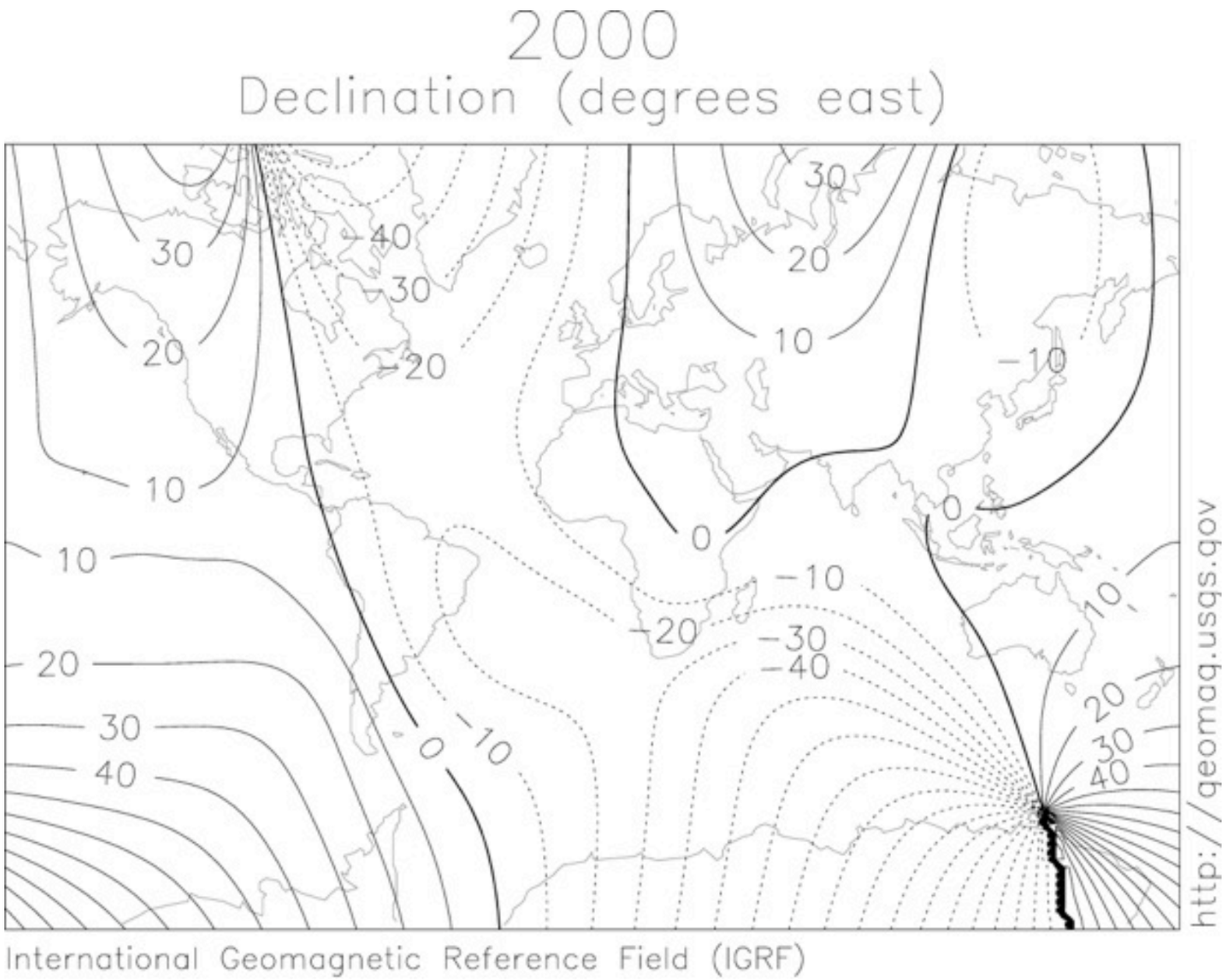
Magnetism

Magnetism

- Magnetism is a property of some metals: primarily **iron**, **nickel** and **cobalt**. It depends on the electron structure and chemistry of materials.
- **Lodestones** were first discovered ~ 5000 years ago. This is the mineral later known as **magnetite** (Fe_3O_4).
- All magnets have two poles (**north** and **south** by convention).
- The **north pole** of a magnet is the end that **will point north**.
- The north pole of the Earth is a south magnetic pole!
- On average, the Earth's field reverses every 200,000 years. The last reversal was around 780,000 years ago - it is long overdue!

