Medical Equipment II - 2010

Magnetic Resonance Imaging(3)

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Web: http://ymk.k-space.org/courses.htm

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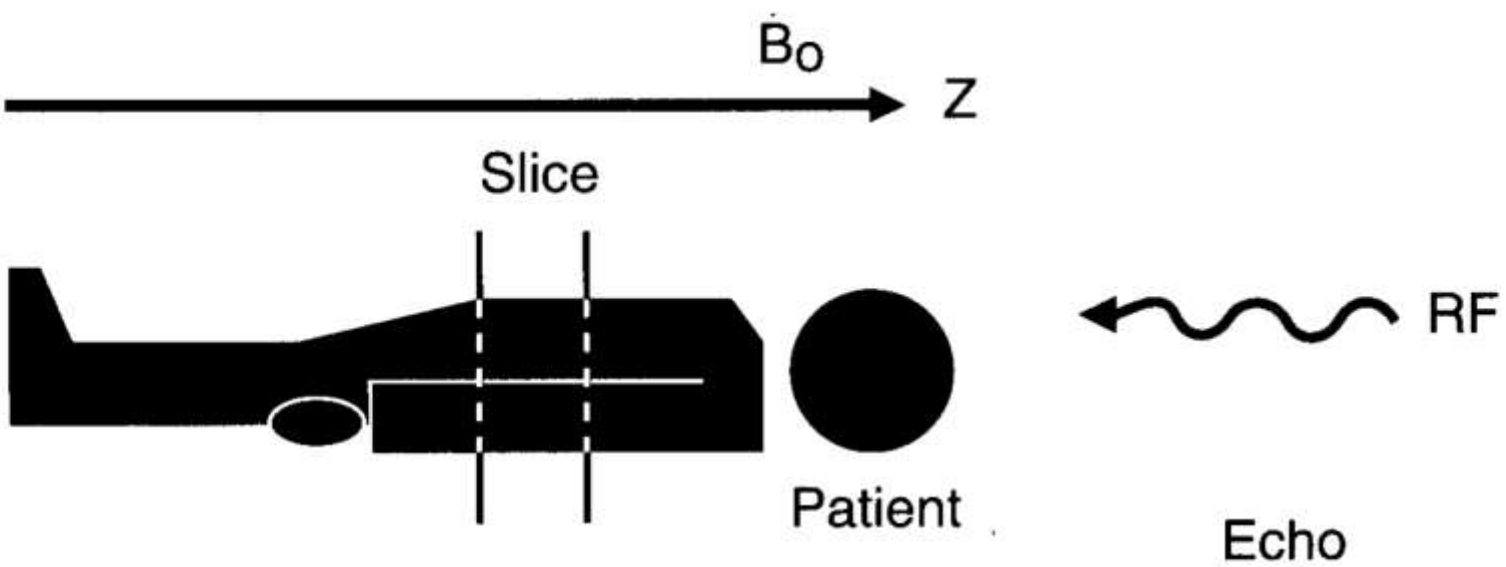
Image Construction

- Relies on Spatial Encoding
  - Differentiation between received signals from different locations
- In 3D, we need encoding in 3 orthogonal directions
  - Slice selection
  - Frequency encoding
  - Phase encoding
- Magnetic field gradients are key

Slice Selection

- Signal is obtained only from a particular slice from the body.
  - Can be in any direction



