Lectures 3
practical Lecture

gradient coils

Third stage

Dr. Mustafa Karim A. Mohammed

Al-Mustaqbal university college

Gradient coil

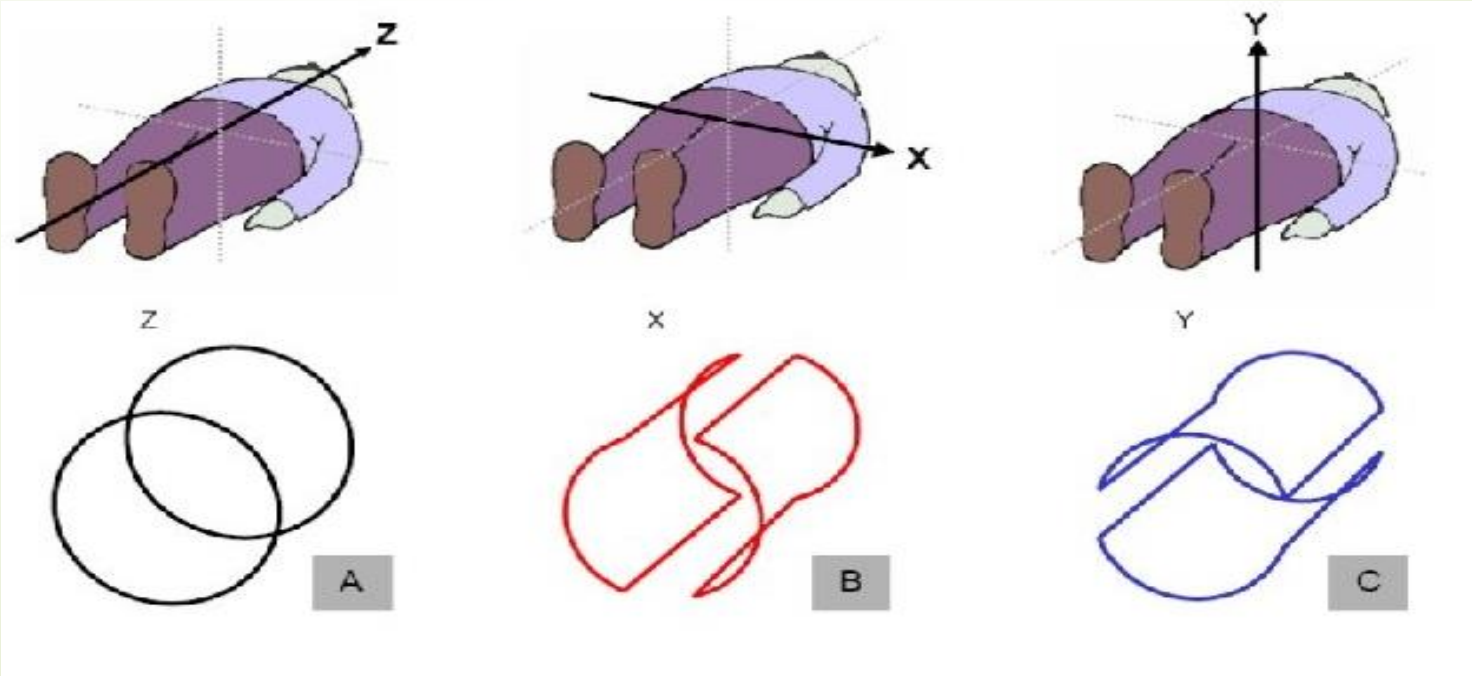
- Gradients coils are loops of wire or thin conductive sheets on a cylindrical shell lying just inside the bore of an MR scanner. When current is passed through these coils a secondary magnetic field is created.
- A gradient coil set is an important component in a standard MRI scanner which produces linear gradient magnetic fields that are superimposed over a strong uniform magnetic field.

Gradient coil

- The superimposed gradient magnetic field slightly changes the proton precession frequency or phase, thus encoding the spatial information of an imaged object in the frequency associated with a position in space.

Spatial encoding

- Three sets of gradients are used along z, y and x axis and they are named as slice selection gradient (SSG), phase encoding gradient (PEG) and frequency encoding gradient (FEG).



