BLOOD PRESSURE MEASUREMENT (OSCILLOMETRIC) 8

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1.0 PURPOSE OF THE EXPERIMENT

Oscillometric Blood Pressure Measurement method is an method to measure the human blood pressure, which consist of both systolic and diastolic pressure. Blood pressure is a very common physiological parameter which is having very useful biological information about the heart. The experiment is designed in such a manner that it can measure the accurate value of systolic and diastolic blood pressure, also you can listen korotkoff sound using the headphone. Blood pressure gives the information about many diseases.

In korotkoff method a cuff is tied around the upper arm of the patient and microphone is applied over the brachial artery. The corresponding electrical signal are fed to a pre amplifier and then passed from a band pass filter having bandwidth 25–125 Hz, with this band pass filter a good signal to noise ratio is achieved when recording the korotkoff sound from the brachial artery beneath the lower edge of the cuff. The system is so designed that after getting first korotkoff sound switches the systolic pressure and lock the reading on the digital meter. In the same manner the diastolic value is fixed by the last korotkoff sound. The cuff is completely deflated automatically after an interval of 2-5 sec. after the determination of the diastolic value. Oscillometric blood pressure measurement kit is shown in Fig. 1.

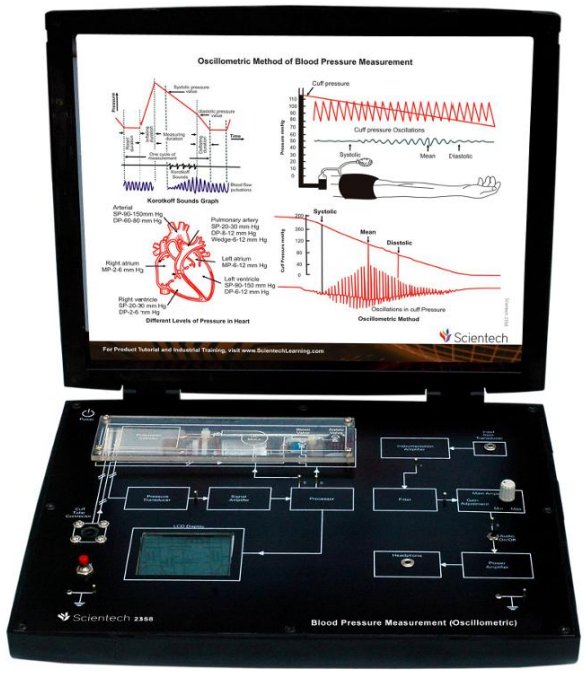


Figure 1.

Explanation of Block Diagram

1. DC motor: DC motor which is operating on 6 volt power supply, used to rotate the fan at a content speed to increase the pressure in the cuff.

2. Pneumatic Cylinder: This cylinder is used to compress the air at a specific point, which is coming from the fan. The output air of the cylinder increases the pressure of the cuff.

3. Pressure Transducer: Pressure detection mechanical capacitance pressure sensor is used to sense the pressure in the cuff and produces the analogous electrical output.

4. Signal amplifier: electrical signal coming from the pressure transducer is very weak signal; signal amplifier is used to amplify the signal.

5. Processor: All the controls of the blood pressure measurement system are controlled by the processor.

6. Bleed valve: Bleed valve is used to release the extra amount of the air after the diastolic pressure, the control are comes from the processor.

7. Safety valve: This valve is used to stop the air at the time when the pressure is increasing in the cuff.

8. LCD display: Liquid crystal display is used for displaying the value of both systolic and diastolic pressures.

9. Phonocardiograph sensor: The basic transducer for the phonocardiograph is a microphone having the necessary frequency response, generally ranging from below 5 Hz to above 1000 Hz.

10. Instrument amplifier: this amplifier is used for the amplification of the signal up to the desired level.

11. Filter : Filter is used to select the frequency ranges between 25-125Hz.(heart sound frequency)

12. Main amplifier: Main amplifier is used for the further amplification of the signal which is compatible to the power amplifier.

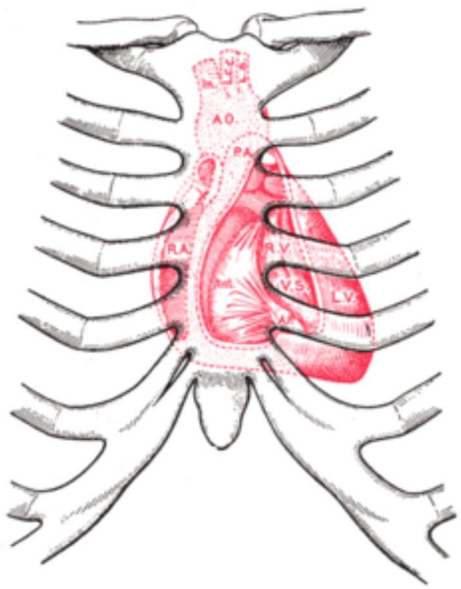
13. Power amplifier: Power amplifier is used to amplify the signal up to the desired audible level.

14. Head phone: Head phone is used to hear the Heart sound.

Human Cardiovascular System

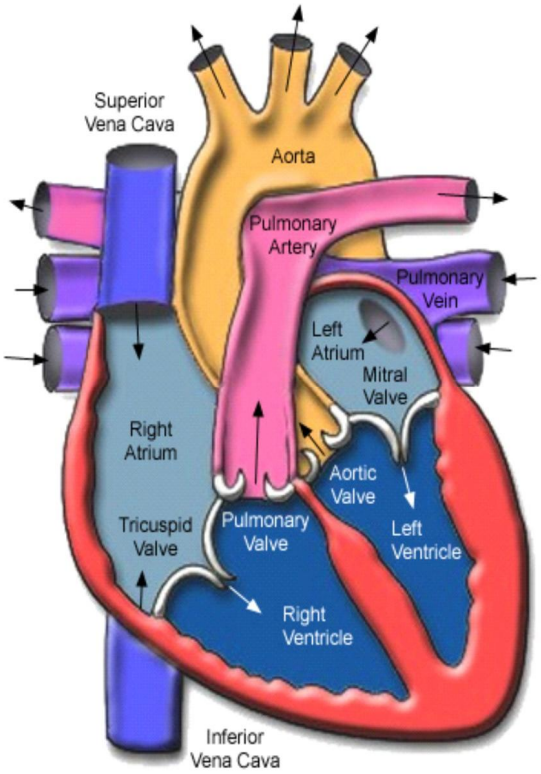
Position of Human Heart:

Heart is located between your lungs in the middle of your chest, behind and slightly to the left of your sternum. A double-layered membrane called the pericardium surrounds your heart like a sac. The outer layer of the pericardium surrounds the roots of your heart's major blood vessels and is attached by ligaments to your spinal column, diaphragm, and other parts of your body. The inner layer of the pericardium is attached to the heart muscle. A coating of fluid separates the two layers of membrane, letting the heart move as it beats; yet still be attached to your body.