Slice Selection

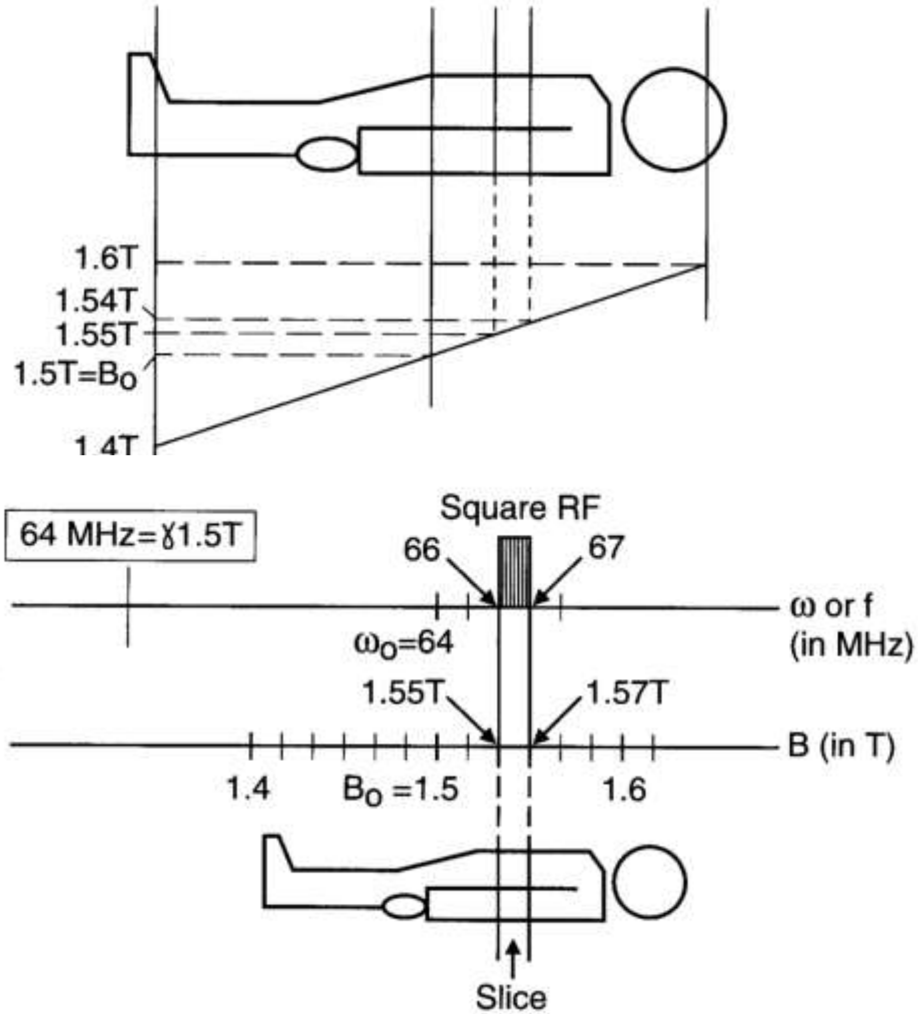
- Larmor equation:

$$\omega_o = \gamma B_0$$

- Larmor equation

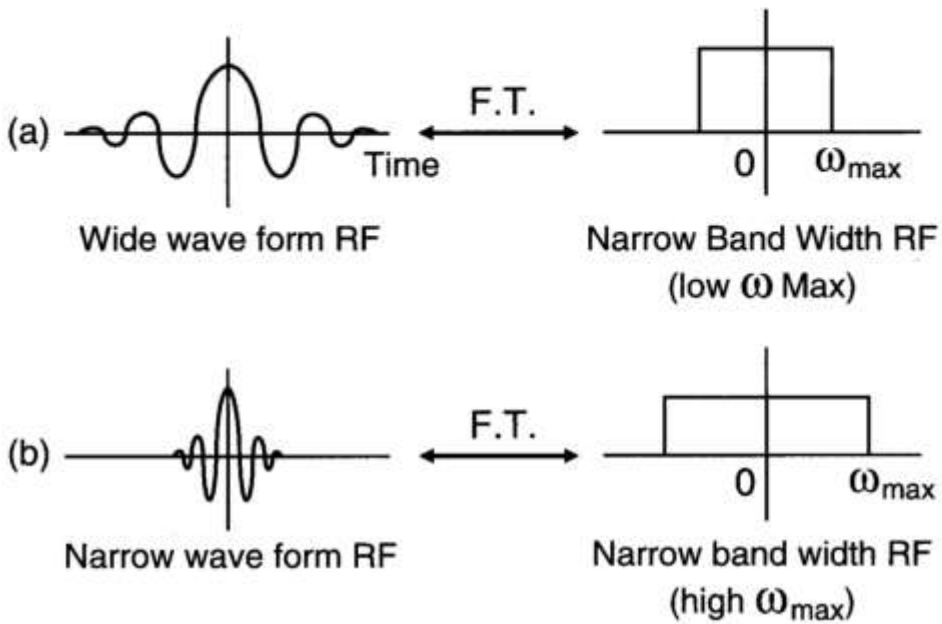
With z-gradient:

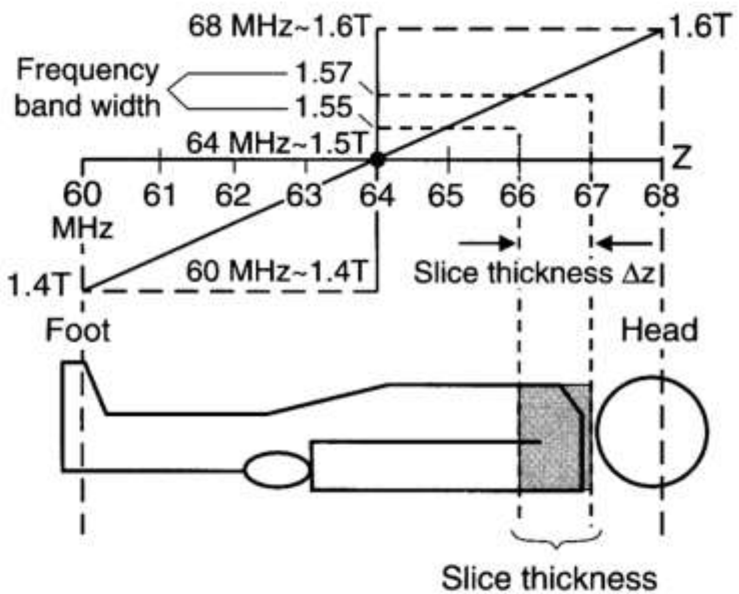
$$\omega_o(z) = \gamma(B_0 + G_z \cdot z)$$