1- Slice Selection Gradient

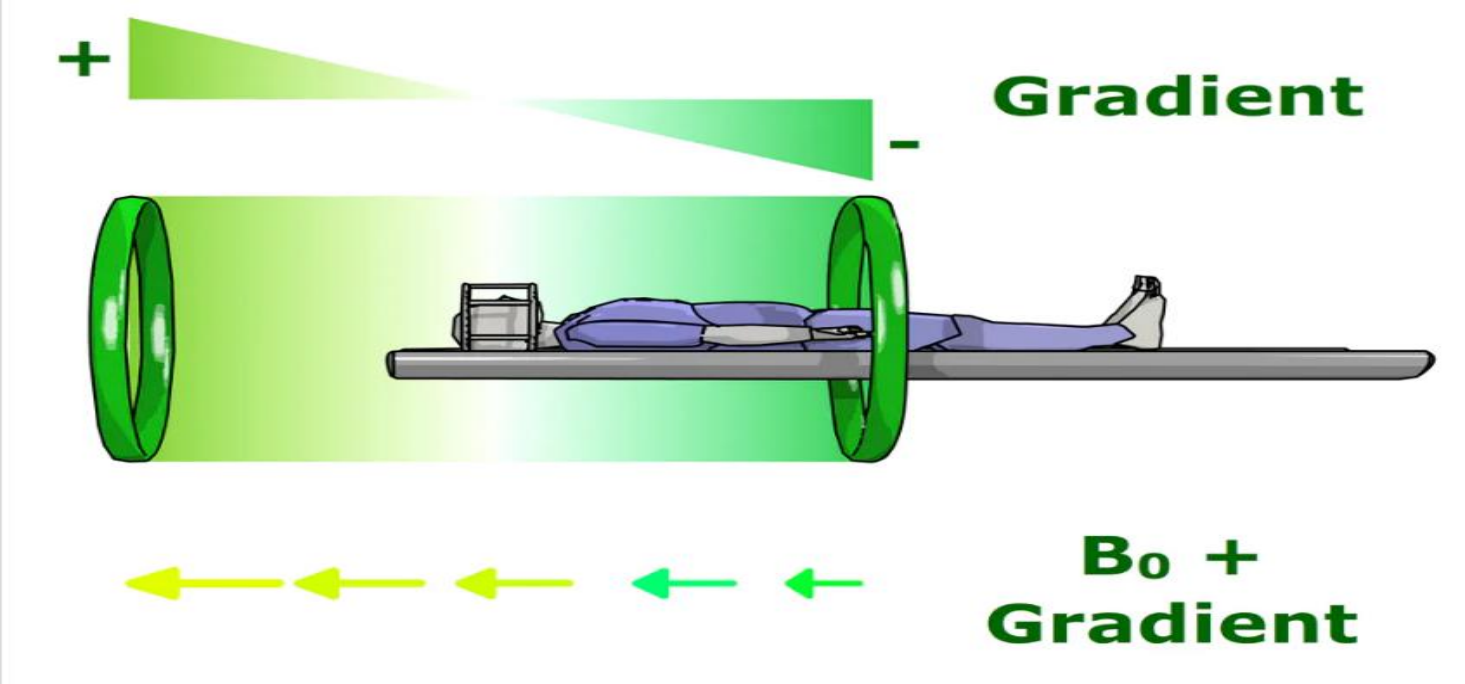
- The first step of spatial encoding consists in selecting the slice plane
- MR image is made up of series of parallel slices, e.g. transverse slices, which are imaged in turn. The pair of Z coil is energized with DC supply. This produces a controlled magnetic field gradienr along z axis (cranial caudal).

1- Slice Selection Gradient

- The total magnetic field increases at the head side and decreases at the feet side, remains the same at the isocenter.
- It varies from head to feet with constant increment of mT per m. Protons at the feet side precess slowly, and are faster at the head side, and have moderate precession at the middle.
- The protons in the selected slice precess with narrow range of frequency.

1- Slice Selection Gradient

- A narrow band RF pulse is applied to the whole volume and only protons in the thinner slice are excited.
- The spins along the gradient that have a processional frequency equal to RF will absorb energy due to resonance.