Position of Heart in Human Body

Figure 2



Structure of Human Heart **Figure 3**

The Heart:

The heart is a hollow, muscular organ about the size of a fist. It is responsible for pumping blood through the blood vessels by repeated, rhythmic contractions. The heart is composed of cardiac muscle, an involuntary muscle tissue that is found only within this organ. The term "cardiac" (as in cardiology) means "related to the heart" and comes from the Greek word kardia, for "heart." It has a four-chambered, double pump and is located in the thoracic cavity between the lungs. The cardiac muscle is self-exciting, meaning it has its own conduction system. This is in contrast with skeletal muscle, which requires either conscious or reflex nervous stimuli. The heart's rhythmic contractions occur spontaneously, although the frequency or heart rate can be changed by nervous or hormonal influence.

Heart Walls:

1. Myocardium:

The myocardium is the muscular tissue of the heart. The myocardium is composed of specialized cardiac muscle cells with an ability not possessed by muscle tissue elsewhere in the body. Cardiac muscle, like other muscles, can contract, but it can also conduct electricity, like nerves. The blood to the myocardium is supplied by the coronary arteries. If these arteries are occluded by atherosclerosis and/or thrombosis, this can lead to angina pectoris or myocardial infarction due to ischemia (lack of oxygen). Failure of the heart to contract properly (for various reasons) is termed heart failure, generally leading

to fluid retention, edema, pulmonary edema, renal insufficiency, hepatomegaly, a shortened life expectancy and decreased quality of life

2. Pericardium:

The pericardium is the thick, membranous sac that surrounds the heart. It protects and lubricates the heart. There are two layers to the pericardium: the fibrous pericardium and the serous pericardium. The serous pericardium is divided into two layers; in between these two layers there is a space called the pericardial cavity.

3. Epicardium:

The layer next to the heart is the visceral layer, also known as the Epicardium. This is the innermost layer and consists of connective tissue.

Heart Chambers:

The heart has four chambers, two atria and two ventricles. The atria are smaller with thin walls, while the ventricles are larger and much stronger.

1. Atrium:

There are two atria on either side of the heart. On the right side is the atrium that contains blood which is poor in oxygen. The left atrium contains blood which has been oxygenated and is ready to be sent to the body. The right atrium receives de-oxygenated blood from the superior vena cava and inferior vena cava. The left atrium receives oxygenated blood from the left and right pulmonary veins.

2. Ventricles:

The ventricle is a heart chamber which collects blood from an atrium and pumps it out of the heart. There are two ventricles: the right ventricle pumps blood into the pulmonary circulation for the lungs, and the left ventricle pumps blood into the systemic circulation for the rest of the body. Ventricles have thicker walls than the atria, and thus can create the higher blood pressure. Comparing the left and right ventricle, the left ventricle has thicker walls because it needs to pump blood to the whole body. This leads to the common misconception that the heart lies on the left side of the body.

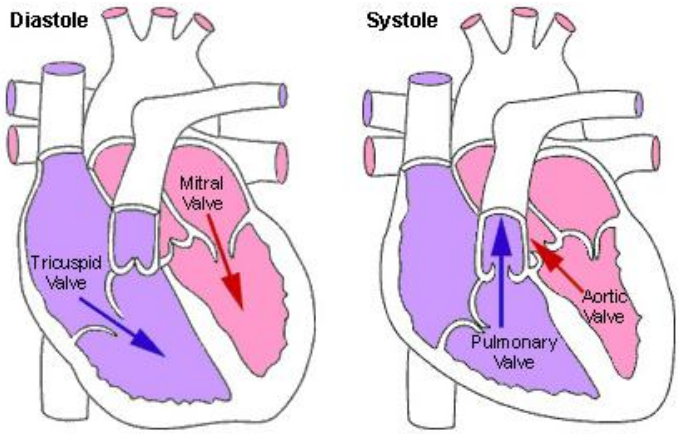
Heart Valves:

The two atrioventricular (AV) valves are one-way valves that ensure that blood flows from the atria to the ventricles, and not the other way. The two semilunar (SL) valves are present in the arteries leaving the heart; they prevent blood from flowing back into the ventricles. The sound heard in a heart beat is the heart valves shutting. The right AV valve is also called the tricuspid valve because it has three flaps. It is located between the right atrium and the right ventricle. The tricuspid valve allows blood to flow from the right atrium into the right ventricle when the heart is relaxed during diastole. When the heart begins to contract, the heart enters a phase called systole, and the atrium pushes blood into the ventricle. Then, the ventricle begins to contract and blood pressure inside the heart rises. When the ventricular pressure exceeds the pressure in the atrium, the

tricuspid valve snaps shut. The left AV valve is also called the bicuspid valve because it has two flaps. It is also known as the mitral valve due to the resemblance to a bishop's mitre (liturgical headdress). This valve prevents blood in the left ventricle from flowing into the left atrium. As it is on the left side of the heart, it must withstand a great deal of strain and pressure; this is why it is made of only two cusps, as a simpler mechanism entails a reduced risk of malfunction. There are two remaining valves called the Semilunar Valves. They have flaps that resemble half moons. The pulmonary semilunar valve lies between the right ventricle and the pulmonary trunk. The aortic semilunar valve is located between the ventricle and the aorta.

Four types of valves regulate blood flow through heart:

- The **tricuspid valve** regulates blood flow between the right atrium and right ventricle.
- The **pulmonary valve** controls blood flow from the right ventricle into the pulmonary arteries, which carry blood to your lungs to pick up oxygen.
- The **mitral valve** lets oxygen-rich blood from your lungs pass from the left atrium into the left ventricle.
- The **aortic valve** opens the way for oxygen-rich blood to pass from the left ventricle into the aorta, your body's largest artery, where it is delivered to the rest of your body.



Heart valve opening and closing during systole and diastole

Figure 4

Blood Flow after The Heart:

Aorta-Arteries-Arterioles-Capillaries-Venules-Veins-Vena Cava

Conduction pathway of Blood:

Blood | Heart → Aorta → Arteries → Arterioles → Capillaries → Venules → Veins → Vena cava → Heart → Pulmonary arteries → Lungs → Pulmonary vein

Right heart circulation:

(Vena cavae, coronary sinus) → Right atrium (auricle, fossa ovalis, limbus of fossa ovalis, crista terminalis, valve of the inferior vena cava, valve of the coronary sinus) → tricuspid valve → right ventricle (conus arteriosus, moderator band/septomarginal trabecula) → pulmonary valve → (pulmonary artery and pulmonary circulation)

Left heart circulation:

(Pulmonary veins) → left atrium (auricle) → mitral valve → left ventricle → aortic valve (aortic sinus) → (aorta and systemic circulation)

Arteries:

Arteries are muscular blood vessels that carry oxygenated blood away from the heart to the body. The only exception being the pulmonary artery that carries deoxygenated blood to the lungs. Arteries have a thick wall that consists of three layers. The inside layer is called the endothelium, the middle layer is mostly smooth muscle and the outside layer is connective tissue. The artery walls are thick so that when blood enters under pressure the walls can expand.