Slice Selection

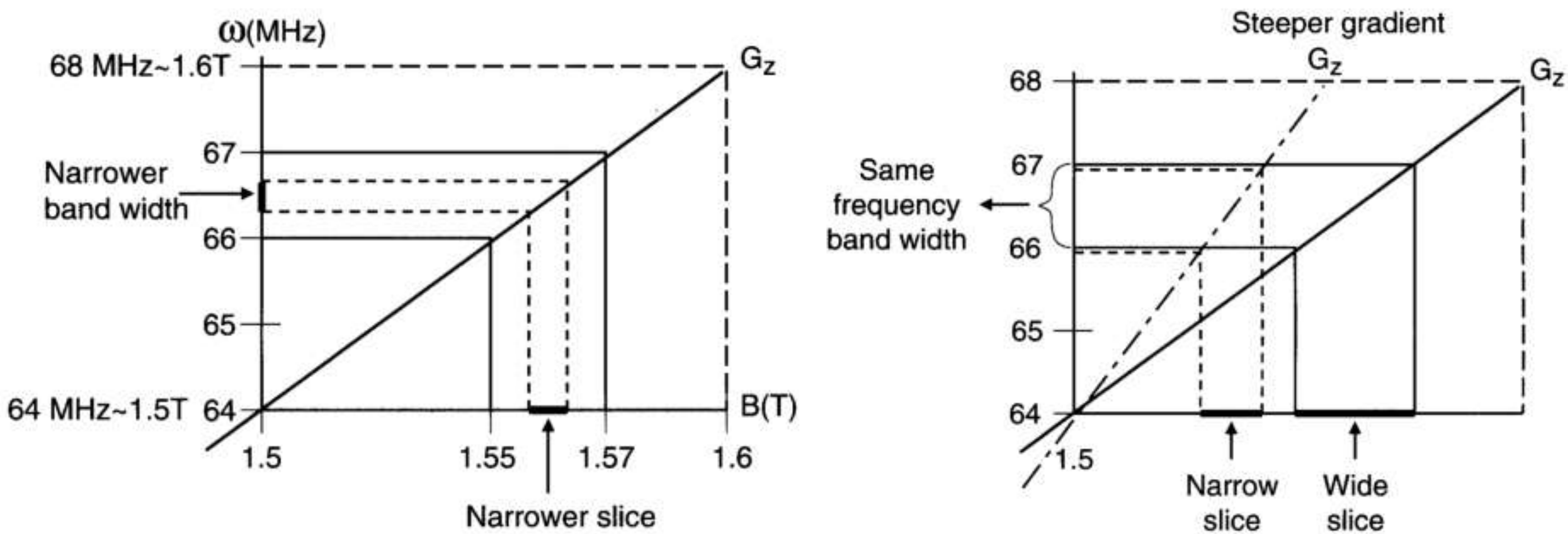
- Slice parameters:
  - Slice position
  - Slice thickness





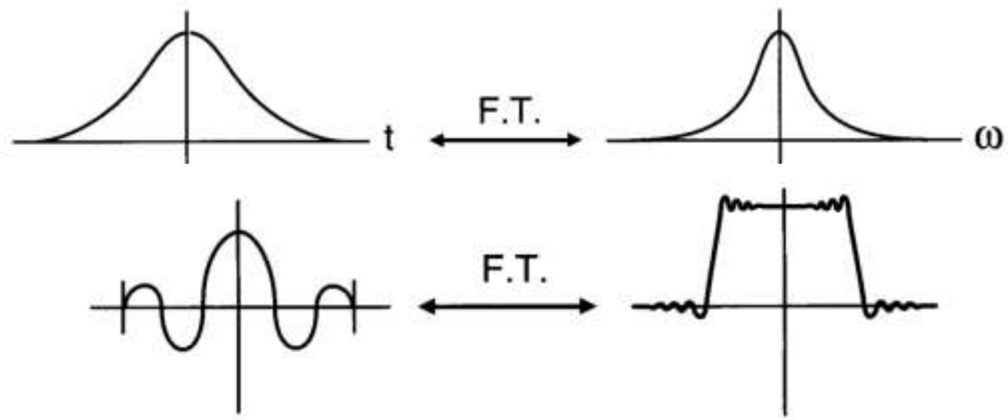
Slice Selection: Changing Slice Thickness

