SEPT 21

ASSIGNMENT

READ 31-43, 67-76 IN TEXT

HOMEWORK 1 WILL GO OUT WEDNESDAY
DUE SEPT 30

TODAY

CLASS STRUCTURE

CHARACTERISTICS OF RF ON WHOLE BODY
SYSTEMS

NEXT TIME

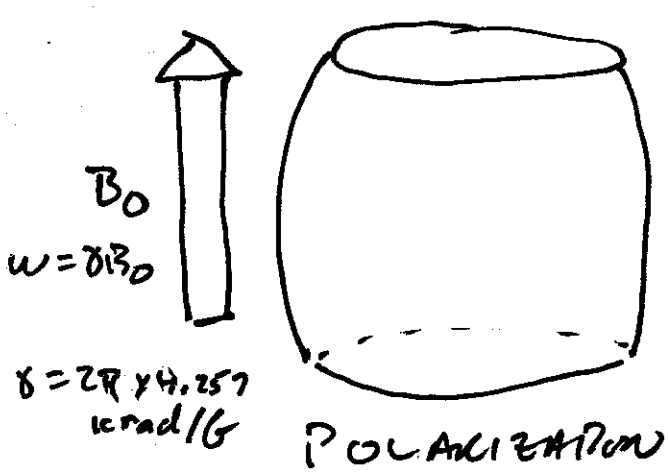
SMALL TIP ANGLE SOLUTION

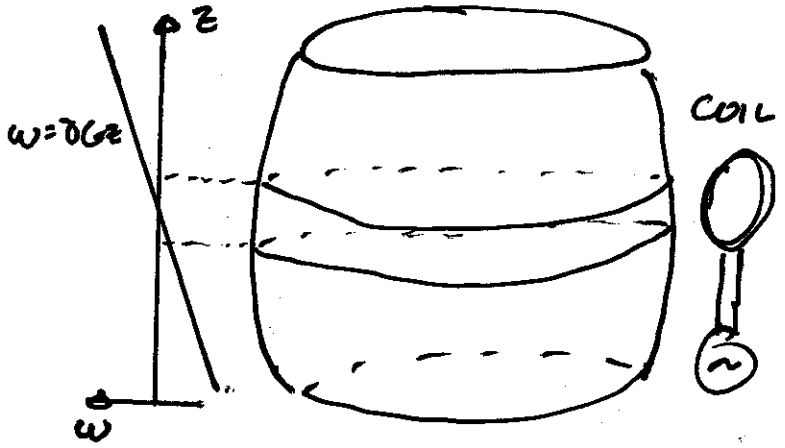
EXCITATION k-SPACE

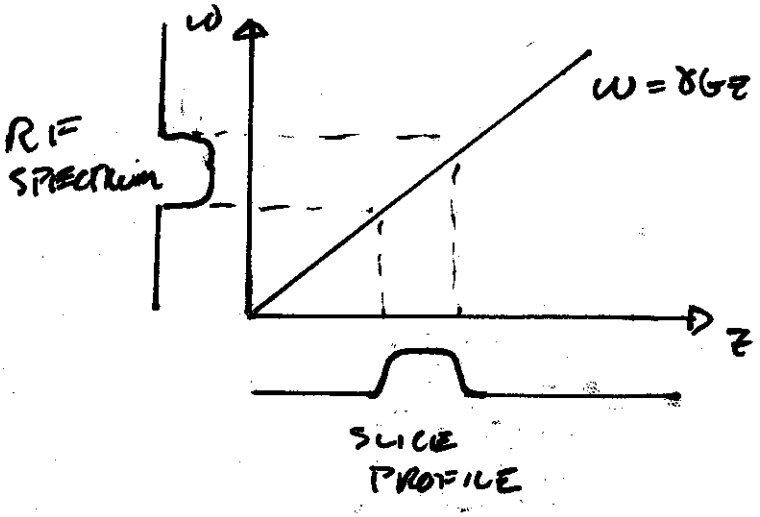
FOURIER DESIGN OF SLICE SELECTIVE
EXCITATION PULSES

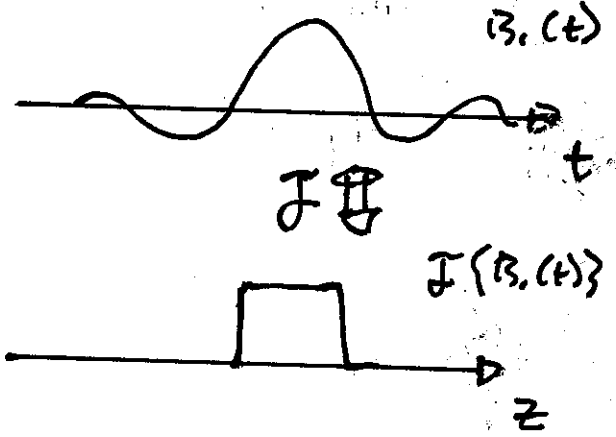
LECTURE 1: CHARACTERISTICS OF RF

BASICS OF SLICE SELECTION



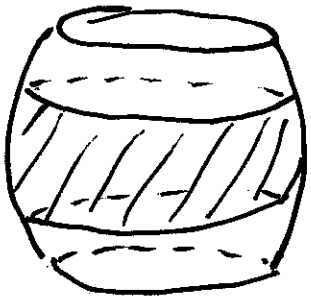