Arterioles:

An arteriole is a small artery that extends and leads to capillaries. Arterioles have thick smooth muscular walls. These smooth muscles are able to contract (causing vessel constriction) and relax (causing vessel dilation). This contracting and relaxing affects blood pressure; the higher number of vessels dilated, the lower blood pressure will be. Arterioles are just visible to the naked eye.

Capillaries:

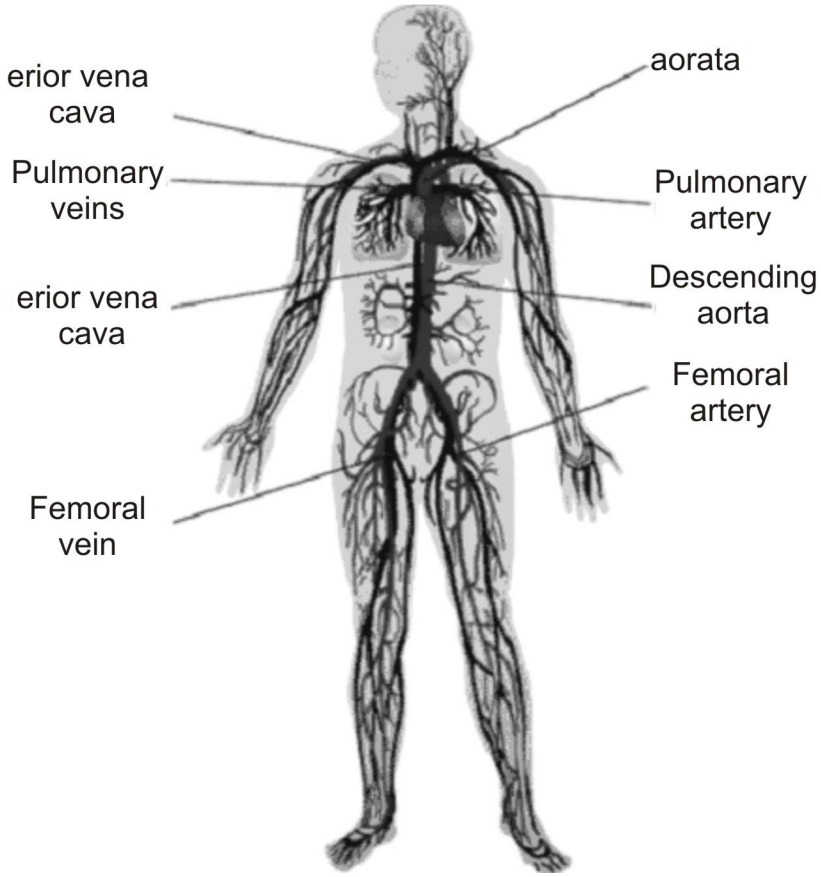
Capillaries are the smallest of a body's vessels; they connect arteries and veins, and most closely interact with tissues. They are very prevalent in the body; total surface area is about 6,300 square meters. Because of this, no cell is ever very far from a capillary. The walls of capillaries are composed of a single layer of cells, the endothelium. This layer is so thin that molecules such as oxygen, water and lipids can pass through them by diffusion and enter the tissues. Waste products such as carbon dioxide and urea can diffuse back into the blood to be carried away for removal from the body. The "capillary bed" is the network of capillaries present throughout the body. These beds are able to be "opened" and "closed" at any given time, according to need. This process is called autoregulation and capillary beds usually carry no more than 25% of the amount of blood it could hold at any time. The more metabolically active the cells, the more capillaries it will require to supply nutrients. Capillaries come in three types:

- **Continuous:** Continuous capillaries have a sealed epithelium and only allow small molecules, water and ions to diffuse.
- **Fenestrated:** Fenestrated capillaries (as their name implies "fenster") have openings that allow larger molecules to diffuse.
- **Sinusoidal:** Sinusoidal capillaries are special forms of fenestrated capillaries that have larger opening allowing RBCs and serum proteins to enter.

Veins:

Veins carry deoxygenated blood to the heart. The only exception to this is in the pulmonary vein that carries oxygenated blood to the heart. Most of the blood volume is found in the venous system; about 70% at any given time.The veins outer walls have the same three layers as the artery, differing only because there is a lack of smooth muscle in the inner layer and less connective tissue on the outer layer. Veins have low blood pressure compared to arteries and need the help of skeletal muscles to bring blood back to the heart. Most veins have one-way valves called venous valves to prevent backflow caused by gravity. They also have a thick collagen outer layer, which helps maintain blood pressure and stop blood pooling. If a person is standing still for long periods or is bedridden, blood can accumulates in veins and can cause varicose veins. The hollow internal cavity in which the blood flows is called the lumen. A muscular layer allows veins to contract, which puts more blood into circulation. Veins are used medically as points of access to the blood stream, permitting the withdrawal of blood specimens (venipuncture) for testing purposes, and enabling the infusion of fluid, electrolytes, nutrition, and medications (intravenous delivery).

The Cardiovascular Pathways:



Human Circulatory System

Figure 5

The double circulatory system of blood flow refers to the separate systems of pulmonary circulation and the systemic circulation in amphibians, birds and mammals (including humans.) In contrast, fishes have a single circulation system. For instance, the adult human heart consists of two separated pumps, the right side with the right atrium and ventricle (which pumps deoxygenated blood into the pulmonary circulation), and the left side with the left atrium and ventricle (which pumps oxygenated blood into the systemic circulation). Blood in one circuit has to go through the heart to enter the other circuit. Blood circulates through the body two to three times every minute. In one day, the blood travels a total of 19,000 km (12,000 miles)

Aorta:

The aorta is the largest of the arteries in the systemic circuit. The blood is pumped from the left ventricle into the aorta and from there it branches to all parts of the body. The aorta is an elastic artery, and as such is able to distend. When the left ventricle contracts to force blood into the aorta, the aorta expands. This stretching gives the potential energy that will help maintain blood pressure during diastole, as during this time the aorta contracts passively.

Superior Venae Cavae:

The superior vena cava (SVC) is a large but short vein that carries de-oxygenated blood from the upper half of the body to the heart's right atrium. It is formed by the left and right brachiocephalic veins (also referred to as the innominate veins) which receive blood from the upper limbs and the head and neck. The azygous vein (which receives blood from the ribcage) joins it just before it enters the right atrium.

