# NEET SS ANESTHESIA

*Updated Notes 2026*

## CRITICAL CARE PART-1

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# HEMODYNAMIC MONITORING : I



Cardiovascular organ dysfunction : 2nd most common organ dysfunction.
Continuously observing changes in physiologic variables :

- To monitor organ function.
- For prompt therapeutic interventions.
- To evaluate response to therapeutic interventions.

monitoring per se does not improve patient outcomes.
Timely applied right interventions can cause imrpovement in outcomes.

## Assessing global and regional perfusion

00:01:19

Initial steps :

1. Clinical assessment.
2. Basic monitoring and assessment of global perfusion.
3. Preload monitoring and fluid responsiveness.

Advanced monitoring measures :

1. Cardiac output monitoring.
2. Assessment of cardiac contractility.
3. Assessment of tissue perfusion.

### Step 1 : Clinical assessment.

- Thirst.
- Cold extremities.
- Poor peripheral pulses.
- Impaired capillary refill.

→

- Tachypnoea, tachycardia.
- Confusion.
- Altered skin perfusion.
- Oliguria.

**Skin mottling :**

Important predictor of adverse outcome.

- Score 0 : No mottling.
- Score 1 : Small area of mottling, localised to centre of knee.
- Score 2 : modest mottling area that does not extend beyond superior border of kneecap.
- Score 3 : mild mottling area that does not extend beyond the mid-thigh.
- Score 4 : Severe mottling area, not going beyond the groin fold.
- Score 5 : Extremely severe mottling area, extending beyond groin fold.

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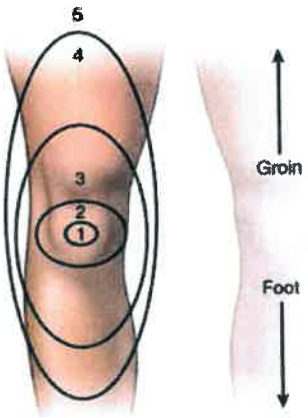
Mottling score