- Narrower RF pulse bandwidth
- Steeper slice selection gradient

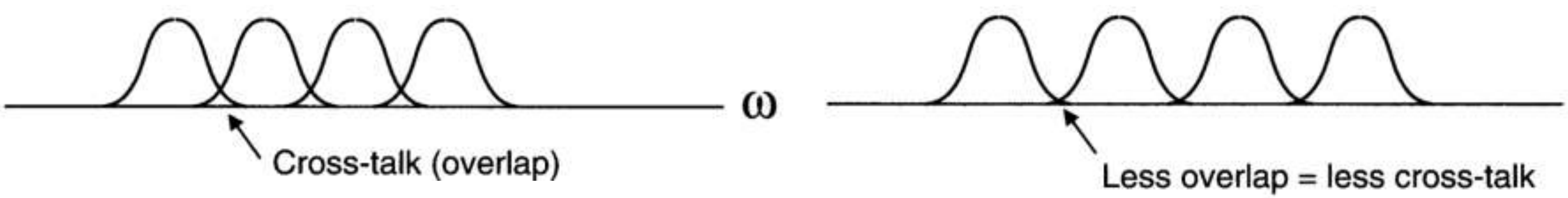


Slice Selection:
Slice Profile and Crosstalk

- Slice profile = Fourier transform of pulse shape



- Cross-talk: overlap between slice profiles



Fourier Encoding

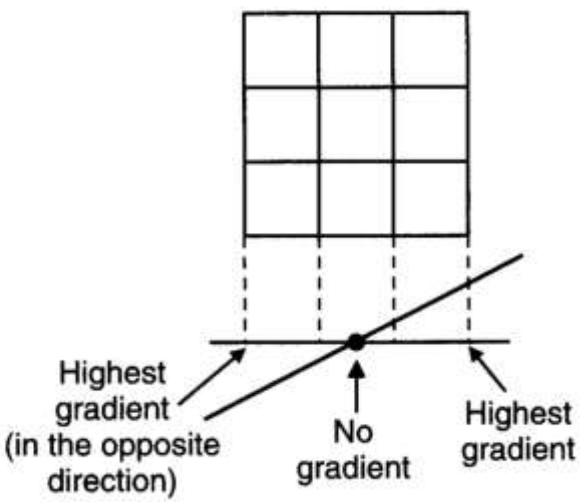
- Basic idea: encode location by frequency
  - Magnetic field gradient is used during reception
- Applied by 2 different methods
  - Frequency encoding
  - Phase encoding