Inferior Venae Cavae:

The inferior vena cava (or IVC) is a large vein that carries de-oxygenated blood from the lower half of the body into the heart. It is formed by the left and right common iliac veins and transports blood to the right atrium of the heart. It is posterior to the abdominal cavity, and runs along side of the vertebral column on its right side.

Cardiac Cycle:

Cardiac cycle is the term used to describe the relaxation and contraction that occur, as a heart works to pump blood through the body. Heart rate is a term used to describe the frequency of the cardiac cycle. It is considered one of the four vital signs. Usually it is calculated as the number of contractions (heart beats) of the heart in one minute and expressed as "beats per minute" (bpm). When resting, the adult human heart beats at about 70 bpm (males) and 75 bpm (females), but this rate varies between people. However, the reference range is nominally between 60 bpm (if less termed bradycardia) and 100 bpm (if greater, termed tachycardia). Resting heart rates can be significantly lower in athletes, and significantly higher in the obese. The body can increase the heart rate in response to a wide variety of conditions in order to increase the cardiac output (the amount of blood ejected by the heart per unit time). Exercise, environmental stressors or psychological stress can cause the heart rate to increase above the resting rate. The pulse is the most straightforward way of measuring the heart rate, but it can be deceptive when some strokes do not lead to much cardiac output. In these cases (as happens in some arrhythmias), the heart rate may be considerably higher than the pulse. Every single 'beat' of the heart involves three major stages: atrial systole, ventricular systole and complete cardiac diastole. Throughout the cardiac cycle, the blood pressure increases and decreases. As ventricles contract the pressure rise, causing the AV valves to slam shut.

The Heart's Electrical Conduction System

The heart is primarily made up of muscle tissue. A network of nerve fibers coordinates the contraction and relaxation of the cardiac muscle tissue to obtain an efficient, wave-like pumping action of the heart

SA Node:

The sinoatrial node (abbreviated SA node or SAN, also called the sinus node) is the impulse generating (pacemaker) tissue located in the right atrium of the heart. Although all of the heart's cells possess the ability to generate the electrical impulses (or action potentials) that trigger cardiac contraction, the sinoatrial node is what normally initiates it, simply because it generates impulses slightly faster than the other areas with pacemaker potential. Because cardiac myocytes, like all nerve cells, have refractory periods following contraction during which additional contractions cannot be triggered, their pacemaker potential is overridden by the sinoatrial node. The SA node emits a new impulse before either the AV or purkinje fibers reach threshold. The sinoatrial node (SA node) is a group of cells positioned on the wall of the right atrium, near the entrance of the superior vena cava. These cells are modified cardiac myocytes. They possess some contractile filaments, though they do not contract. Cells in the SA node will naturally discharge (create action potentials) at about 70-80 times/minute. Because the sinoatrial node is responsible for the rest of the heart's electrical activity, it is sometimes called the primary pacemaker. If the SA node doesn't function, or the impulse generated in the SA node is blocked before it travels down the electrical conduction system, a group of cells further down the heart will become the heart's pacemaker. These cells form the atrioventricular node (AV node), which is an area between the right atrium and ventricle, within the atrial septum. The impulses from the AV node will maintain a slower heart rate (about 40-60 beats per a minute). When there is a pathology in the AV node or purkinje fibers, an ectopic pacemaker can occur in different parts of the heart. The ectopic pacemaker typically discharges faster than the SA node and causes an abnormal sequence of contraction. The SA node is richly innervated by vagal and sympathetic fibers. This makes the SA node susceptible to autonomic influences. Stimulation of the vagus nerve causes decrease in the SA node rate (thereby causing decrease in the heart rate). Stimulation via sympathetic fibers causes increase in the SA node rate (thereby increasing the heart rate). The sympathetic nerves are distributed to all parts of the heart, especially in ventricular muscles. The parasympathetic nerves mainly control SA and AV nodes, some atrial muscle and ventricular muscle. Parasympathetic stimulation from the vagal nerves decreases the rate of the AV node by causing the release of acetylcholine at vagal endings which in turn increases the K+ permeability of the cardiac muscle fiber. Vagal stimulation can block transmission through AV junction or stop SA node contraction which is called "ventricular escape." When this happens, the purkinje fibers in the AV bundle develops a rhythm of their own. In the majority of patients, the SA node receives blood from the right coronary artery, meaning that a myocardial infarction occluding it will cause ischemia in the SA node unless there is a sufficiently good anastomosis from the left coronary artery. If not, death of the affected cells will stop the SA node from triggering the heartbeat.

AV node:

The atrioventricular node (abbreviated AV node) is the tissue between the atria and the ventricles of the heart, which conducts the normal electrical impulse from the atria to the ventricles. The AV node receives two inputs from the atria: posteriorly via the crista terminalis, and anteriorly via the interatrial septum. [1] An important property that is unique to the AV node is decremental conduction. This is the property of the AV node that prevents rapid conduction to the ventricle in cases of rapid atrial rhythms, such as atrial fibrillation or atrial flutter. The atrioventricular node delays impulses for 0.1 second before spreading to the ventricle walls. The reason it is so important to delay the cardiac impulse is to ensure that the atria are empty completely before the ventricles contract (Campbell et al, 2002). The blood supply of the AV node is from a branch of the right coronary artery in 85% to 90% of individuals, and from a branch of the left circumflex artery in 10% to 15% of individuals. In certain types of supraventricular tachycardia, a person could have two AV Nodes; this will cause a loop in electrical current and uncontrollably-rapid heart beat. When this electricity catches up with itself, it will dissipate and return to normal heart-beat speed.

AV Bundle:

The bundle of HIS is a collection of heart muscle cells specialized for electrical conduction that transmits the electrical impulses from the AV node (located between the atria and the ventricles) to the point of the apex of the fascicular branches. The fascicular branches then lead to the Purkinje fibers which innervate the ventricles, causing the cardiac muscle of the ventricles to contract at a paced interval. These specialized muscle fibers in the heart were named after the Swiss cardiologist Wilhelm His, Jr., who discovered them in 1893. Cardiac muscle is very specialized, as it is the only type of muscle that has an internal rhythm; i.e., it is myogenic which means that it can naturally contract and relax without receiving electrical impulses from nerves. When a cell of cardiac muscle is placed next to another, they will beat in unison. The fibers of the Bundle of HIS allow electrical conduction to occur more easily and quickly than typical cardiac muscle. They are an important part of the electrical conduction system of the heart as they transmit the impulse from the AV node (the ventricular pacemaker) to the rest of the heart. The bundle of HIS branches into the three bundle branches: the right left anterior and left posterior bundle branches that run along the intraventricular septum. The bundles give rise to thin filaments known as Purkinje fibers. These fibers distribute the impulse to the ventricular muscle. Together, the bundle branches and purkinje network comprise the ventricular conduction system. It takes about 0.03-0.04s for the impulse to travel from the bundle of HIS to the ventricular muscle. It is extremely important for these nodes to exist as they ensure the correct control and co-ordination of the heart and cardiac cycle and make sure all the contractions remain within the correct sequence and in sync.