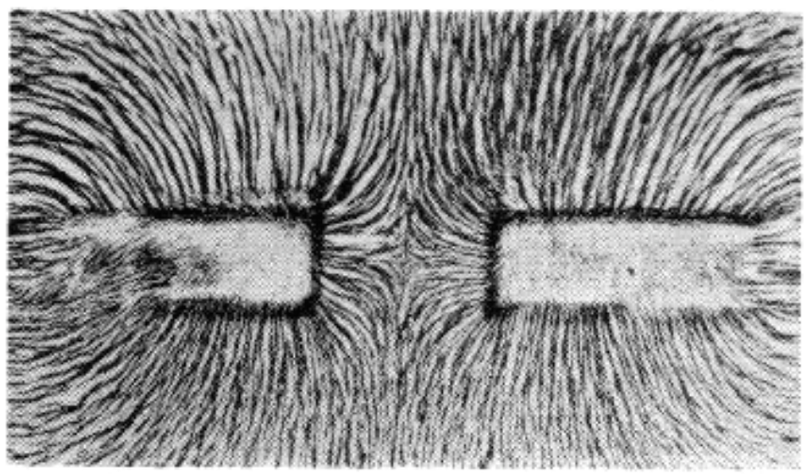
Earth's magnetic field

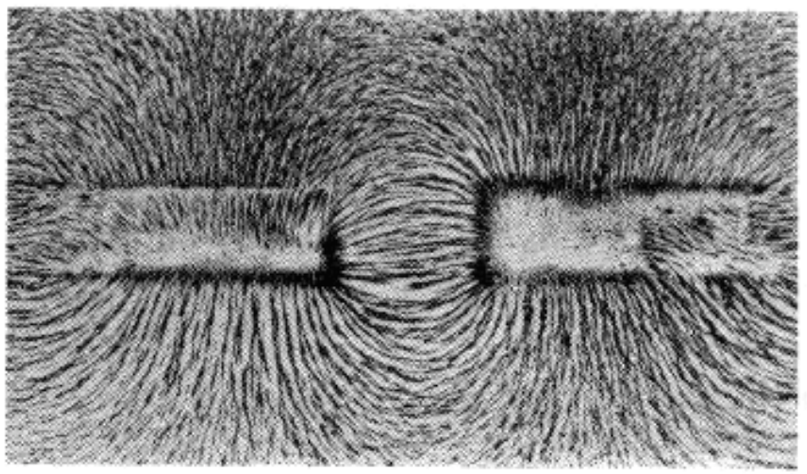
- The Earth's magnetic field is not uniform.
- Declination measures how far from true north the local field deviates.



Magnetic fields

- A magnetic field exists between the two poles.
- Similar poles produce a repulsive force, **opposite poles attract**.
- Magnetic fields are vector quantities - they can add or subtract depending on the directions.
- The direction of the field is shown by the arrows (**north → south** outside magnet).
- The strength of the field is shown by the closeness of the field lines.