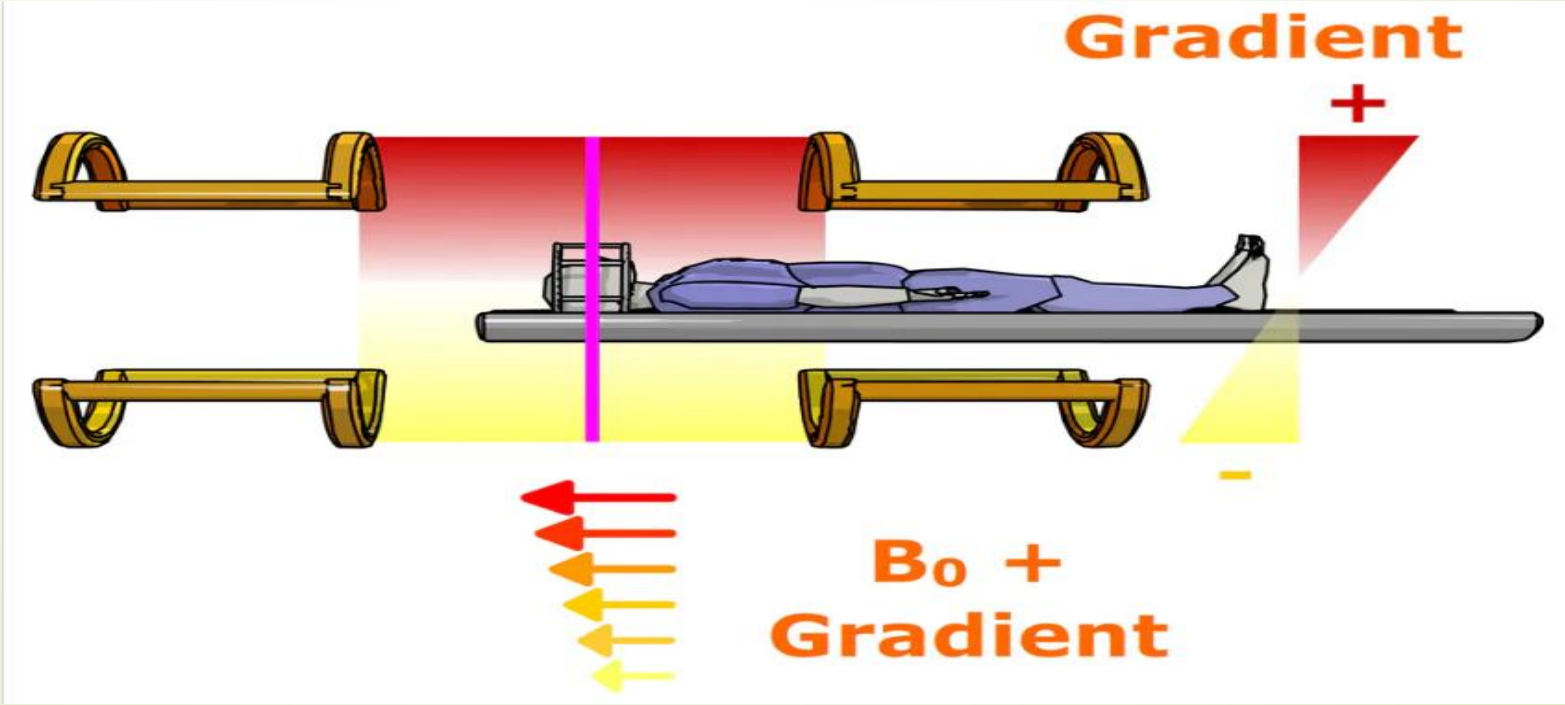


2- Phase Encoding Gradient

- The protons in the slice are excited initially by RF pulse, which are in phase coherence. Now, the Y gradient coil is switched on for few msec by DC voltage.
- It produces magnetic field-gradient, along y direction (front to back). Spins in the upper (front) voxel precess faster, and that are in the bottom (back) precess slowly.

2- Phase Encoding Gradient

- Thus, spins in the bottom voxel lags behind that of upper voxel. Even if the gradient pulse is over, all precess at the same rate, but phase differences exist, depending on the position.