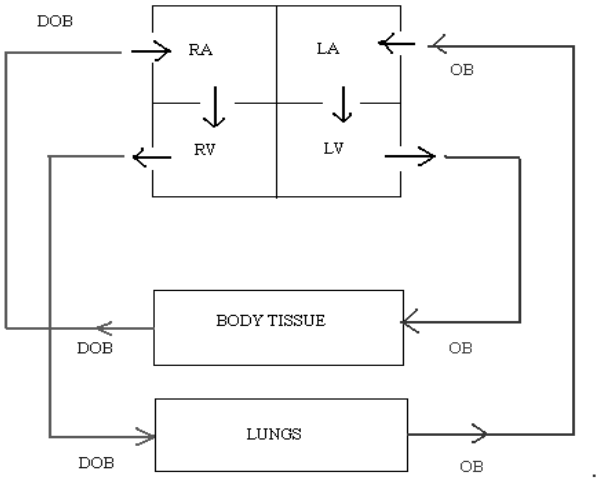
Purkinje Fibers:

Purkinje fibers (or Purkyne tissue) are located in the inner ventricular walls of the heart, just beneath the endocardium. These fibers are specialized myocardial fibers that conduct an electrical stimulus or impulse that enables the heart to contract in a coordinated fashion. Purkinje fibers work with the sinoatrial node (SA node) and the atrioventricular node (AV node) to control the heart rate. During the ventricular contraction portion of the cardiac cycle, the Purkinje fibers carry the contraction impulse from the left and right bundle branches to the myocardium of the ventricles. This causes the muscle tissue of the ventricles to contract and force blood out of the heart — either to the pulmonary circulation (from the right ventricle) or to the systemic circulation (from the left ventricle). They were discovered in 1839 by Jan Evangelista Purkinje, who gave them his name.

Pacemaker:

The contractions of the heart are controlled by electrical impulses, these fire at a rate which controls the beat of the heart. The cells that create these rhythmical impulses are called pacemaker cells, and they directly control the heart rate. Artificial devices also called pacemakers can be used after damage to the body's intrinsic conduction system to produce these impulses synthetically.

Double circulation of blood:



Flow of Blood in Heart, Lung and Body

Figure 6

The diagram shown above shows the double circulation of the human heart which means blood passes two times in the heart, when Deoxygenated blood (DOB) coming from the body tissue goes to the right auricle contraction of the heart takes place, the blood from RA goes to the right ventricle (RV), from the right ventricle blood comes outside of the heart and goes to the lungs for the oxygenation of the blood.

After the oxygenation of the blood in the lungs it goes to the left auricle (LA), left auricle pump the blood into left ventricle and finally this chamber of the heart pump the oxygenated blood towards the body tissue. This twice circulation of the blood is the special characteristics of the mammalians (Humans) and called as Double circulation of the mammalians heart.

OB…….Oxygenated blood

DOB …….. Deoxygenated blood

RA …… Right auricle

LA …… Left auricle

RV …… Right ventricle

LV …… Left ventricle

Blood pressure

Refers to the force exerted by circulating blood on the walls of blood vessels, and constitutes one of the principal vital signs. The pressure of the circulating blood decreases as blood moves through arteries, arterioles, capillaries, and veins; the term blood pressure generally refers to arterial blood pressure, i.e., the pressure in the larger arteries, arteries being the blood vessels which take blood away from the heart. Blood pressure is most commonly measured via a Sphygmomanometer, which uses the height of a column of mercury to reflect the circulating pressure (Non-invasive measurement). Although many modern blood pressure devices no longer use mercury, blood pressure values are still universally reported in millimetres of mercury (mmHg).

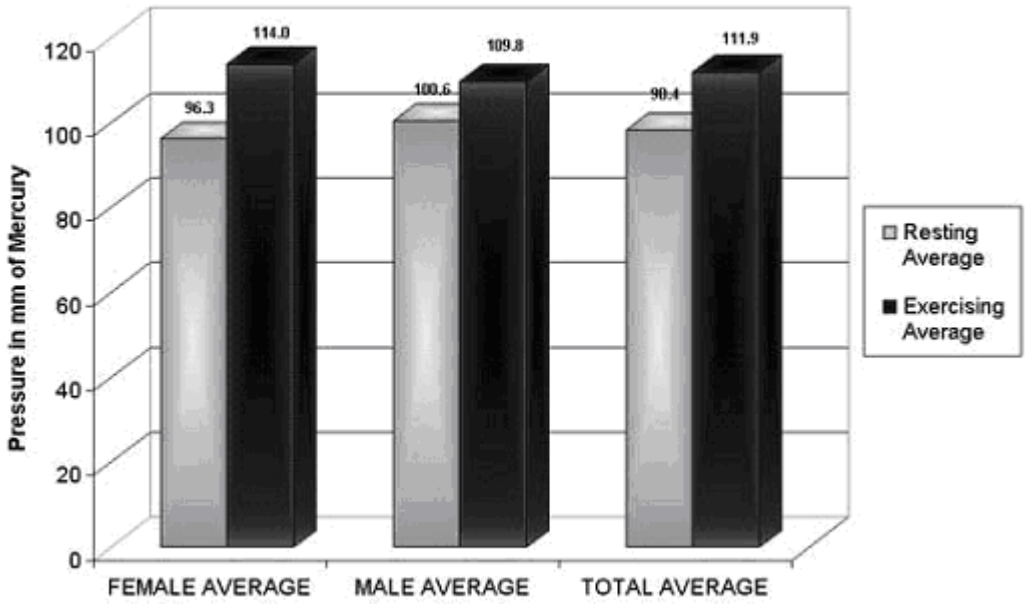
The systolic pressure is defined as the peak pressure in the arteries, which occurs near the beginning of the cardiac cycle; the diastolic pressure is the lowest pressure (at the resting phase of the cardiac cycle). The average pressure throughout the cardiac cycle is reported as Mean Arterial Pressure; the pulse pressure reflects the difference between the maximum and minimum pressures measured.

Typical values for a resting, healthy adult human are approximately 120 mmHg systolic and 80 mmHg diastolic (written as 120/80 mmHg, and spoken as "one twenty over eighty"), with large individual variations. These measures of blood pressure are not static, but undergo natural variations from one heartbeat to another and throughout the day (in a circadian rhythm); they also change in response to stress, nutritional factors, drugs, or disease. Hypertension refers to blood pressure being abnormally high, as opposed to hypotension, when it is abnormally low.