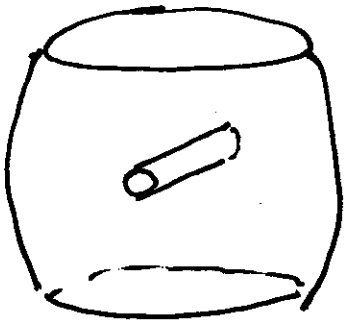


CHOOSE $B_1(t)$ TO HAVE BANDLIMITED SPECTRUM

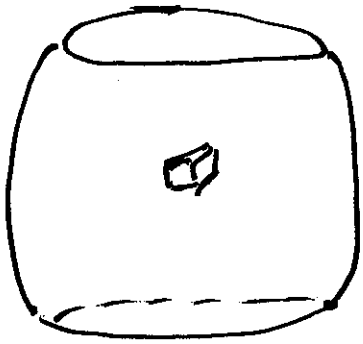
OTHER GEOMETRIES



SLAB

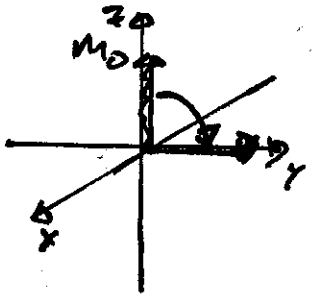


CYLINDER

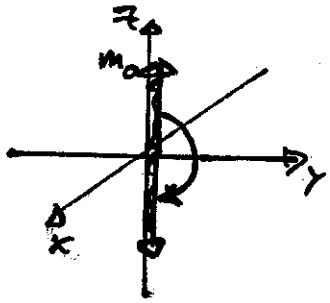


VOXEL

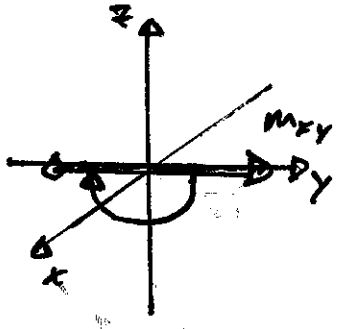
TYPES OF OPERATORS



EXCITATION



INVERSION



SPIN ECHO

EACH CAN BE DONE IN ANY OF THE GEOMETRIES!

TYPICAL SIZES OF THE MAGNETIC FIELDS IN MRI

B_0 15,000 G (1.5 T)

G (4 G/cm)(20 cm) = 80 G

B_1 1/4 G (EARTH'S FIELD IS 1/2 G!)