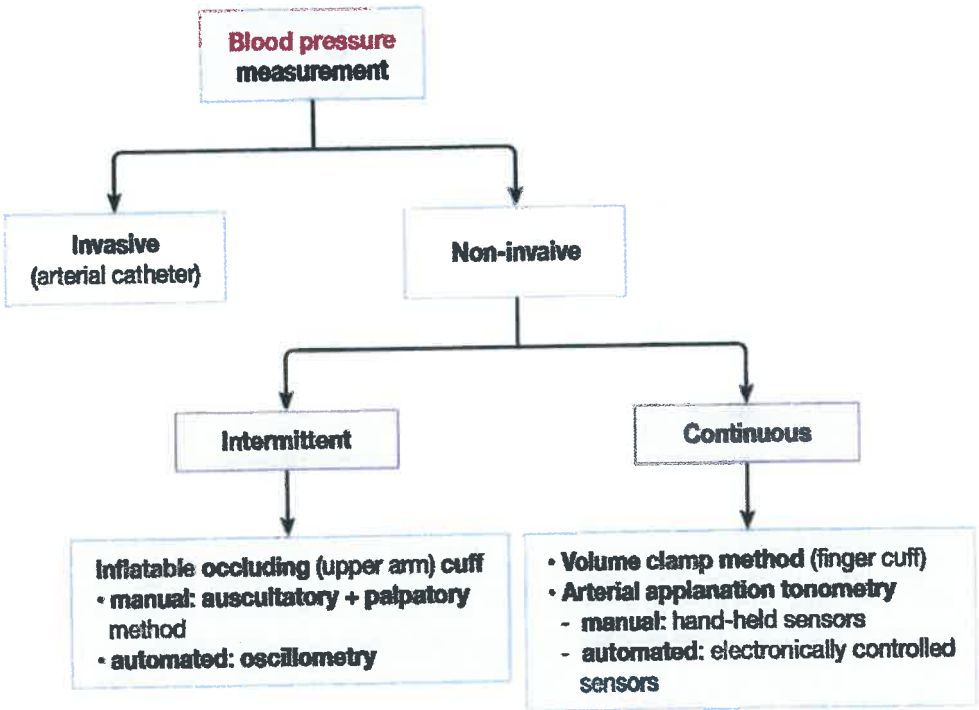




## Step 2 : Basic monitoring and assessment of global perfusion :

- 12 lead ECG.
- Blood pressure : Non invasive and invasive.
- Pulse oximetry ($SpO_2$).
- Lactate levels.
- Biochemical variables.

### Blood pressure monitoring :



NIBP : Intermittent.

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| Manual intermittent | Automated intermittent |
|---|---|
| • Described by Korotkow in 1905.<br>• Sphygmomanometer, cuff, and stethoscope needed.<br>• Auscultating sounds generated by turbulent arterial blood flow beyond cuff.<br>• Systolic : First Korotkoff sound.<br>• Diastolic : Before disappearance. | • Based on oscillometry.<br>• Cuff is coupled to an oscillometer.<br>• The cuff inflated above systolic pressure → Then gradually deflates.<br>• MAP : pressure at peak amplitude of arterial pulsations.<br>• SBP & DBP : Derived from proprietary formulas (Rate of change of pressure pulsations). |

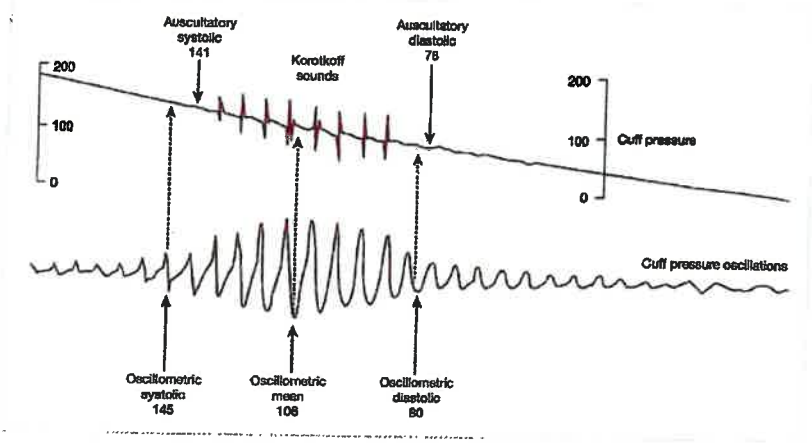
Cuff Size :

- Bladder length : 80% of arm circumference.
- Bladder width : 40% of arm circumference.
- Midline of cuff bladder should be positioned over the arterial pulsation.

| Patient | Recommended cuff size |
|---|---|
| **Adults (by arm circumference)** | |
| 22 to 26 cm | 12 x 22 cm (small adult) |
| 27 to 34 cm | 16 x 30 cm (adult) |
| 35 to 44 cm | 16 x 36 cm (large adult) |
| 45 to 52 cm | 16 x 42 cm (adult thigh) |

BP cuff size

Comparison of blood pressure measurements via Korotkoff sounds and oscillometry :



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Non invasive :

CNAP : Continuous noninvasive arterial pressure.

Volume clamp method (finger cuff) :

- Inflatable finger cuff with infrared
- plethysmography & monitor.
- Adjusts its pressure multiple times per second to keep volume in finger artery constant.
- Produce a brachial arterial waveform.