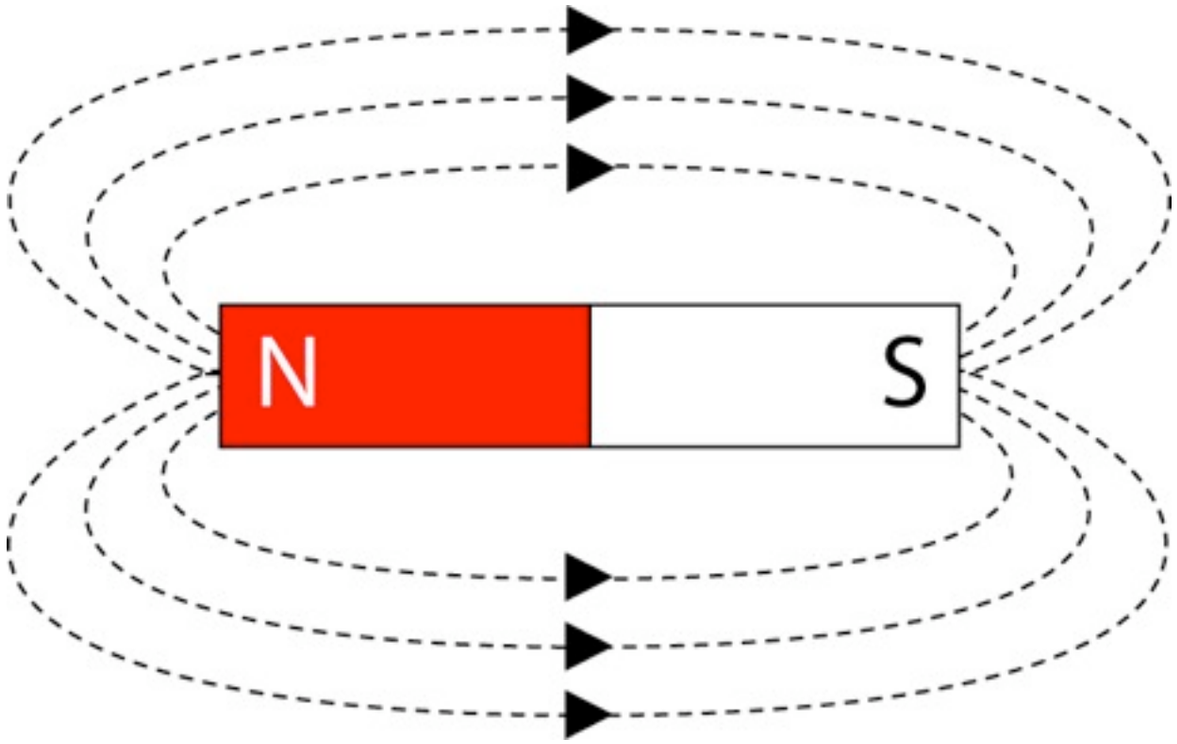




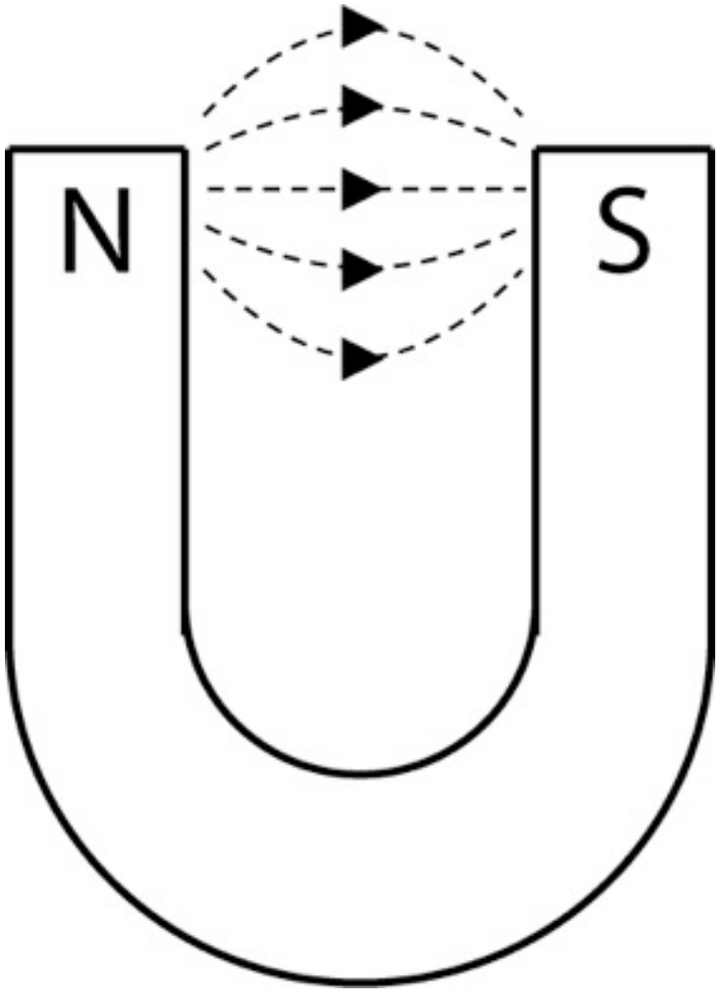
Field around magnet

Drawing the magnetic fields

- Field lines are closest at poles.
- Field lines are continuous & do not cross.
- Vectors point from north to south outside the magnet.



Bar magnet



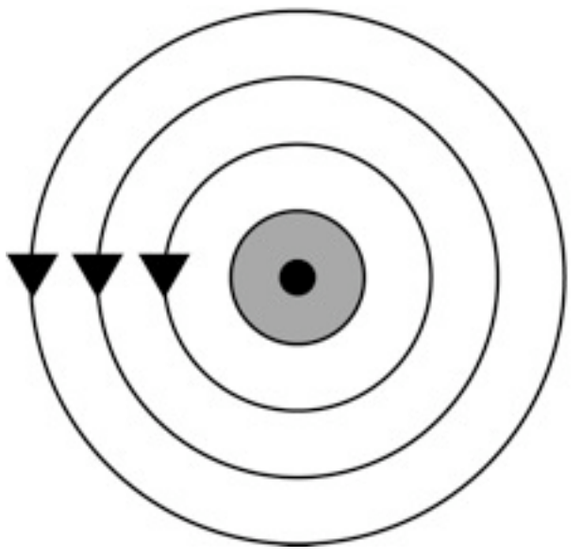
Horseshoe magnet

Strength of magnetic fields

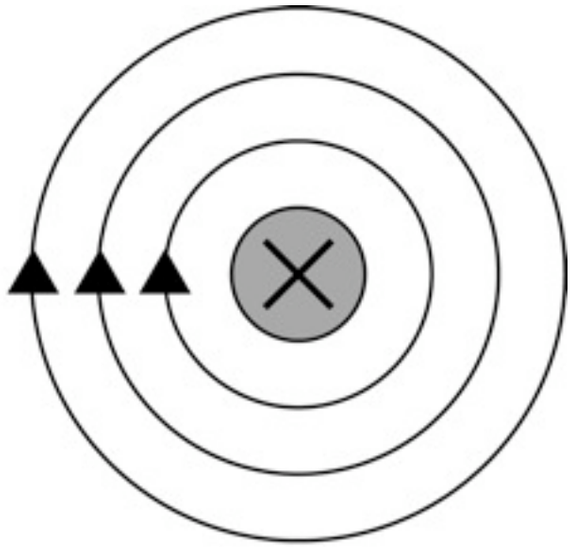
- Unit of measurement of **magnetic field** (magnetic flux density) is the **Tesla** (T), symbol in equations is B.
- Earth's field is ~5 x 10^{-5} T.
- Earth's field strength varies with location - generally higher at the poles.
- 1Tesla = 10,000 Gauss (Based on Earth's field).
- Common magnets are ~10^{-3} → 1T. Strongest magnets ~10 T.

Magnetic fields around wires

- Magnetism ⇔ electricity (Oersted, Faraday)
- A magnetic field is produced around a wire carrying current.



