Because magnets always have two poles, they are referred to as magnetic dipoles.



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- Only certain materials, such as iron, cobalt, nickel, and gadolinium, exhibit strong magnetic effects.
- Such materials are called **ferromagnetic**.
- Ferromagnetic materials can also be magnetized (turned into a permanent magnet).
- When a magnet is brought near a previously unmagnetized ferromagnetic material, it causes local magnetization of the material.

- On a microscopic scale, regions within the material called **domains** act like small bar magnets.
- Within domains, the magnetic poles of individual atoms are aligned.
- Each atom acts like a tiny bar magnet.
- Domains are small and randomly oriented in an unmagnetized ferromagnetic object.



• In response to an external magnetic field, the domains may grow to millimeter size, aligning themselves.



- This induced magnetization can be made permanent if the material is heated and then cooled, or simply tapped in the presence of other magnets.
- A permanent magnet can be demagnetized by hard blows or by heating it in the absence of another magnet.
- Increased thermal motion at higher temperature can disrupt and randomize the orientation and size of the domains.
- There is a well-defined temperature for ferromagnetic materials, which is called the Curie temperature, above which they cannot be magnetized.
 - Iron (770°C)



- A magnet creates a magnetic field around it that describes the force exerted on other magnets placed in the field.
- The direction of magnetic field lines is defined to be the direction in which the north pole of a compass needle points.
- The magnetic field lines point away from the north pole of a magnet and toward its south pole.

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- Magnetic field is measured in teslas, T.
 - Earth: 25 to 65 µT
 - Typical refrigerator magnet: 5 mT
 - Sun: 0.3 T
 - Neodymium–iron–boron (Nd₂Fe₁₄B) rare earth magnet: 1.25T
 - MRI: 9.4T
 - Magnetic field required to levitate a frog: 16T
 <u>https://www.newscientist.com/article/mg15420771-600-frog-defies-gravity/</u>

Auroras

• Auroras are created by high-energy particles from the solar wind trapped in the Earth's magnetic field.