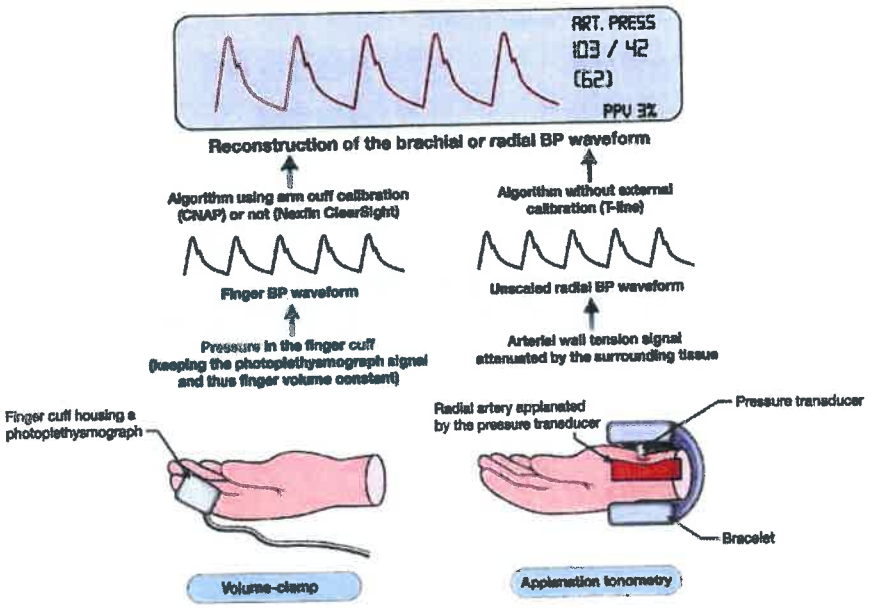

T- line system :

Based on applanation tonometry.

T- line system: Based on applanation tonometry

- Radial artery applanation :
- A pressure sensor applied over radial artery :
- Gently compresses artery : Applanates.
- The sensor is automatically moves over radial artery until optimal waveform is recorded.
- External applanation leads to reconstruction of BP waveform.
- mean BP measured directly (optimal waveform).

**Oscillometric, volume-clamp, and applanation tonometry technol arterial BP**




Invasive blood pressure :

- Gold standard for BP monitoring :
  - Arterial cannulation.
  - Continuous pressure transduction.
  - Waveform display.

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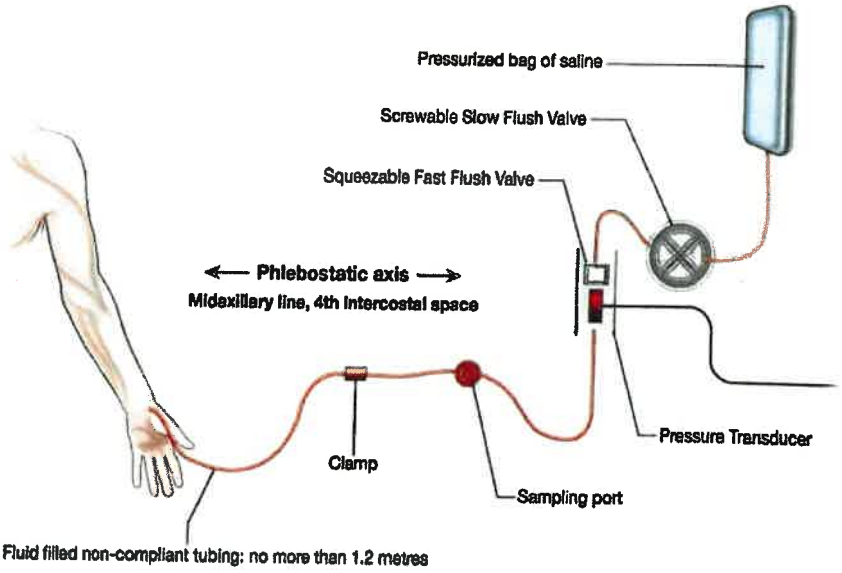
- Conventions :
  - Pressures expressed as mmHg.
  - Referenced to phlebostatic axis.
  - Zeroed to ambient pressure.