Normal values:

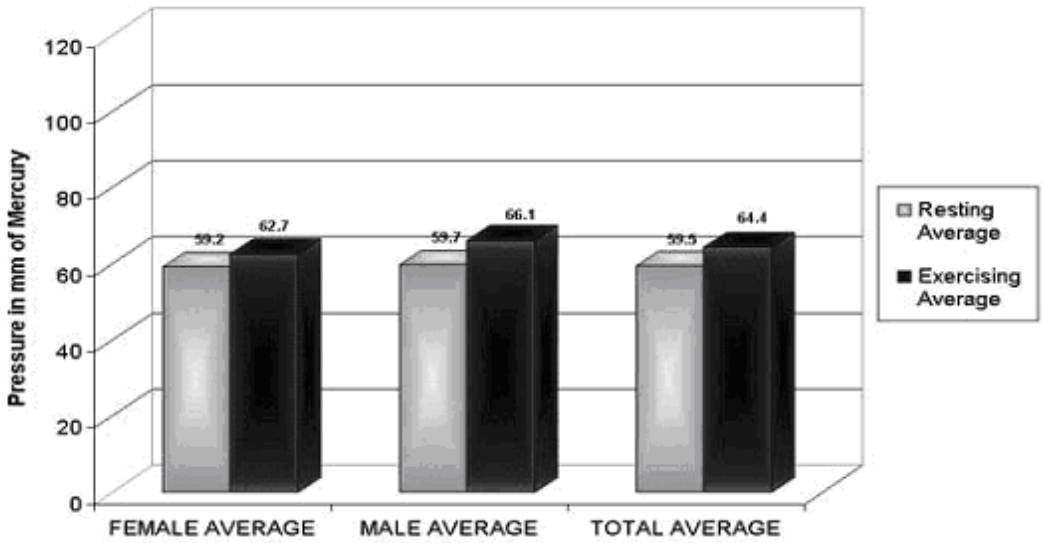
- **Systolic :** less than 120 mmHg (2.32 psi or 15 kPa)
- **Diastolic :** less than 80 mmHg (1.55 psi or 10 kPa)

Levels above 120 but below 140 mmHg in systolic pressure, or above 80 but below 95 mmHg in diastolic pressure, are referred to as "prehypertensive" and often progress to frankly hypertensive levels.



Systolic resting vs. exercising blood pressure

Figure 7



Diastolic resting vs. exercising blood pressure

Figure 8

1.1 PHYSIOLOGICAL PRINCIPLES

High blood pressure (Hypertension):

Blood pressure exceeding normal values is called arterial hypertension. Persistent hypertension is one of the risk factors for strokes, heart attacks, heart failure, arterial aneurysms, and is the leading cause of chronic renal failure.

Low blood pressure (Hypotension):

Blood pressure that is too low is known as hypotension. Low blood pressure may be a sign of severe disease and requires urgent medical attention.When blood pressure and blood flow decrease beyond a certain point, the perfusion of the brain becomes critically decreased (i.e., the blood supply is not sufficient), causing lightheadedness, dizziness, weakness and fainting.

Measurement of Blood Pressure

Non-invasive measurement:

The non-invasive auscultatory (from the Latin for listening) and oscillometric measurements are simpler and quicker than invasive measurements, require less expertise in fitting, have virtually no complications, and are less unpleasant and painful for the patient. However, non-invasive measures may yield somewhat lower accuracy and small systematic differences in numerical results. Non-invasive measurement methods are more commonly used for routine examinations and monitoring.The auscultatory method uses a stethoscope and a sphygmomanometer. This comprises an inflatable (*Riva-Rocci*) cuff placed around the upper arm at roughly the same vertical height as the heart, attached to a mercury or aneroid manometer. The mercury manometer, considered to be the gold standard for blood pressure measurement, measures the height of a column of mercury, giving an absolute result without need for calibration, and consequently not subject to the errors and drift of calibration which affect other methods. The use of mercury manometers is often required in clinical trials and for the clinical measurement of hypertension in high risk patients, including pregnant women.

A cuff of appropriate size is fitted and inflated manually by repeatedly squeezing a rubber bulb until the artery is completely occluded. Listening with the stethoscope to the brachial artery at the elbow, the examiner slowly releases the pressure in the cuff. When blood just starts to flow in the artery, the turbulent flow creates a "whooshing" or pounding sound (first Korotkoff sounds). The pressure at which this sound is first heard is the systolic blood pressure. The cuff pressure is further released until no sound can be heard (fifth Korotkoff sound), at the diastolic blood pressure.

1.1 PHYSIOLOGICAL PRINCIPLES

Oscillometric methods

Oscillometric methods are sometimes used in the long-term measurement and sometimes in general practice. The equipment is functionally similar to that of the auscultatory method, but has distinct advantages over auscultatory method, since sound is not used to measure blood pressure in this method. In addition this technique does not require a microphone or transducer in the cuff, placement of the cuff is not as critical as it with other methods.

This method work without a signifiocance loss in accuracy even the cuff is placed over the light sleeve. The disadvantage of this method is that excessive movement or vibration during the measurment can cause inaccurate reading.

This technique is based on the principle as that as an occluding cuff deflates from a level above the systolic pressure,the artery wall began to vibrate as the blood flowsturbulently,through the partially occluded artery and these vibration will be sensed in the transducer system monitoring cuff pressure.as the pressure in the cuff further decreases the oscillation increase to a maximum amplidude and then decreases untll the cuff fully deflate and blood flow returne to normal. Cuff pressure at the point of maximum oscillation usually coresponde to the mean arterial pressure (average pressure),the point above the mean pressure at which the oscillation begains to rapiddly increase in amplitude correlates with the diastolc pressure. Oscillomatric is based on oscillomatric pulses (pressure pulses) generated in the cuff during inflation or deflation. Pulse pressure is the difference between systolic and diastolic pressure.

The cuff is inflated to a pressure initially in excess of the systolic blood pressure, and then deflated to below diastolic pressure over a period of about 30 seconds. When blood flow is nil (cuff pressure exceeding systolic pressure) or unimpeded (cuff pressure below diastolic pressure) cuff pressure will be essentially constant. It is essential that the cuff size is correct: undersized cuffs may yield too high a pressure, whereas oversized cuffs yields too low a pressure. When blood flow is present, but restricted, the cuff pressure, which is monitored by the pressure sensor, will vary periodically in synchrony with the cyclic expansion and contraction of the brachial artery, i.e., it will oscillate. The values of systolic and diastolic pressure are computed, not actually measured from the raw data, using an algorithm; the computed results are displayed.