3- Frequency Encoding Gradient

- When the gradient field is applied in X-direction, X-gradient coil is energized, applied in orthogonal direction (patient side-side).
- Spins in the left side precess slowly, and that in right precess faster, resulting in a frequency gradient from left to right. The MR signal from a given slice consists of range of RF frequencies, on either side of the applied pulse.

3- Frequency Encoding Gradient

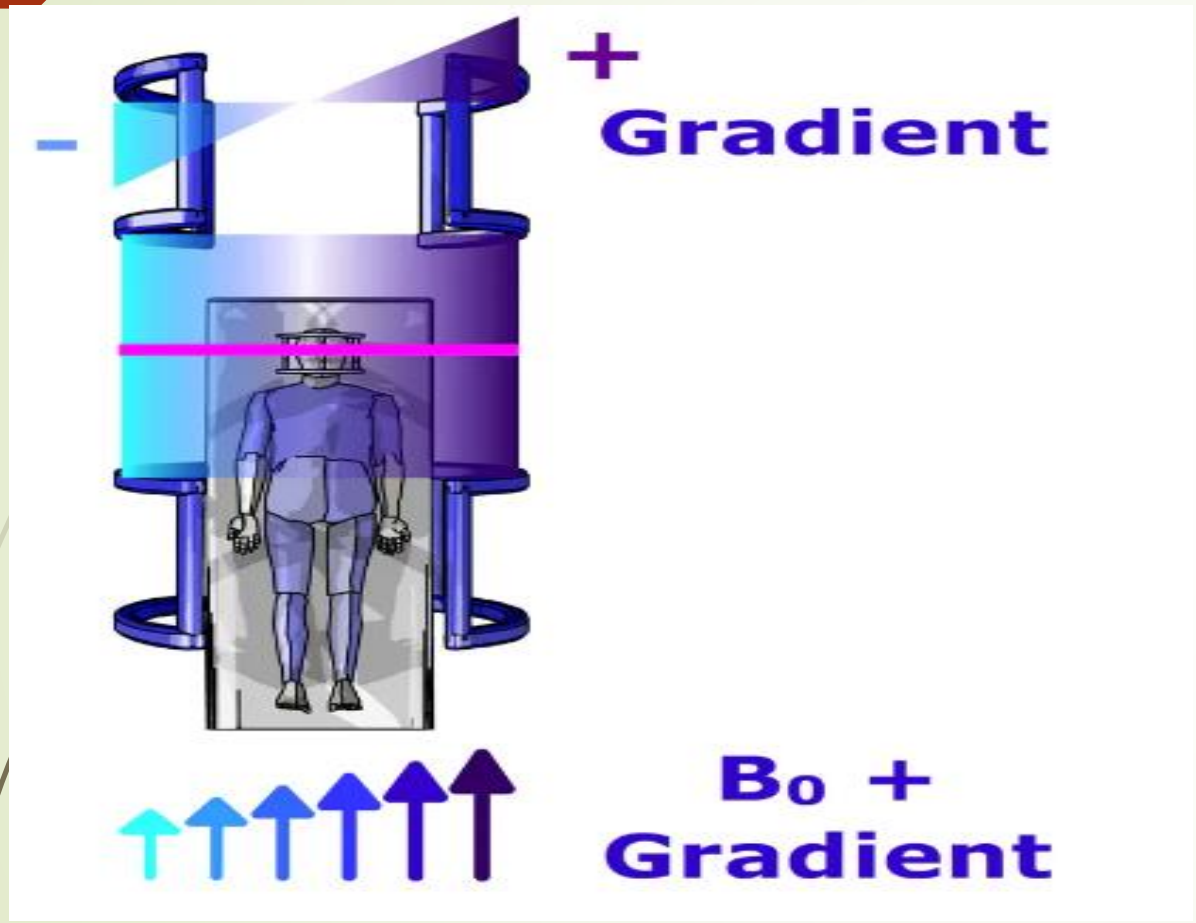


Figure 1: X-axis gradient coil, for frequency encoding

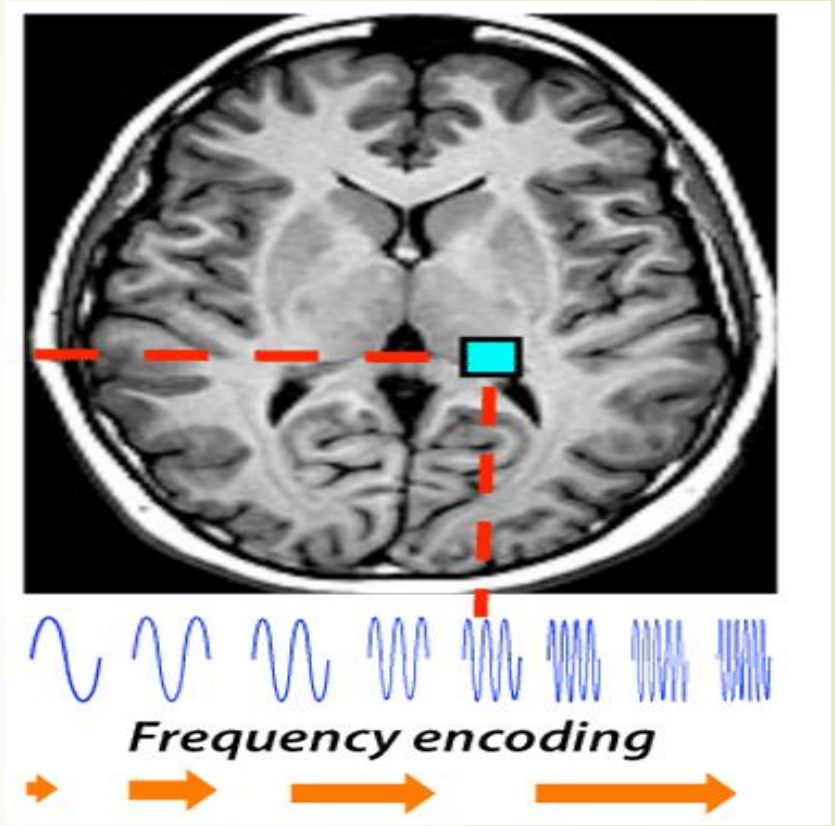
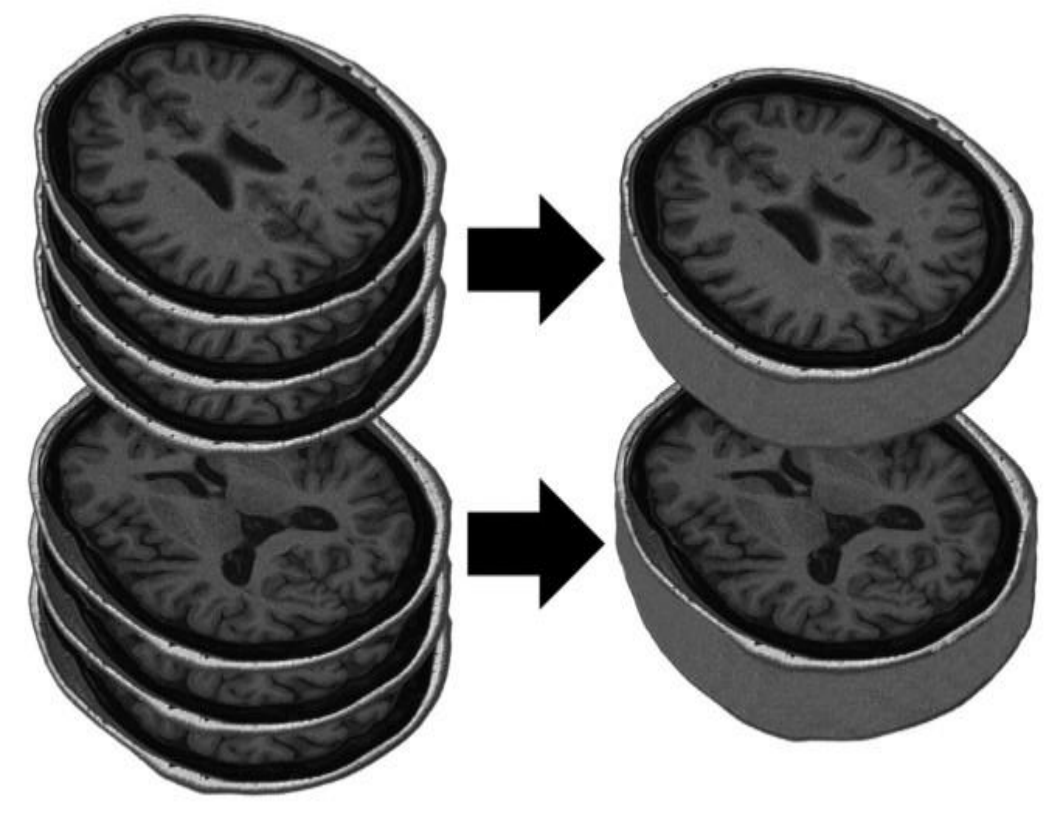
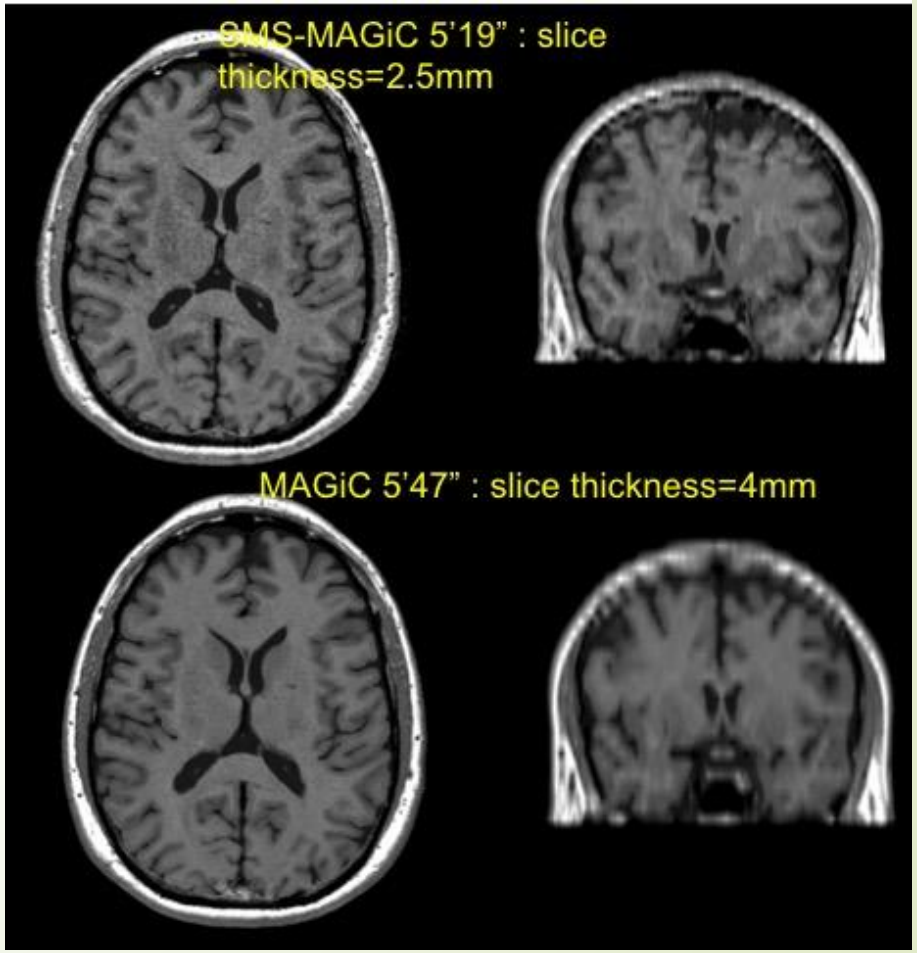


Figure 2: shows the frequency encoding gradient begins at the left side of the image and increases along the horizontal direction to the right side

Effect of slice thickness in MRI





Questions

- 1- List the steps of spatial encoding and explain one of them.
- 2- What is the frequency encoding gradient?
- 3- Draw the phase encoding gradient.
- 4- Why are the gradient coils in three dimensions (*x*, *y*, and *z*)?
- 5- Does it continue to run the phase encoding gradient during the scan?