Ministry of Higher Education and Scientific Research
Al-Mustaqbal University College
Radiology Techniques Department

Radiological Physics

Al-Mustaqbal University College

2nd

Radiology Techniques Department

By

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MS.C. Theoretical Physics

First Semester

Practical 2: Doppler Sonography

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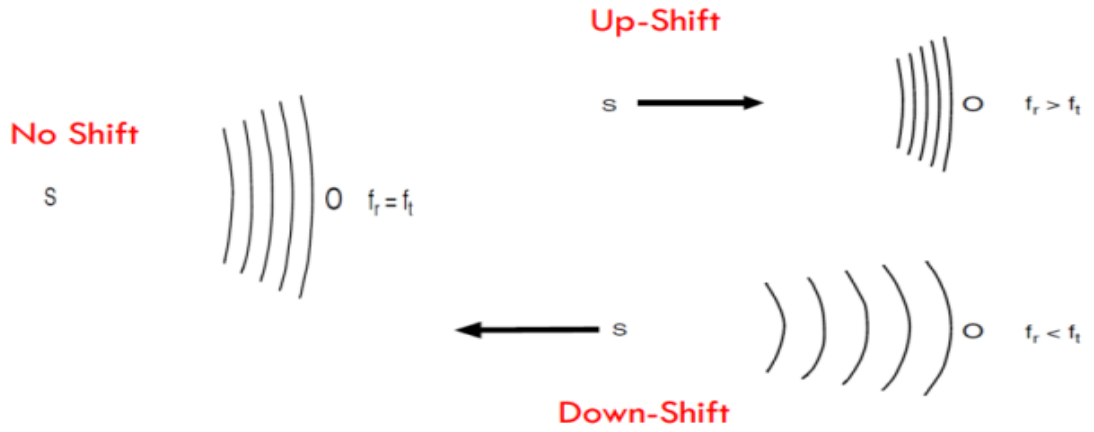
Doppler Effect: is the apparent change in frequency (or wavelength) that occurs because of motion of the source or observer of a wave