1.1 PHYSIOLOGICAL PRINCIPLES

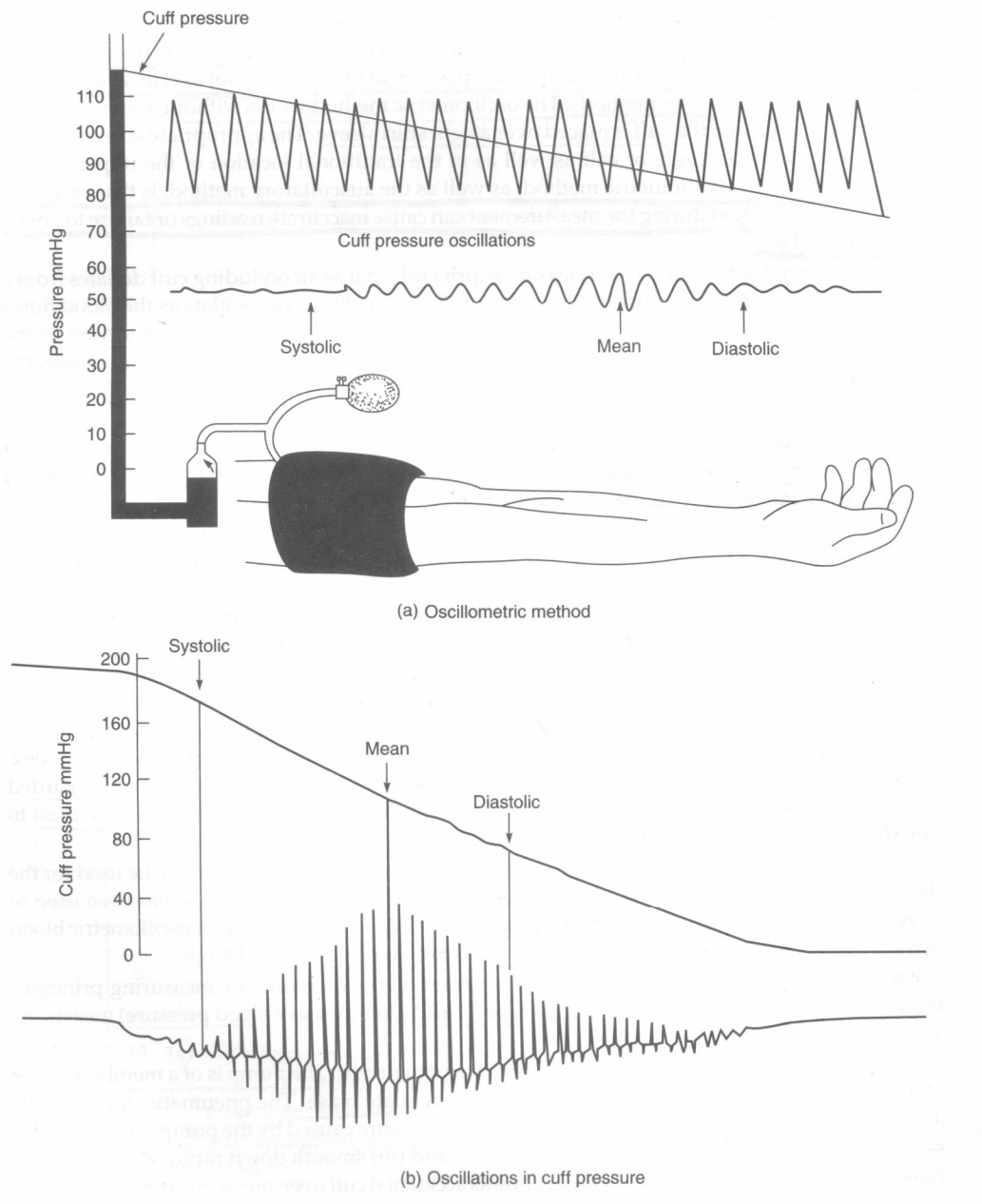
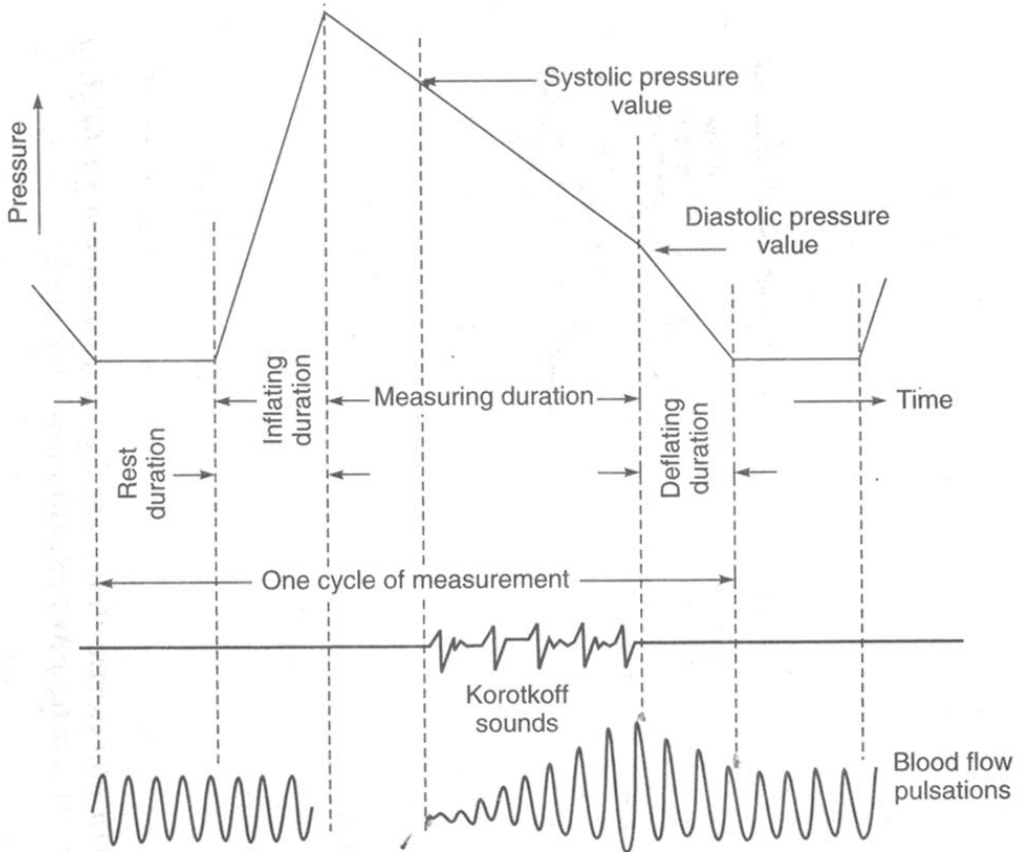


Illustration of Oscillometric method of blood pressure measurement

Figure 9

Korotkoff Sound:



Blood pressure measurement based on korotkoff's sound

Figure 10

Heart Sounds

heart sound are the noises (sound) generated by the beating heart and the resultant flow of blood through it. This is also called a heartbeat. In cardiac auscultation, an examiner uses a stethoscope to listen for these sounds, which provide important information about the condition of the heart.