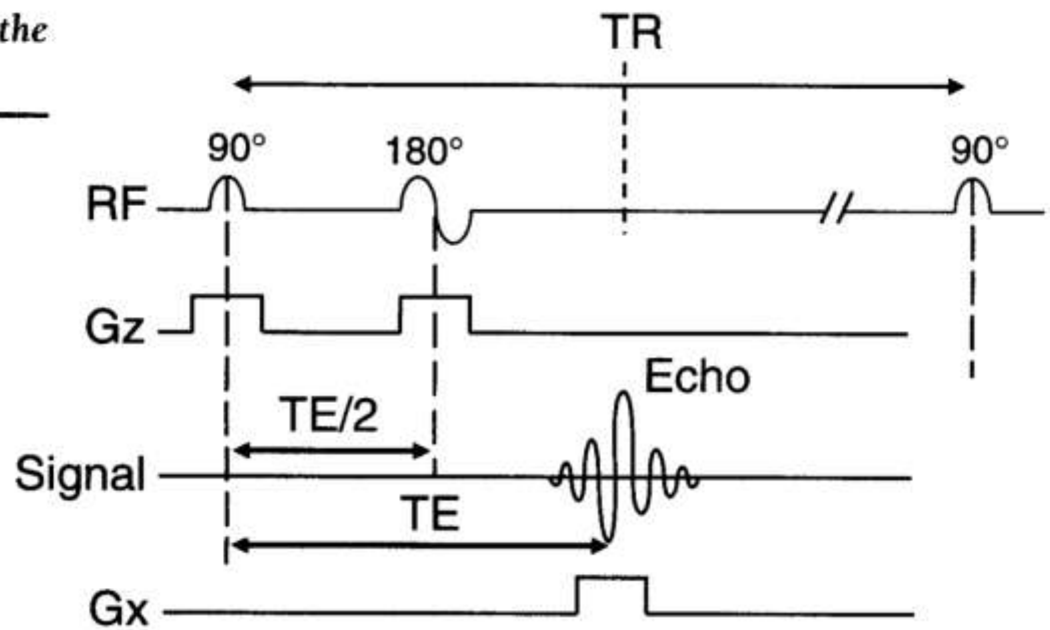
Frequency Encoding

- Read-out gradient

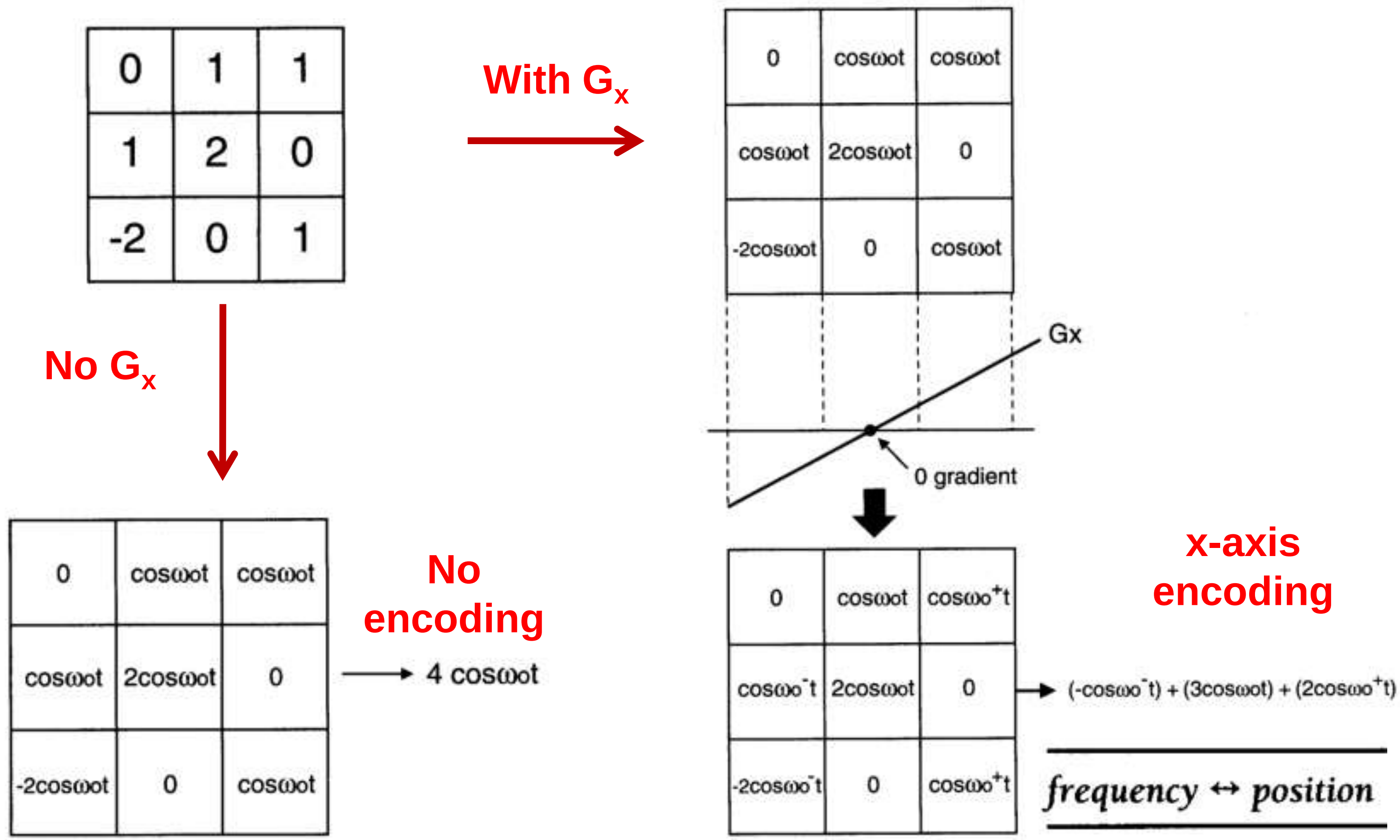
$$F(k_x) = \int f(x) \cdot e^{-j2\pi k_x \cdot x} dx$$

The Gx gradient is applied during the time the echo is received, i.e., during read out.