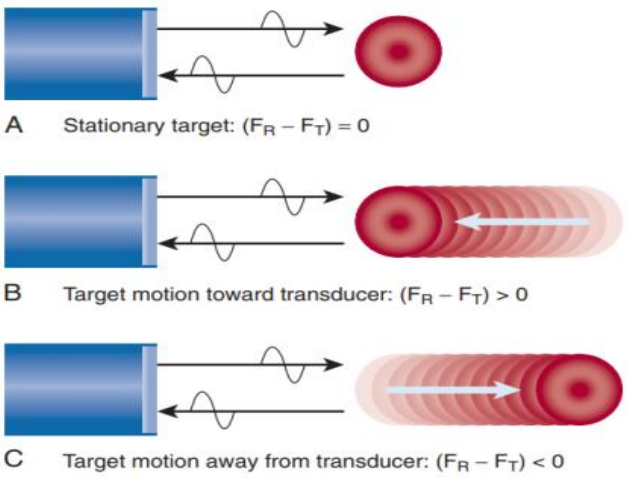


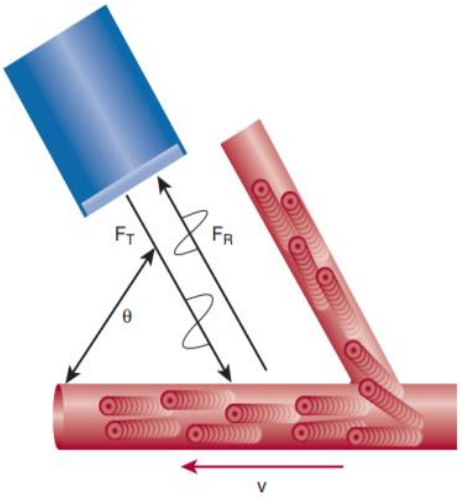
Doppler Shift Equation

$$f_d = f_r - f_t = \frac{2 f_t v \cos\theta}{c}$$

Where

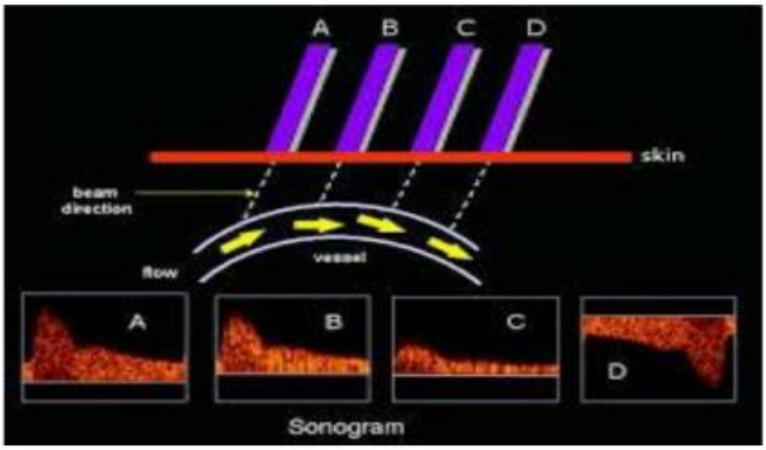
- v is the velocity of moving blood
- c is the speed of sound,
- f_t is the e transmitted frequency
- f_r the received frequency
- f_d The Doppler shift frequency
- θ the angle between the direction of the motion red blood cells and the beam of ultrasound transmitted.





(H.W) In a Doppler examination fi = 5 MHz, v = 25 cm/s, θ = 45 deg., sound speed (154,000 cm/s), calculate the Doppler shift?

- If θ = 0, Cos θ =1 The maximum shift
- At large angle (θ > 60) The shift is small.
- Doppler frequency shift of the moving blood occurs in the audible range



In the diagram above,

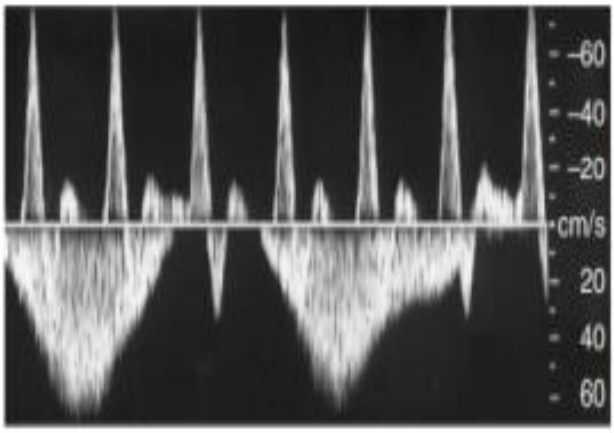
- Beam (A) is more aligned than (B) and produces higher-frequency Doppler signals.
- The beam/flow angle at (C) is almost 90° and there is a very poor Doppler signal.
- The flow at (D) is away from the beam and there is a negative signal

Doppler displays

The main display modes used in a modern Doppler system are described below.

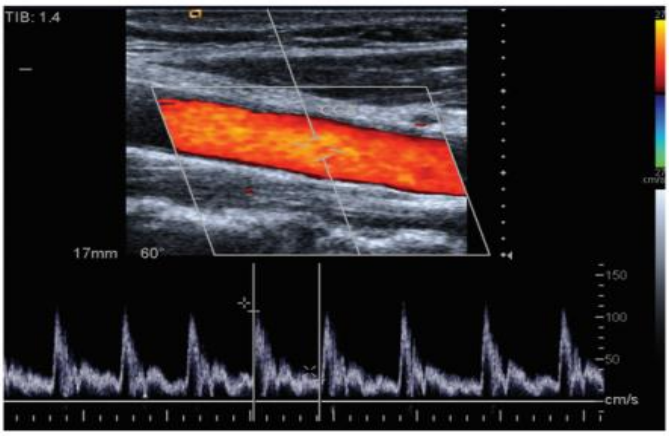
Spectral Doppler: all the velocity information detected from a single location within the blood vessel is displayed in the form of a frequency shift –time plot. Vertical distance from the baseline corresponds to Doppler shift , while the greyscale indicates the amplitude of the detected ultrasound with that particular frequency.