## Arterial Line Transducer Setup




Indications :

- Unstable blood pressure/severe hypotension.
- Use of rapidly acting vasoactive drugs : Vasodilators, vasopressors, inotropes.
- Frequent sampling of arterial blood.

Relative contraindications for invasive arterial pressure monitoring :

- Anticipation of thrombolytic therapy.
- Severe peripheral vascular disease preventing catheter insertion.
- Vascular anomalies : AV fistula, local aneurysm, local haematoma, Raynaud's disease.
- Lack of collateral blood flow distally (Eg : Radial artery previously used for coronary artery bypass surgery).

**Modified Allen test :**

- Used to assess adequacy of collateral circulation.
- Reduced collateral flow when palm remains pale >6 to 10 seconds.
- Disadvantage : Sensitivity (70-80%).

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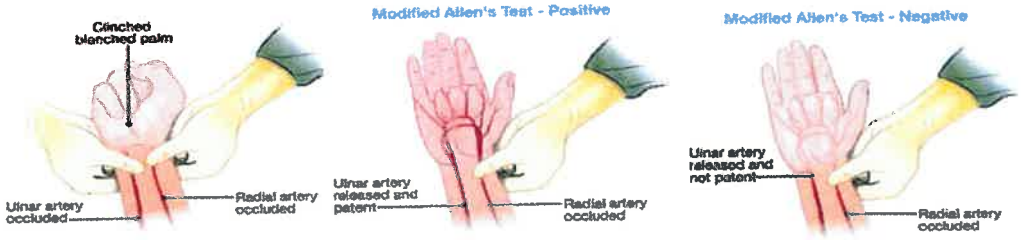


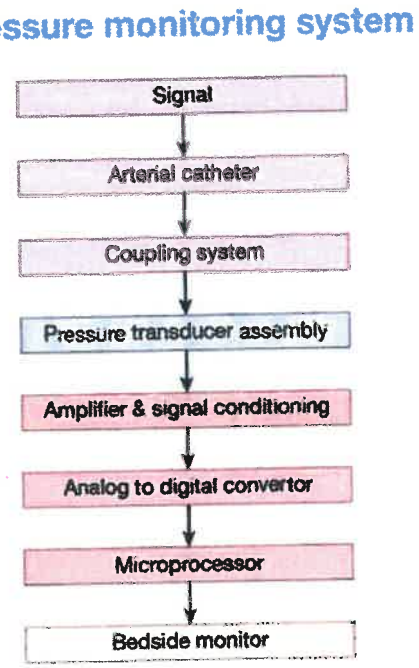

Common sites :

1. Radial.
2. Femoral.
3. Dorsalis pedis.
4. Posterior tibial.

Complications of direct arterial pressure monitoring :

- Distal ischemia, pseudoaneurysm, arteriovenous fistula.
- Hemorrhage.
- Arterial embolization.
- Infection.
- Peripheral neuropathy.
- Misinterpretation of data.
- Misuse of equipment.

Pressure monitoring system :



### Zeroing & levelling :

- Levelling : At level of the right atrium, we establish the 0 baseline..
- Zeroing : Opening the transducer stopcock to atmosphere.
- Stopcock at level of midaxillary line 4th ICS : Flavostatic axis.
- With the stopcock open, monitor displays 0.

Zeroing and Levelling

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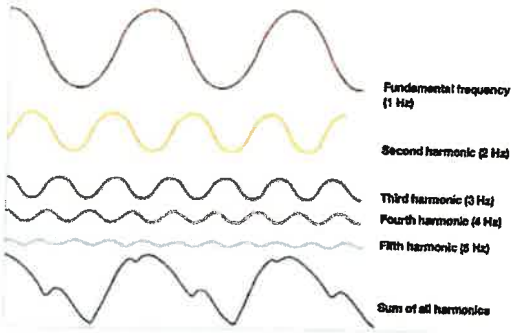
## Physics of arterial waveform 00:20:27

### Fourier analysis of complex waveform :

Arterial waveform is a composite of many waveforms of increasing frequencies (Harmonics).
8-10 harmonics.

