

FRAME RATE CALCULATION PRACTICE

STUDENT WORKSHEET | Pulse-Listen Time, Frame Time & Frame Rate

Name: _____ Date: _____

Assumptions: Speed of sound = 1540 m/s; round-trip PLT $\approx 13 \mu\text{s}$ per cm of imaging depth.
Assume no additional processing or steering delays; each focal zone uses a separate pulse per line.
Equations: $\text{PLT } (\mu\text{s}) = 13 \times \text{depth (cm)}$ | $\text{FT} = \text{PLT} \times \text{lines} \times \text{pulses/line}$ | $\text{FR} = 1/\text{FT}$ (seconds)

Problems 1-5

1. A grayscale image is acquired to a depth of 6 cm. Calculate the minimum PLT in microseconds.

2. Imaging depth is increased to 12 cm. Calculate the minimum PLT in microseconds.

3. An image uses a depth of 8 cm, 100 scan lines, and one pulse per line. Calculate FT in milliseconds.

4. An image uses a depth of 10 cm, 120 scan lines, and one pulse per line. Calculate FT in milliseconds.

5. A system requires 20 ms to acquire one frame. Calculate FR in frames per second (fps).

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Problems 6-10

6. Frame time increases to 40 ms. Calculate FR in fps.

7. An image uses 10 cm depth, 100 scan lines, and one pulse per line. Calculate PLT, FT, and FR.

8. An image uses 15 cm depth, 128 scan lines, and two focal zones. Calculate PLT, FT, and FR.

9. An image uses 8 cm depth, 160 scan lines, and three focal zones. Calculate PLT, FT, and FR.

10. At 12 cm depth with 100 scan lines, frame acquisition changes from one to two focal zones. Calculate the original and new FR. What happens to temporal resolution?

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INSTRUCTOR ANSWER KEY | Pulse-Listen Time, Frame Time & Frame Rate

Unit reminders: $1,000 \mu\text{s} = 1 \text{ ms}$; $1,000 \text{ ms} = 1 \text{ s}$. $\text{FR (fps)} = 1 \div \text{FT (seconds)}$.

Results rounded to one decimal place where appropriate.

1. $\text{PLT} = 13 \mu\text{s/cm} \times 6 \text{ cm} = 78 \mu\text{s}$.

2. $\text{PLT} = 13 \mu\text{s/cm} \times 12 \text{ cm} = 156 \mu\text{s}$.

3. $\text{PLT} = 13 \times 8 = 104 \mu\text{s}$. $\text{FT} = 104 \mu\text{s} \times 100 \times 1 = 10,400 \mu\text{s} = 10.4 \text{ ms}$.

4. $\text{PLT} = 13 \times 10 = 130 \mu\text{s}$. $\text{FT} = 130 \mu\text{s} \times 120 \times 1 = 15,600 \mu\text{s} = 15.6 \text{ ms}$.

5. $\text{FT} = 20 \text{ ms} = 0.020 \text{ s}$. $\text{FR} = 1 \div 0.020 \text{ s} = 50 \text{ fps}$.

6. $\text{FT} = 40 \text{ ms} = 0.040 \text{ s}$. $\text{FR} = 1 \div 0.040 \text{ s} = 25 \text{ fps}$.

7. $\text{PLT} = 13 \times 10 = 130 \mu\text{s}$. $\text{FT} = 130 \mu\text{s} \times 100 \times 1 = 13,000 \mu\text{s} = 13.0 \text{ ms}$. $\text{FR} = 1 \div 0.013 = 76.9 \text{ fps}$.

8. $\text{PLT} = 13 \times 15 = 195 \mu\text{s}$. Two focal zones = 2 pulses/line. $\text{FT} = 195 \mu\text{s} \times 128 \times 2 = 49,920 \mu\text{s} = 49.92 \text{ ms}$. $\text{FR} = 1 \div 0.04992 = 20.0 \text{ fps}$.

9. $\text{PLT} = 13 \times 8 = 104 \mu\text{s}$. Three focal zones = 3 pulses/line. $\text{FT} = 104 \mu\text{s} \times 160 \times 3 = 49,920 \mu\text{s} = 49.92 \text{ ms}$. $\text{FR} = 1 \div 0.04992 = 20.0 \text{ fps}$.

10. $\text{PLT} = 13 \times 12 = 156 \mu\text{s}$. One focal zone: $\text{FT} = 156 \times 100 \times 1 = 15,600 \mu\text{s} = 0.0156 \text{ s}$; $\text{FR} = 64.1 \text{ fps}$. Two focal zones: $\text{FT} = 156 \times 100 \times 2 = 31,200 \mu\text{s} = 0.0312 \text{ s}$; $\text{FR} = 32.1 \text{ fps}$. Doubling the number of focal zones doubles FT and halves FR, reducing temporal resolution.

Teaching note

Teaching note: PLT is the minimum two-way travel time for one pulse at the selected depth. Increasing pulses per line does not change individual-pulse PLT; it increases total acquisition time. Displayed clinical frame rates may differ from these idealized calculations.