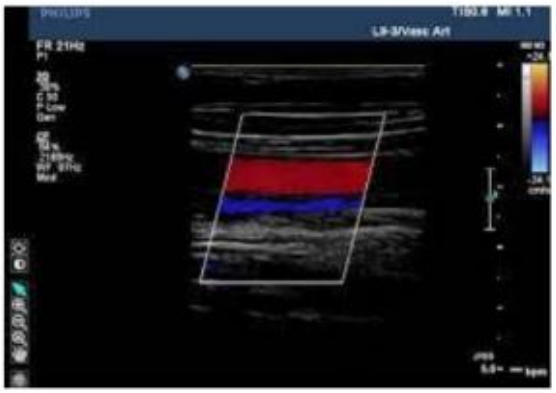
❖ The spectrum contains information about the speed and direction of the blood flow as well as the degree of pulsatility of the flow.



- Normal blood flow is represent by a specific characteristic spectrum. Disturbed and turbulent flow alters the spectrum proportional to disease pattern.
- The Doppler spectrum is display below the 2D B-mode image as a moving trace, on a monitor.
- The flow velocity (a frequency) is in Y axis and the time in X axis.
- Intensity of the Doppler signal at a particular frequency and moment in time is display as brightness at that point.

<u>2D colour flow imaging:</u> the Doppler signal is displayed in the form of a 2D color image superimposed on the B-scan image (Figure 7.6). Color represents the Doppler shift for each pixel, averaged over the area of the pixel.





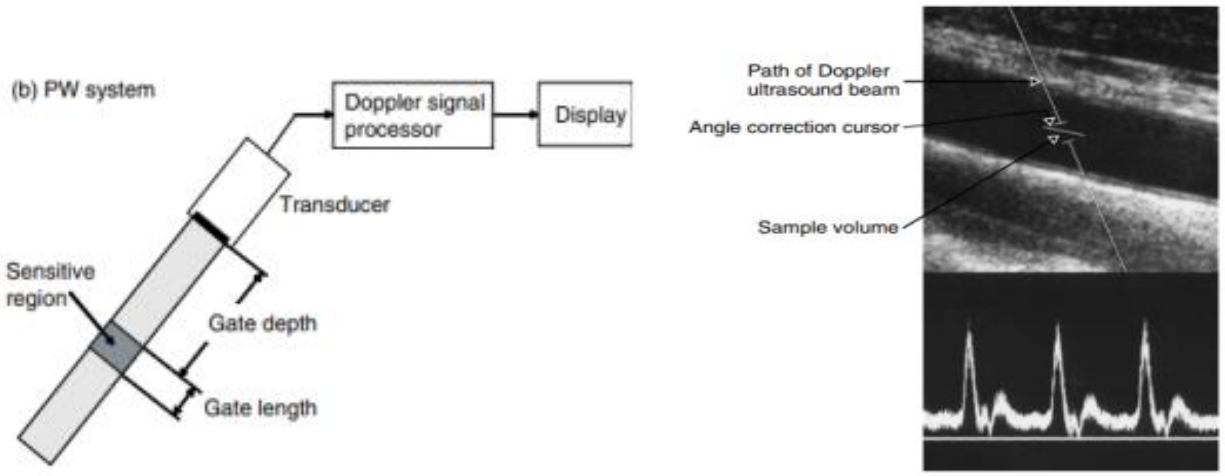
- Blood flow towards the transducer is coded red
- Blood flow away from the transducer is coded blue