Fourier analysis of a complex waveform




### Natural frequency :

Frequency at which a system oscillates.

$$\text{Natural frequency } f_n = \frac{1}{2\pi}\sqrt{\frac{\pi D^2}{4\rho L}\cdot\frac{\triangle P}{\triangle V}}$$

Dependent on :

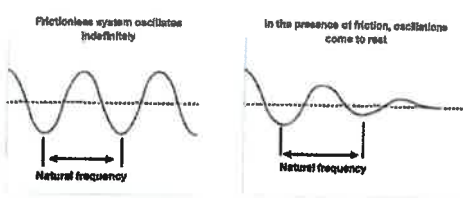
- Maximum diameter.
- Minimum length.
- Low compliance.

### The coupling system :

Fluid between artery and transducer acts as simple harmonic oscillator :

- Analogous to a pendulum.
- When the pendulum is displaced, it undergoes simple harmonic motion it oscillates around the equilibrium point.

The Coupling system



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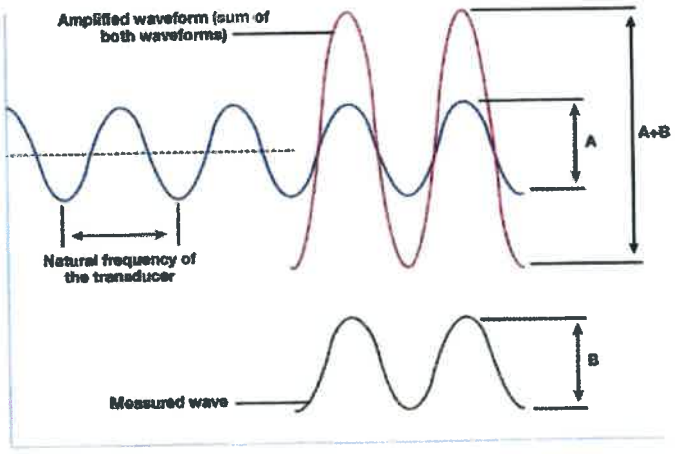
- Resonance : Amplification of a signal.
  Occurs when it's frequency is close to natural frequency of a system.

The Coupling system




- If natural frequency of pressure transducer matches with each peak of arterial pressure wave → Increase amplitude of the measured values.
- Transducer system must have a natural frequency well above the 8th harmonic frequency of a rapid pulse : >24Hz (Taking HR upto 180/min).

**Damping :**

- Absorption of energy (Amplitude) of oscillations :
  - Decreases amplitude of waves.
  - Reduces natural frequency of a system.
- Adequately damped → Amplitude should not change due to resonance.
- Diameter of the tubing has the greatest effect on damping.
- Damping increases by third power of any decrease in tubing diameter.

**Dynamic response :**

Ability of the system to accurately reproduce hemodynamic waveform.

**Damping coefficient :**

To assess how quickly an oscilating fluid filled system comes to rest.

Test : Fast flush test.

Arterial line setup : Damping adequacy.