Frequency Encoding: Example



Phase Encoding

- 2D Fourier transform

$$F(k_x, k_y) = \iint f(x, y) \cdot e^{-j2\pi(k_x \cdot x + k_y \cdot y)} dxdy$$

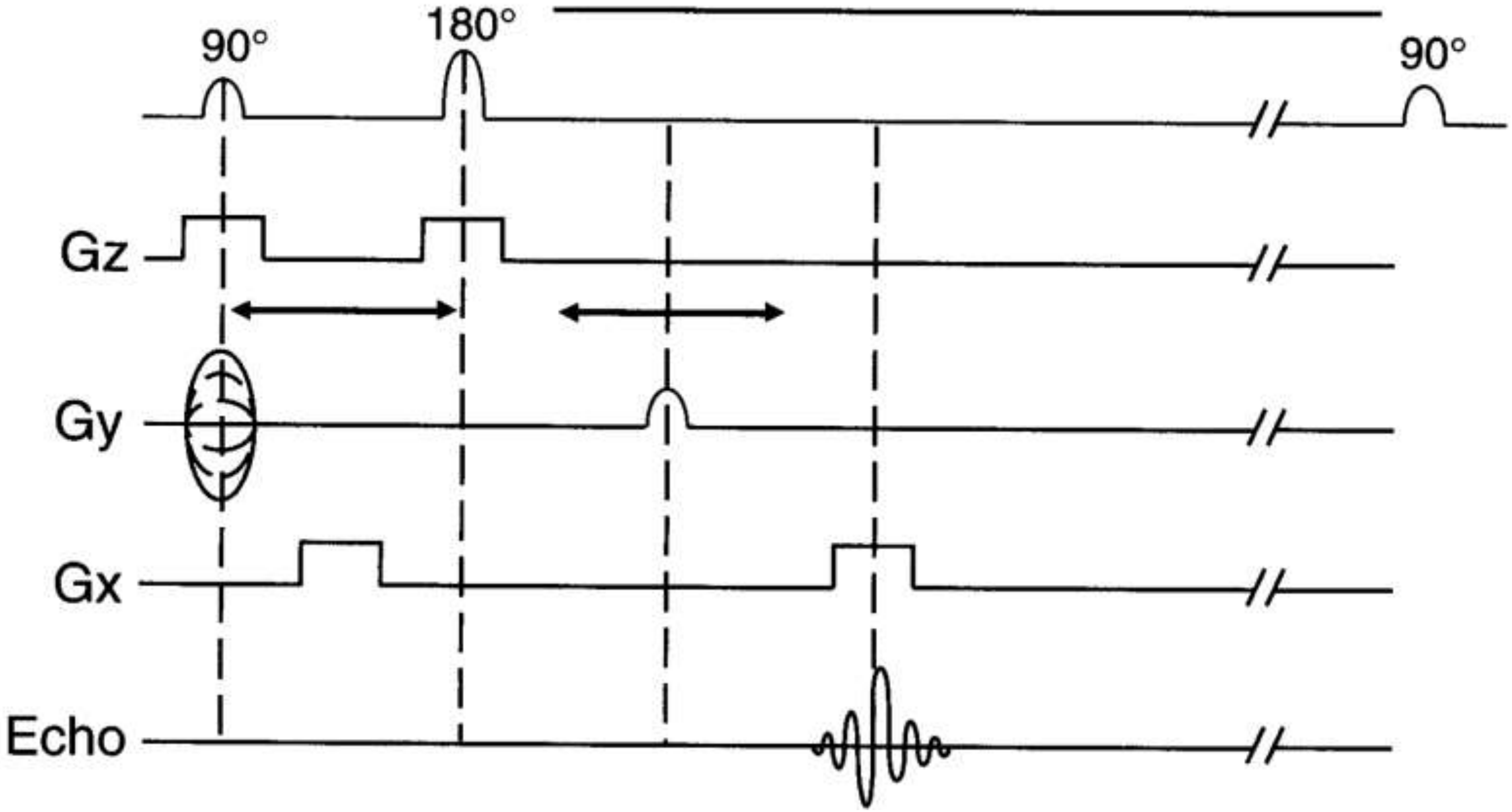
- With frequency encoding only:

$$F(k_x, 0) = \iint f(x, y) \cdot e^{-j2\pi(k_x \cdot x)} dxdy$$

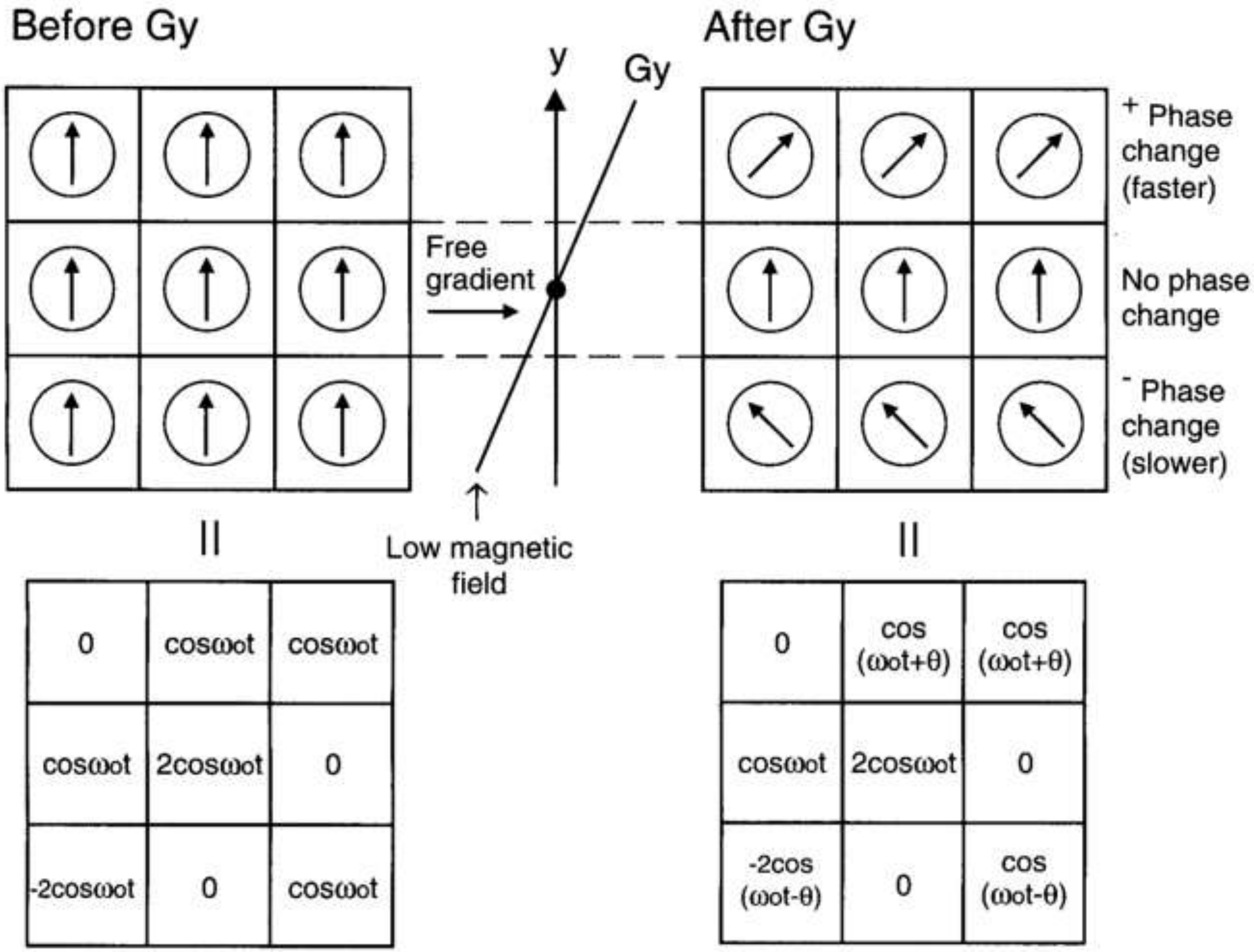
- Need to add another gradient in y-axis to encode spins in that direction

Phase Encoding

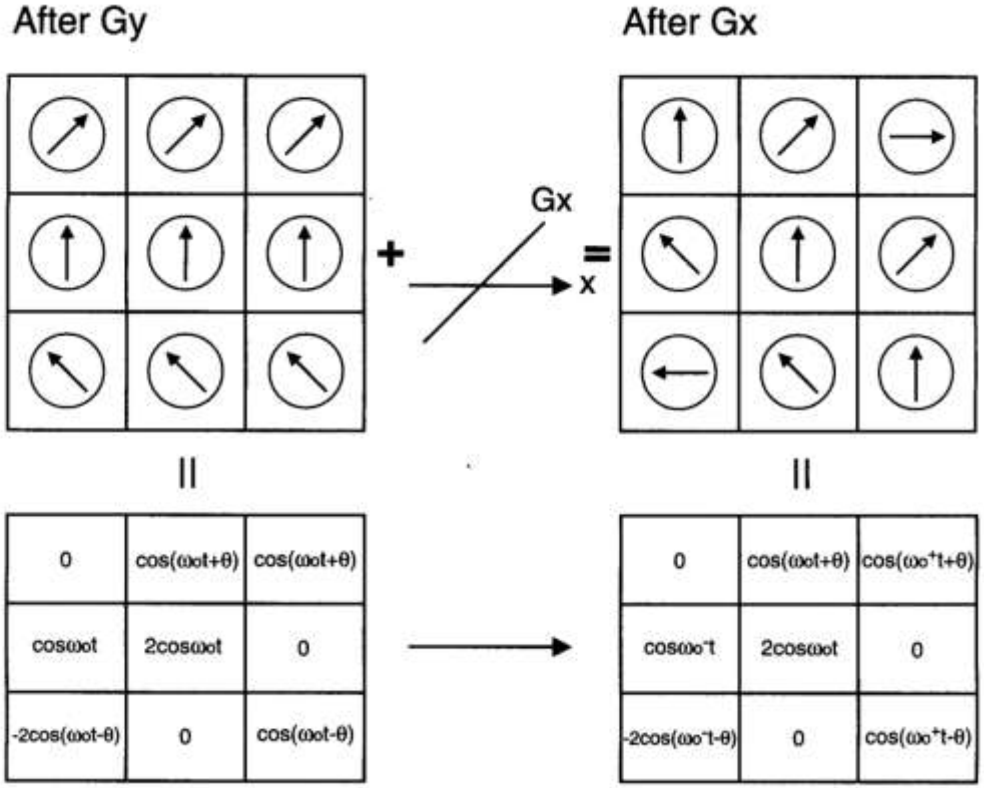
Gy is usually applied between the 90° and the 180° RF pulses or between the 180° pulse and the echo.