RF IS THE WEAKEST FIELD IN MRI

TYPICAL POWER USED TO GENERATE THESE FIELDS

B_0 NONE (SUPERCON, ALWAYS ON)

G 2 KW/CHANNEL (SIMPLE PULSE SEQ)

B_1 20 KW! (BODY AMP, 1.5 T)

WHERE DOES THE POWER GO?

20 KW PEAK POWER FOR RF AMP

2 KW AVERAGE POWER (10% DUTY CYCLE)

200 W DISIPATED IN SUBJECT (50 kg)

20 W IMPARTED TO SPINS (NON-SELECTIVE)

NOT VERY EFFICIENT!

PHYSICAL EFFECTS (NORMAL OPERATION)

B_0 NONE (EXCEPT FOR MOTION IN FRINGE FIELDS)

G NONE (OPERATE BELOW PNS, IGNORE NOISE)

B_1 HEATING (1-3°C)

RF POWER DEPOSITION

MEASURED AS SPECIFIC ABSORPTION RATE (SAR)

BASIC CONCEPT: LIMIT TEMPERATURE RISE TO:

1°C HEAD

2°C BODY

3°C EXTREMITIES

FOR ANY 1g OF TISSUE.

THIS IS THE SAME TEMPERATURE RISE AS PRODUCED BY EXERCISE, BODY CAN DEAL WITH IT.

SAME LIMITS AS ULTRASOUND, CELL TELEPHONES

HARD TO MEASURE!

SAR DEPENDS ON:

TISSUE VASCULARIZATION
TISSUE CONDUCTIVITY
TISSUE GEOMETRY
COIL VOLUME
PULSE SEQUENCE

POWER PER ANY ONE GRAM OF TISSUE

8 W/kg	HEAD/BODY	5 MINUTES
12 W/kg	EXTREMITY	5 MINUTES

AVERAGE POWER OVER BODY PART

3 W/kg	HEAD	10 MINUTES
4 W/kg	BODY	15 MINUTES

THESE ALL REQUIRE MODELS OF POWER DEPOSITION FOR A PARTICULAR BODY PART

VERY DEPENDENT ON GEOMETRY

SAR DEPENDENCE

$$SAR \sim B_1^2 B_0^2 (\Delta f)$$

SELDOM A PROBLEM AT 0.5T

CAN BE A PROBLEM AT 1.5T

ALWAYS AN ISSUE AT 3.0T

TYPICAL RF PARAMETERS

AMPLITUDE:

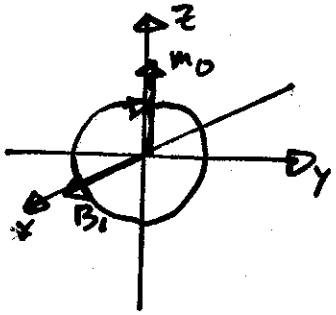
ACTUALLY MEASURED IN G OR μT

GE WHOLE BODY SYSTEMS (0.5T - 3T)

MAX B_1 HEAD ~ 1/4 G

MAX B_1 BODY ~ 1/8 G

FREQUENTLY QUOTE B_1 IN kHz (PROTONS)



HOW FAST WOULD MAGNETIZATION SPIN WITH A CONSTANT B_1?

$$B_1(kHz) = \frac{\gamma}{2\pi} B_1(G)$$

1/4 G ≃ 1 kHz

2π ROTATION IN 1 ms

π ROTATION IN 1/2 ms

TYPICAL RF PARAMETERS

HOMOGENEITY (@1.5 T)

HEAD COIL ~ 10 ppm

BODY COIL ~ 30 ppm

SURFACE COIL ~ 100 ppm

TOLERANCE TO B_1 VARIATIONS IS AN IMPORTANT CONCERN, AND NOT EASY TO ACHIEVE.