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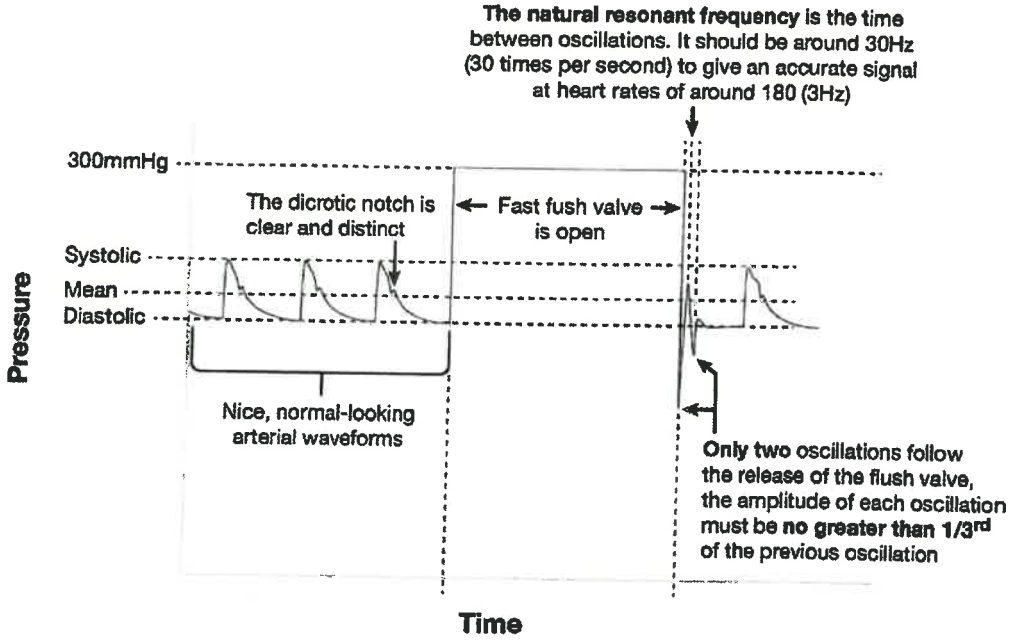
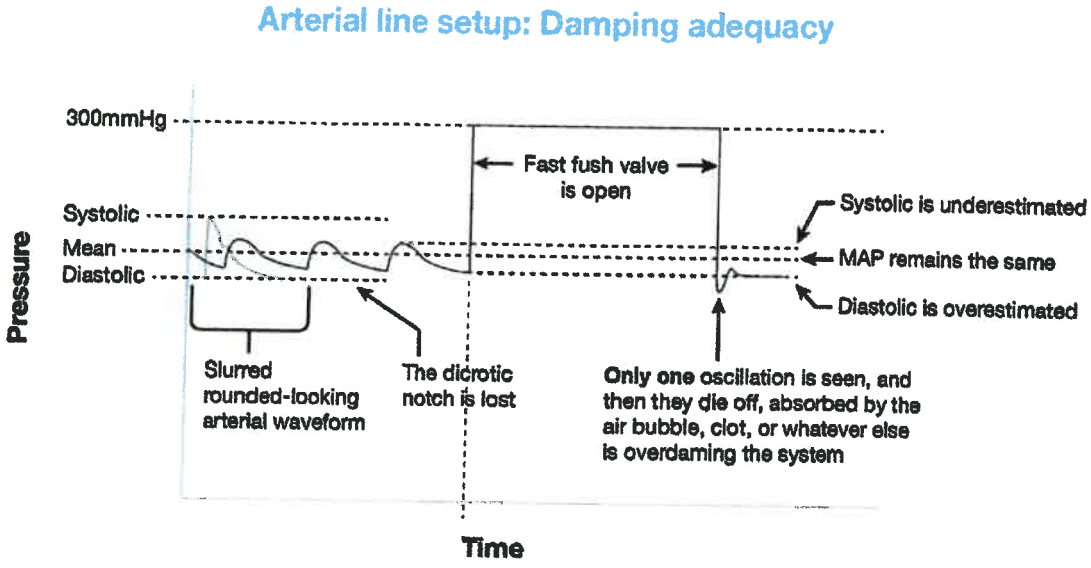



Over damped system :




Occurs in cases of : Clots, kinks, air bubbles, low compliant tubings, loose connection.

