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FACULTÉ DES SCIENCES


# Tutorial

# Series 4 answers

# Advanced Biomedical Signal and Image Processing

# Master: Plasturgy & Biomedical Engineering

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### Exercise 1

1. **NMR and MRI**: NMR detects hydrogen nuclei in a magnetic field, used in MRI for imaging based on proton relaxation.
2. **Hydrogen Nuclei**: They provide contrast in MRI due to their abundance in body tissues.
3. **Larmor Frequency**:

$$f = \frac{\gamma B_0}{2\pi}$$

It increases with stronger magnetic fields.

4. **Flip Angle**: Affects signal intensity and contrast; typical values are 5° to 90°.
5. **Ultrasound Imaging**: Uses sound waves to create images; types include 2D, 3D, and Doppler ultrasound.
6. **Applications**: Obstetric imaging, organ assessment, and guiding procedures.
7. **Time-of-Flight**: Measures the time for sound pulses to travel to tissues and back.
8. **Axial vs. Lateral Resolution**: Axial resolution is along the beam direction; lateral is perpendicular.
9. **Doppler Effect**: Measures blood flow velocity; advantages include real-time data, but it's angle-dependent

## Exercise 2

1. **T1 vs. T2 Relaxation**: T1 (longitudinal) and T2 (transverse) influence tissue brightness in MRI images.
2. **Free Induction Decay (FID)**: Signal from relaxing nuclei; crucial for MRI signal detection.

### Exercise 3

1. **Spatial Encoding**: Uses gradient fields to localize signals from different body areas.
2. **Slice Selection**: Applies gradients and RF pulses to image specific tissue slices.
3. **Fourier Transform**: Converts k-space data to images; inverse transform reconstructs the spatial image.

## Exercise 4

3. **T1 vs. T2-weighted Images**: T1 highlights fat; T2 highlights water. Applications vary based on tissue contrast.
4. **Contrast Agents**: Gadolinium enhances visibility by shortening T1 relaxation times.

## Exercise 5

1. **SNR Calculation**:

$$\text{SNR} = \frac{10\,\mu V}{0.5\,\mu V} = 20$$

2. Total Time=2000ms×4=8000ms=8s





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## Exercise 6

1. **Max Deviation**: T=7.5mT
2. Bandwidth =10063.87MHz=0.6387MHz
3. **Power Absorbed**: 2W/kg×70kg=140W

## Exercise 7

1. **Remaining Nuclei**: $N \approx 367 \text{ nuclei}$
2. **Half-Life**: $t_{1/2} = 1 \text{ day}$
3. **Activity After 20 Days**: $A \approx 183 \text{ Bq}$
4. **Intensity After Lead**: $I \approx 736.4 \text{ CPM}$

## Exercise 8

1. **Concentration After 5 Hours**: $C \approx 18.4 \, \text{mg/L}$
2. **Absorbed Dose**: $D \approx 0.057 \, \text{Gy}$

## Exercise 9

1. **Initial Activity in Bq**: $A_0 = 370 \, \text{MBq} = 370 \times 10^6 \, \text{Bq}$
2. **Absorbed Dose After 1 Hour**: $D \approx 0.057 \, \text{Gy}$
3. **Effective Dose**: $E \approx 0.00684 \, \text{Sv}$

## Exercise 10

1. **Time for Ultrasound Pulse**: $\text{Time} \approx 0.13 \, \text{ms}$
2. **Axial Resolution**: $\text{Axial Resolution} \approx 0.231 \, \text{mm}$
3. **Doppler Shift**: $\Delta f \approx 1840 \, \text{Hz}$

## Exercise 11

1. **Time for Ultrasound Pulse**: $\text{Time} \approx 0.13 \, \text{ms}$
2. **Axial Resolution**: $\text{Axial Resolution} \approx 0.231 \, \text{mm}$
3. **Doppler Shift**: $\Delta f \approx 2600 \, \text{Hz}$
4. **Lateral Resolution**: **1 cm** under ideal conditions.
5. **Continuous Wave Doppler Limitation**: Cannot localize sources despite accurate velocity measurements.





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## Exercise 12





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