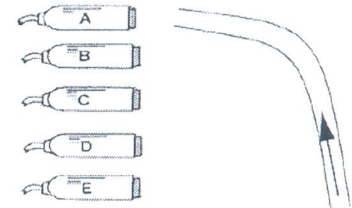


Please answer the following questions

Question_1) [15 Marks]

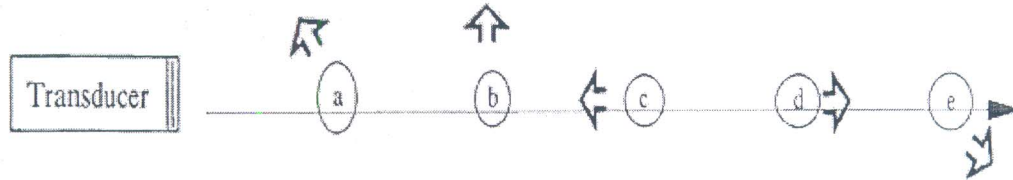
a) Compare between pulsed wave and continuous wave doppler in terms of minimum number of transducers, their Q-factor, maximum velocity, and range?

b) If blood is flowing at a constant velocity in a vessel in the direction of the arrow shown in the following figure, then answer the following and give reason:



- i. Which transducer measures the greatest Doppler shift?
- ii. Will the Doppler shift be positive or negative?
- iii. Which transducer measures a reflection with the greatest amplitude?

c) In the following figure, a sound beam from the transducer is going to the right. All the blood cells (RBC) are traveling at 2 m/s in a direction identified by the small arrows.



Answer the following and give reason:

- i. Are the red blood cells traveling at the same velocity?
- ii. Which RBC produces the maximum negative Doppler shift?
- iii. Which RBC produces the maximum positive Doppler shift?
- iv. Which RBC produces a reflection with no Doppler shift?
- v. Which two RBCs produce negative Doppler shifts?
- vi. Which RBC creates a reflection with the highest amplitude?
- vii. Which RBC creates a reflection with the lowest amplitude?

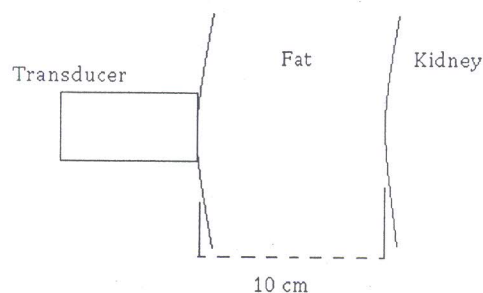
Question_2) [20 Marks]

- a) Draw the equivalent circuit of an ultrasound piezoelectric transducer at resonance and off-resonance? Define each element in this circuit.
- b) How would you efficiently match this transducer to a driving voltage source?
- c) List the different types of array transducer and then explain the basic principle of beam steering and focusing of a phased array transducer. Support your answer with drawings and/or diagrams.

Question_3) [20 Marks]

- a) Draw a diagram depicting the A-Mode ultrasound system and discuss one of its clinical applications. Include all the necessary information on the diagram.

- b) In the configuration of the ultrasound imaging system shown below, what is the PRP and PRF if the maximum imaging depth is 10 cm? If the average power density is 10 mW/cm²:
- How much average power will be received back at the transducer from the reflection at the fat/kidney interface if the area of the transducer is 10 cm² and its frequency is 3 MHz. Neglect beam spreading.
 - Find peak pressure and peak particle velocity for such wave if the fat/kidney medium is replaced by water.
 - Show that for this power level in water the assumption that “the variation in density of water due to the action of the waves \ll average unperturbed density” is valid.



- c) An 8 MHz transducer with a pulse repetition frequency of 5,000 Hz is imaging to a depth of 7 cm. What is the Nyquist frequency?

Question_4) [15 Marks]

- a) Define what is meant by the Q-factor and the Axial Resolution “AR” of a piezoelectric crystal? What is the relation between them? Support your answer with curves and diagrams.
- b) Is it desirable to have Low-Q or High-Q in medical ultrasound field? Demonstrate your answer with examples.
- c) Find the time-average power density and the space-average power density carried by a pressure wave of the form:

$$P(t, z) = P_+ \cos(\omega t - kz)$$

Tissue	Density (g/cm ³)	Phase velocity (m/s)	Compressibility constant (m ² /N)
Fat	0.937	1479	---
Kidney	1.04	1572	---
water	1	1500	4.48 x 10 ⁻¹⁰

Best wishes.....Dr Mohamed El-Brawany