Doppler ultrasound systems

Some Doppler ultrasound systems, known as continuous-wave (CW) systems, transmit ultrasound continuously. Other Doppler systems, known as pulsed-wave (PW) systems, transmit short pulses of ultrasound

Pulsed-wave Doppler

One main advantage of pulsed Doppler is its ability to provide Doppler shift data selectively from a small segment along the ultrasound beam, referred to as the "sample volume"



- The main advantage of PW Doppler is that Doppler signals can be acquired from a known depth
- The main disadvantage is that there is an upper limit to the Doppler frequency shift which can be detected, making the estimation of high velocities more challenging.

Continuous-Wave Doppler

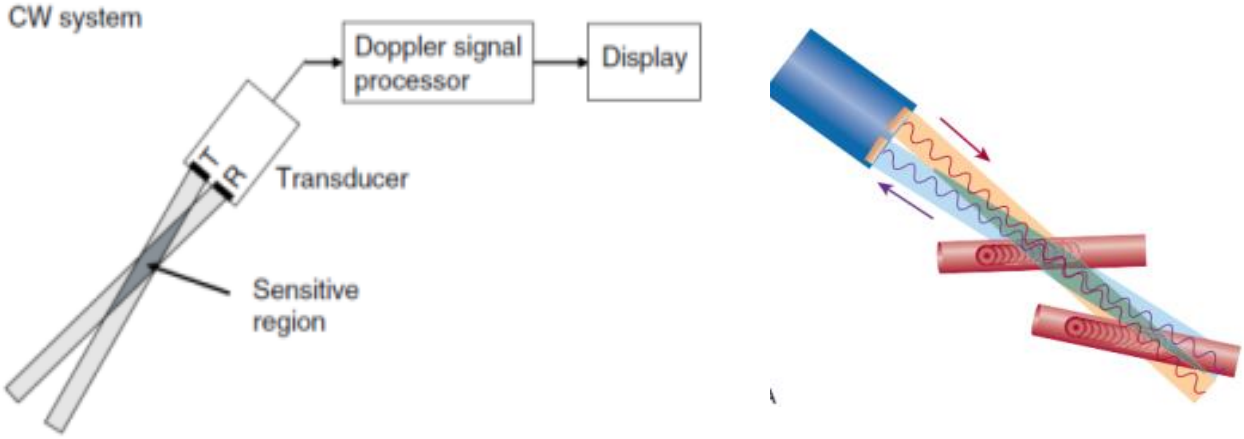
In a CW Doppler system there must be separate transmission and reception of ultrasound. It has two different piezoelectric crystals.

The advantage of CW Doppler

1. It has ability to measure high blood velocities along the ultrasound line (for example in aortic stenosis).

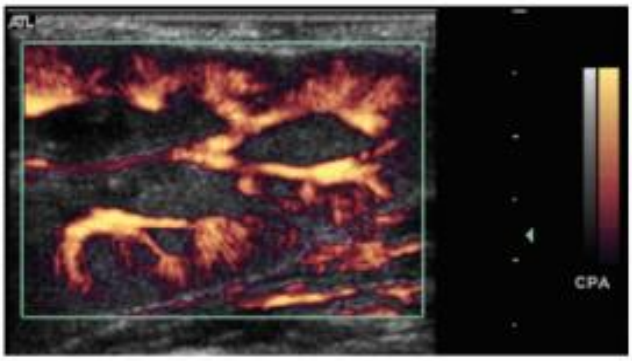
2. High accuracy of Doppler shift measurement is possible,

- The disadvantage CW devices are unable to distinguish signals arising from vessels at different depths (green-shaded area).



Power Doppler

Power Doppler uses a color map to show the distribution of the power or amplitude of the Doppler signal. Flow direction and velocity information are not provided, but noise is reduced



Advantages of Power Doppler

1. Much less angle dependence
2. Noise: a homogeneous background color
3. Increased sensitivity for low detection