1. (4 points) Fill in the acoustic impedance in the table for bone.

<table>
<thead>
<tr>
<th></th>
<th>( \rho ) (kg/m(^3))</th>
<th>( c ) (m/s)</th>
<th>( \alpha ) (dB/cm/MHz)</th>
<th>( Z ) (MRayl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>1.16</td>
<td>344</td>
<td>12</td>
<td>0.0004</td>
</tr>
<tr>
<td>Muscle</td>
<td>1041</td>
<td>1580</td>
<td>0.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Fat</td>
<td>950</td>
<td>1430</td>
<td>1</td>
<td>1.35</td>
</tr>
<tr>
<td>Bone</td>
<td>1600</td>
<td>3360</td>
<td>10</td>
<td>5.38</td>
</tr>
</tbody>
</table>

2. (4 points) You have an incident beam on Tissue 1 shown above. Assume this is the spatial peak of the pulse. Assume Tissue 1 is muscle. What is \( I_{SPPA} \)? Give in W/m\(^2\)

\[
I_{SPPA} = \frac{P \cdot P}{(2 \cdot Z)} = \frac{0.1 \cdot 0.1 \cdot 1000 \cdot 1000}{(2 \cdot 1.6 \cdot 1000000)} = 3.039 \text{ mW/m}^2
\]
3. (4 points) What is the attenuation of the intensity of the beam when it hits the interface (in dB)?

\[
\text{attenuation} = 0.5 \text{ dB/MH/cm} = 0.5 \times 6 = 3 \text{ dB}
\]

4. (4 points) What is the ratio of the intensity hitting the interface compared to that incident on the left?

\[
\frac{I}{I_0} = \frac{1}{2}
\]

5. (4 points) What is the reflected intensity at the interface between the two tissues if the second tissue is fat? Give in W/m²

\[
R = \frac{(Z_2-Z_1)^2}{(Z_2+Z_1)^2} = \frac{(1.6-1.35)/(1.6+1.35))^2}{1.6+1.35)^2} = (0.25/2.95)^2 = 0.007
\]

\[
\text{attenuation} = \frac{1}{2}
\]

\[
\text{reflected beam is } 3.039 \text{ mW/m}^2 \times 0.007 \times 0.5 = 10 \times 10^{-6} \text{ W/m}^2
\]

6. (4 points) What is the transmitted intensity in W/m²?

\[
\text{transmitted intensity is } 3 \text{ mW/m}^2 \times 0.5 \times 0.993 = 1.48 \text{ mW/m}^2
\]
7. (4 points) What is the axial resolution on page 1?

\[ \text{ax res} = n \lambda/2 = 3 \times 1.5 \, \text{mm}/2 = 2.25 \, \text{mm} \]

8. (4 points) What about a transducer determines the location of grating lobes?

the pitch, or the spacing between elements relative to the wavelength

9. (4 points) What is the maximum frame rate for a depth of 10 cm and 100 lateral lines?

\[
\text{time/pulse} = 0.10 \, \text{m}^2/1540 \, \text{m/s} = 130 \, \text{us} \\
\text{time/image} = 13 \, \text{ms} \\
\text{frame rate} = 1/13 \, \text{ms} = 76 \, \text{frames/s}
\]
10. (2 points) Imagine the situation where the transmitted beam is at an angle \( \theta_i \) shown above. Which is true?

a) the transmitted beam is given by the yellow line or

b) the transmitted beam is given by the purple line.

11. (2 points) Why did the frame rate decrease in going from the imaging parameters used on the left to those used on the right?

- the fat of tissue 2 has a lower speed of sound. This will cause the beam to go toward the normal to the interface.

multiple focal zones are picked. these require an image/focal zone.
12. (4 points) The picture above shows a beam profile and image blurred out except at the focus. Name and describe one method for improving the lateral resolution throughout the image.

- dynamic receive beamforming
- aperture growth and apodization

13. (4 points) What is speckle and where does it come from?

Speckle arises from the variable interference of echoes returning from each voxel. It gives texture/pattern to the image that allows some diagnostic information. Eg. The speckle pattern of liver is different from that of a cyst.
14. (4 points) Match the following

a. CW Doppler
   i. is an intensity modulated spectral line

b. Color Doppler
   ii. is used to listen to the fetal heart beat

c. Power Doppler
   iii. is most sensitive to slow flow

d. Pulsed Doppler
   iv. is a qualitative method for determining flow direction

15. (4 points) Images from two different patients are shown.

What is the organ indicated by the yellow \(*\)?

What is the organ indicated by \($\)?

What is encircled by the red circle?

Why is the tissue indicated by the white arrow brighter than the tissue indicated by the yellow arrow?