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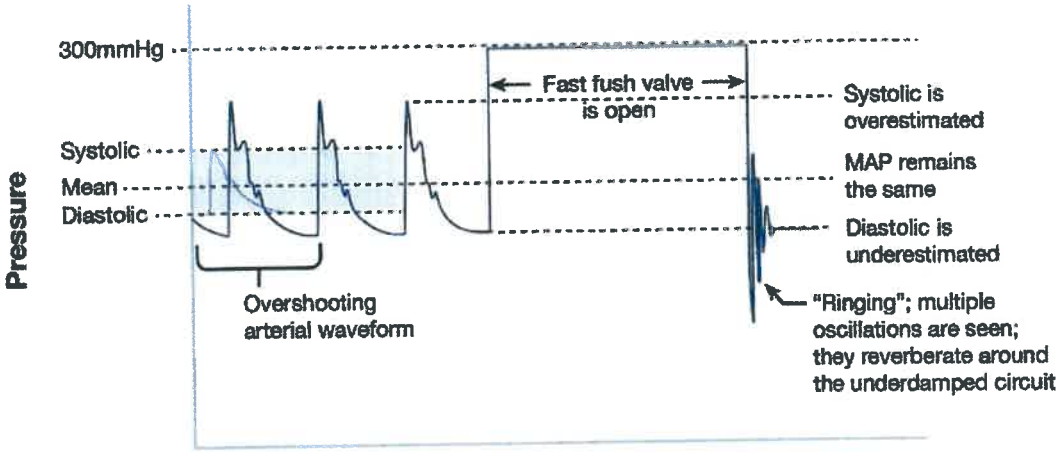
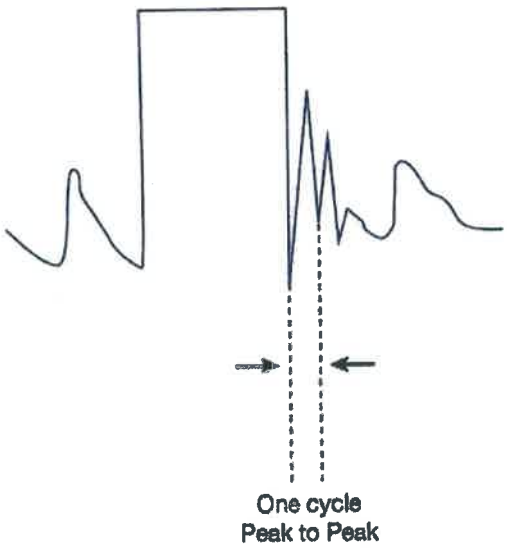
Underdamped system :




occurs in : Long tubing, hyperdynamic circulation, tachycardia, hypertension, atherosclerosis.

Determining frequency of a system :

## Determining $f_n$




$$f_n = \frac{\text{Paper speed (mm/sec)}}{\text{T ( time of one cycle) mm}}$$

If t = 1.2 mm, $f_n$ = 20Hz

**Amplitude ratio :**

Height of waves generated following a fast flush test.

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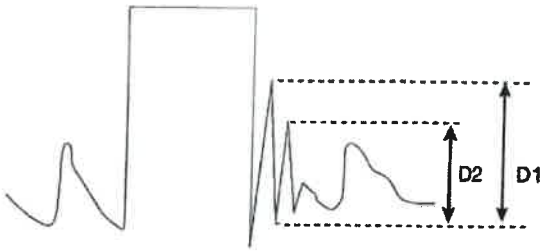
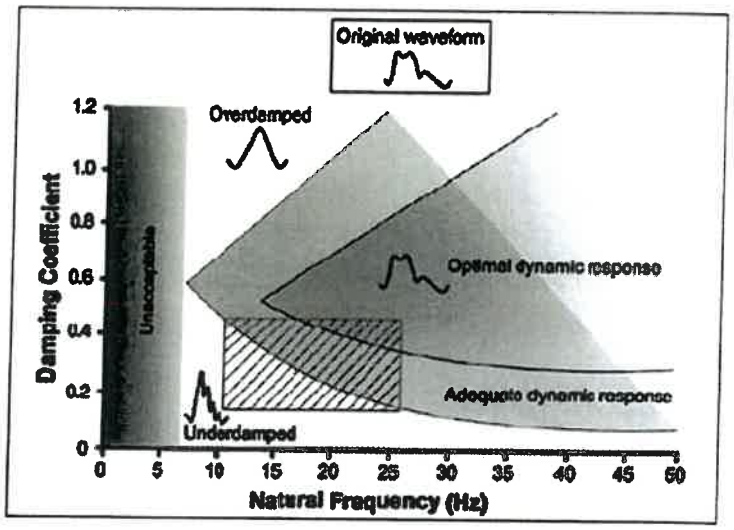