Current out of page:
anti-clockwise field

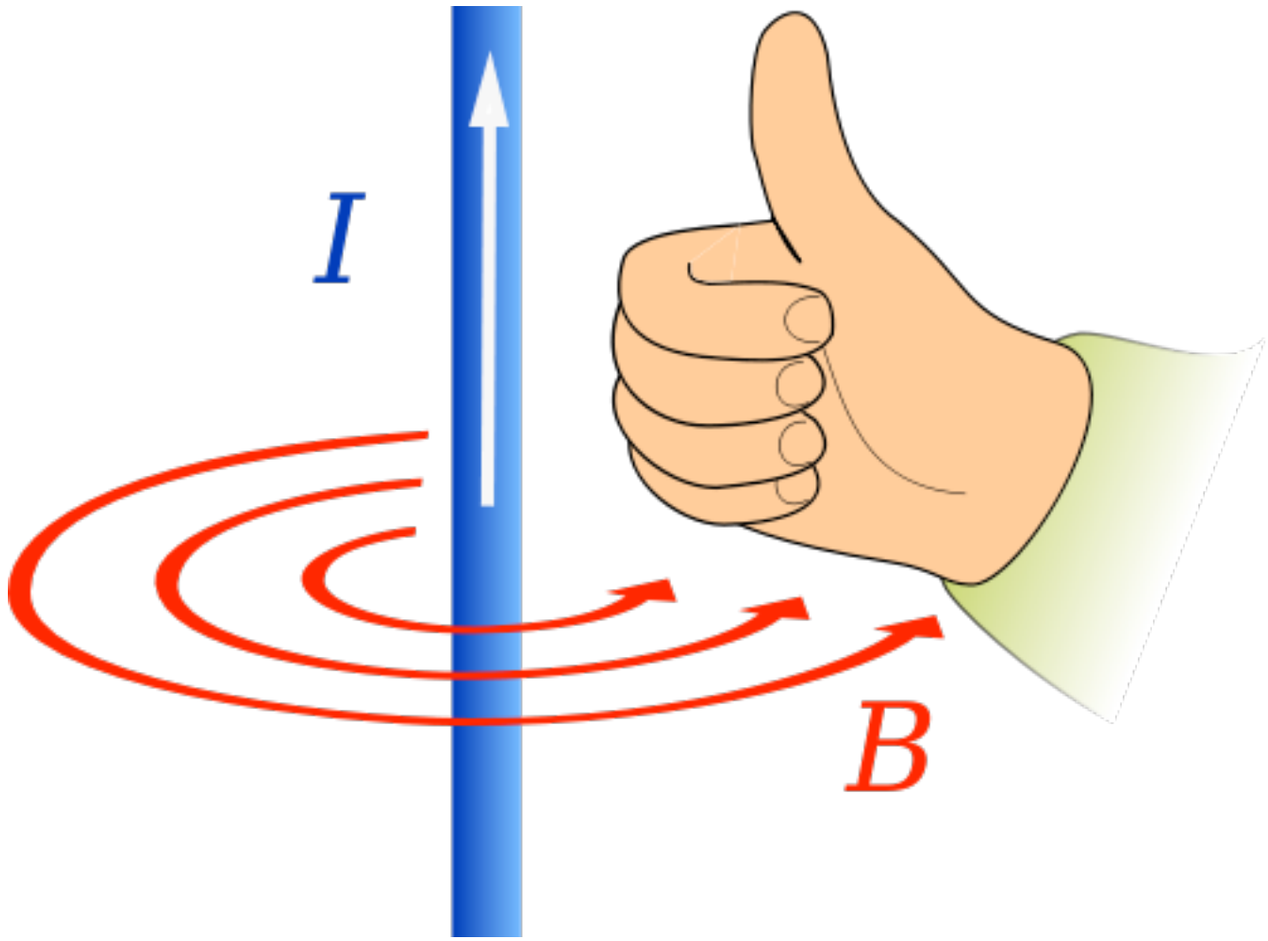


Current into page:
clockwise field

Field around a wire

The right-hand grip rule

- Right hand grip rule: thumb indicates current direction of conventional current (positive to negative)
- Curled fingers indicate the direction of the field.



The solenoid

- The circular magnetic fields around each turn are concentrated & combine to make a north & south pole.
- Use a modified right-hand grip rule for solenoids.
- This time the fingers indicate current & the thumb indicates magnetic field.