According to the way the field is generated; there are three types of magnet, with advantages and disadvantages as shown in table1;

1. Permanent magnet.
2. Resistive electromagnet.
3. Superconducting electromagnet.

Magnet type	Properties	Advantages	Disadvantages
Permanent	Made of iron alloy blocks (permanently Magnetized	Cheap; zero running costs Open design	Low field (<0.6 T) Weight > 40 tonnes
Electromagnetic	Water-cooled copper coils	Field can be turned off in emergency Open design Mid cost	High power requirements Poor stability
Superconducting	Liquid helium cooled wires	High field Good homogeneity	High capital cost Cost of helium Relatively enclosed bore

Permanent Magnet:

Permanent magnets are made from a material that is magnetized and creates its own persistent magnetic field. The permanent magnet consists of two flat opposing pole pieces (iron, alloys Al, nickel, and cobalt).

*It is expensive, but cheaper in running cost

*It requires no power

*Use low strength, vertical magnetic field up to 0.3 T

*.No claustrophobia issue, suitable for children, aged, and interventional work

*The weight of permanent MRI magnet generally is very high, and depends on the choice of magnetic material

*Example; 0.2 T whole body magnet constructed from iron might weigh 25 tons, while the weight of similar magnet built from a neodymium alloy could be 5 tons.

Permanent magnets have predominantly been designed with a vertical field format, with the field constrained between the top and bottom pole faces; this design requires a flux return path. The magnets are very heavy and cannot be switched off, but have a small stray field. A recent innovation has been a permanent magnet with a horizontal field, allowing patients to be positioned in the upright position, which is of value for examining joints.

ADVANTAGES	DISADVANTAGES
Low power consumption . Low operating cost . Small fringe field . No cryogen	Limited field strength (<0.5T) Very heavy No quench possibility

Resistive Electromagnet:

Resistive electromagnet has set of coils run by direct current with 50–100 kW (Al or copper).

* It produces heat, and require water cooling.

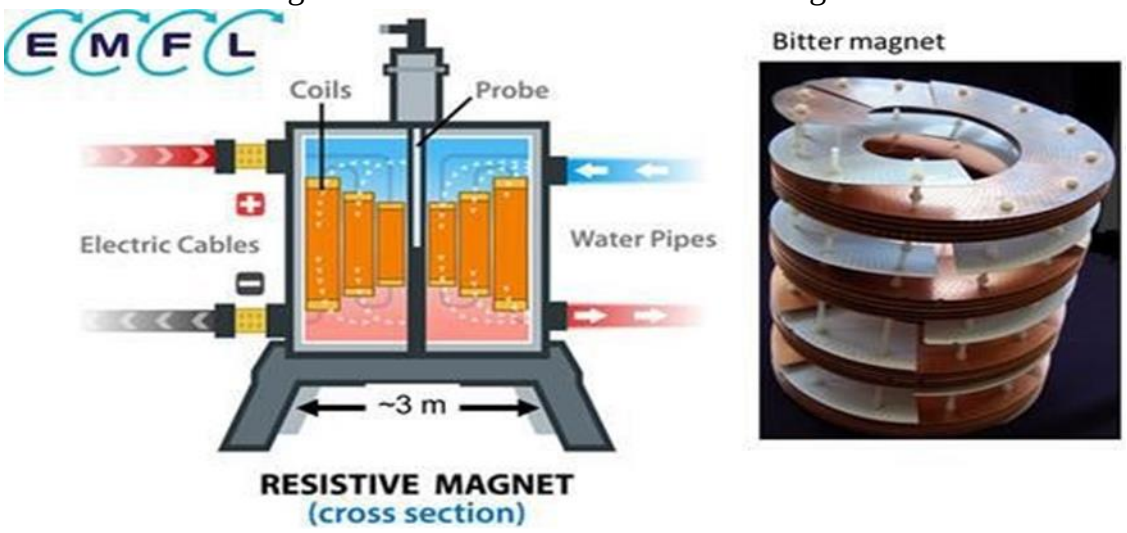
* It can provide both vertical and horizontal magnetic field up to 0.5 T.

* large fringe field.

*It can be switched off during emergency. Cheapest, smaller, and weighs 2 ton.

Electromagnets reduce the electrical current requirement of resistive magnets by incorporating a ferromagnetic core and also by providing greater stability and minimizing cooling requirements.

Figure 1: Cross Section of Resistive Magnet.



ADVANTAGES	DISADVANTAGES
— Low capital cost — Light weight — Can be shut off	— High power consumption — Limited field strength (<0.2T) — Water cooling required — Large fringe field

Superconducting Magnet:

Superconducting magnet is made by a direct current solenoid (niobium-titanium alloy in copper matrix).

- It is basically an air core cylinder of 1 m diameter and 2–3 m depth (Figure2).
- It is cooled by a cryogen, liquid helium at 4 K (–269°C).
- It has negligible resistance, and large current can be used without overheating.
- It provides horizontal fields up to 3.0 T with high field uniformity.

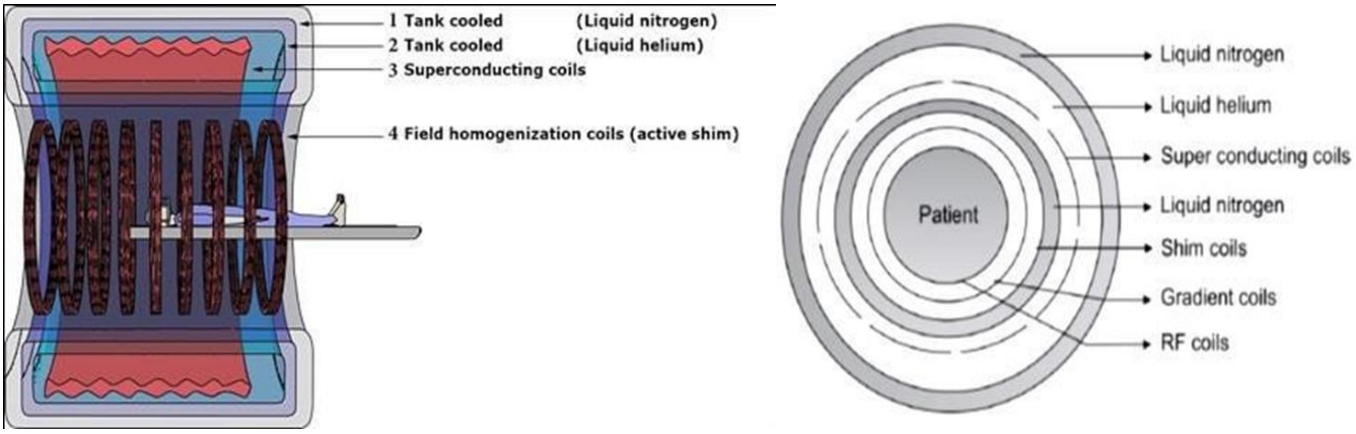


Figure 2: Superconducting Magnet & Cross-sectional view of MR gantry design using superconductive magnet.

- It is large in size & Expensive Claustrophobia to patients.
- Weighs about 6 ton.
- It takes hours to cool and current build up. Current flows, even with no power, but consume cryogen liquid.
- To shut down, the stored electromagnetic energy in the coil has to be removed carefully, to avoid quench. The liquid helium is kept in a cryostat, replenished periodically.

ADVANTAGES	DISADVANTAGES
High field strength High field homogeneity Low power consumption High SNR Fast scanning	High initial capital and sitting cost, and cryogen cost. Difficulty in turning off the field. Extensive fringe field. Uncontrolled quenching due to boiling of helium.