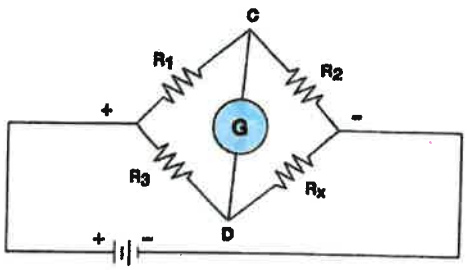

| Amp Ratio (D2/D1) | Damping coefficient |
|---|---|
| 0.9 | 0.034 |
| 0.8 | 0.071 |
| 0.7 | 0.113 |
| 0.6 | 0.160 |
| 0.5 | 0.215 |
| 0.4 | 0.280 |
| 0.3 | 0.358 |
| 0.2 | 0.456 |
| 0.1 | 0.591 |
| 0.05 | 0.690 |

**Arterial line setup : Dynamic response.**




**Pressure transducer :**

- A transducer is a device which converts energy from one form to another : Pressure into electrical energy.
- It acts on the principle of Wheatstone bridge.
- Wheatstone bridge : Electrical circuit with one unknown resistor.



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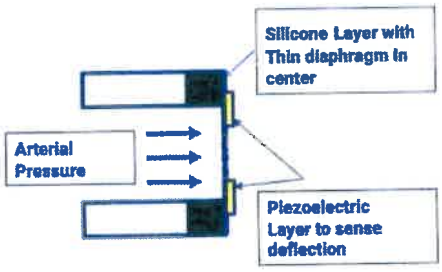
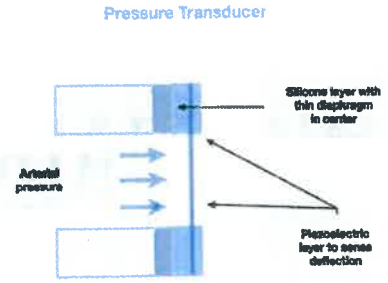
Mechanism :

- Piezoresistive strain gauges is used to complete the circuit.
- Wheatstone bridge is used to measure the unknown resistance (Of strain gauge).
- Resistance of unknown resistor is determined by pressure.



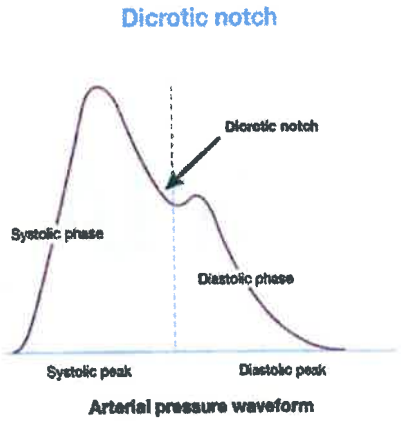

## Components of arterial pulse waveform 00:33:21

Components :

i. Systolic phase :
- Rapid increase in pressure to a peak.
- Begins with opening of aortic valve.
- Corresponds to LV ejection.

ii. Dicrotic notch :
Closure of aortic valve.

iii. Diastolic phase :
Run-off of blood into peripheral circulation.



Arterial pressure waveform

Analysis :

- On ECG, R wave signals beginning of systole.
- Systolic upstroke does not occur immediately following systole. There is 160-180 millisecond delay.