Phase Encoding



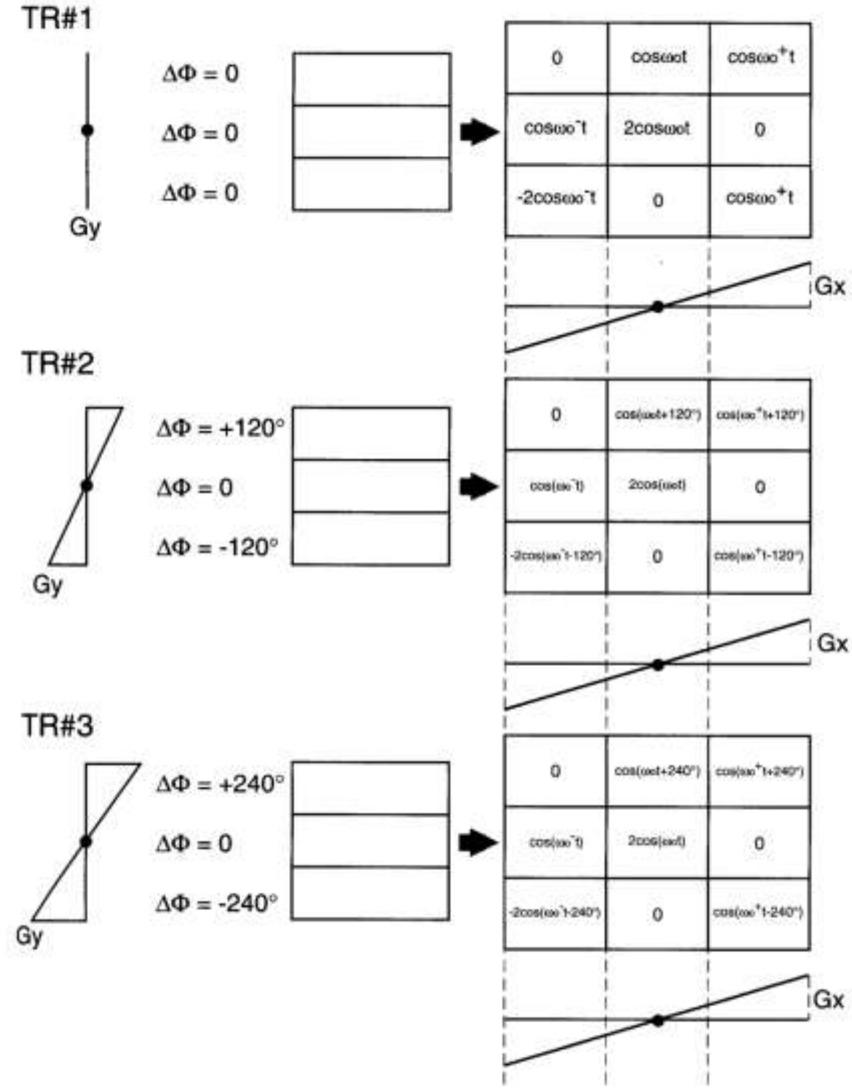
Phase Encoding



The protons in each pixel have a distinct frequency and a distinct phase, which are unique and encode for the x and y coordinates for that pixel.

Phase Encoding

- Each phase encoding requires 1 RF pulse
  - Acquisition time = #phase encoding steps x TR



Problem Assignments

- Solve the problems at the end of each chapter.