In healthy adults, there are two normal heart sounds often described as a lub and a dub (or dup), that occur in sequence with each heart beat. These are the first heart sound (S_1) and second heart sound (S_2), produced by the closure of the AV valves and semilunar valves respectively. In addition to these normal sounds, a variety of other sounds may be present including heart murmurs and adventitious sounds.

Heart murmurs are generated by turbulent flow of blood, which may occur inside or outside the heart. Murmurs may be physiological (benign) or pathological (abnormal). Abnormal murmurs can be caused by stenosis restricting the opening of a heart valve, causing turbulence as blood flows through it. Valve insufficiency (or regurgitation) allows backflow of blood when the incompetent valve is supposed to be closed. Different murmurs are audible in different parts of the cardiac cycle, depending on the cause of the murmur.

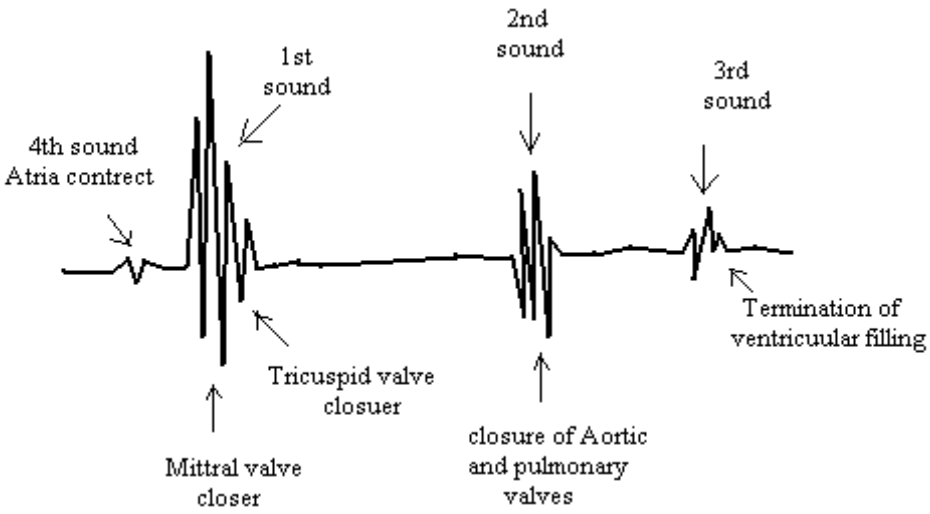


Figure 11

Heart Sounds

First heart tone S_1, the "LUB":

The first heart tone, or S_1, is caused by the sudden block of reverse blood flow due to closure of the atrioventricular valves, mitral and tricuspid, at the beginning of ventricular contraction, or systole. When the pressure in the ventricles rises above the pressure in the atria, venous blood flow entering the ventricles is pushed back toward the atria, catching the valve leaflets, closing the inlet valves and preventing regurgitation of blood from the ventricles back into the atria. The **S_1** sound results from reverberation within the blood associated with the sudden block of flow reversal by the valves.

Second heart tone S_2 the "DUB":

The second heart tone, or S_2, is caused by the sudden block of reversing blood flow due to closure of the aortic valve and pulmonary valve at the end of ventricular systole, i.e beginning of ventricular diastole. As the left ventricle empties, its pressure falls below the pressure in the aorta, aortic blood flow quickly reverses back toward the left ventricle, catching the aortic valve leaflets and is stopped by aortic (outlet) valve closure. Similarly, as the pressure in the right ventricle falls below the pressure in the pulmonary artery, the pulmonary (outlet) valve closes. The S_2 sound results from reverberation within the blood associated with the sudden block of flow reversal.

Extra heart sounds:

The rarer extra heart sounds are heard in both normal and abnormal situations.

Third heart sound S_3:

Rarely, there may be a third heart sound S3. The third heart sound or protodiastolic sound is not of valvular origin, as it occurs at the beginning of diastole just after S2. This sound occurs when the left ventricle is not very compliant, and at the beginning of diastole the rush of blood into the left ventricle causes vibration of the valve leaflets and the chordae tendinae.The third heart sound is normal in children and young adults, but disappears before middle age. Abnormal reemergence of this sound late in life indicates a pathological state, often a sign of a failing left ventricle as in dilated congestive heart failure (CHF). This sound is called a protodiastolic gallop, a type of gallop rhythm.

Fourth heart sound S_4:

The rare fourth heart sound S4 is sometimes audible in healthy children, but when audible in an adult is called a presystolic gallop. This gallop is a sign of a pathologic state, usually a failing left ventricle. This sound occurs just after atrial contraction ("atrial kick") and is the sound of blood being forced into a stiff/hypertrophic left ventricle. The combined presence of S3 and S4 is a quadruple gallop. At rapid heart rates, S3 and S4 may merge to produce a summation gallop.

Cardiovascular Disease:

Cardiovascular disease refers to the class of diseases that involve the heart and/or blood vessels (arteries and veins). While the term technically refers to any disease that affects the cardiovascular system, it is usually used to refer to those related to atherosclerosis (arterial disease). These conditions have similar causes, mechanisms, and treatments. Over 50 million Americans have cardiovascular problems, and most other Western countries face high and increasing rates of cardiovascular disease. It is the number 1 cause of death and disability in the United States and most European countries. By the time that heart problems are detected, the underlying cause (atherosclerosis) is usually quite advanced, having progressed for decades. There is therefore increased emphasis on preventing atherosclerosis by modifying risk factors, such as healthy eating, exercise and avoidance of smoking.

Hypertension:

Hypertension or high blood pressure is a medical condition wherein the blood pressure is chronically elevated. Persistent hypertension is one of the risk factors for strokes, heart attacks, heart failure and arterial aneurysm, and is a leading cause of chronic renal failure.

Heart Attack:

Acute myocardial infarction (AMI or MI), commonly known as a heart attack, A heart attack occurs when the supply of blood and oxygen to an area of heart muscle is blocked, usually by a clot in a coronary artery. Often, this blockage leads to arrhythmias (irregular heartbeat or rhythm) that cause a severe decrease in the pumping function of the heart and may bring about sudden death. If the blockage is not treated within a few hours, the affected heart muscle will die and be replaced by scar tissue. It is the leading cause of death for both men and women all over the world

1.2 HOW to CONDUCT THE EXPERIMENT

Operating instructions

1. Insert the air connector plug into the air socket firmly.
2. When relaxed, rest your left elbow on the table with palm up so that the centre of your upper arme is at the same level as your heart.
3. Wrap the cuff very care fully in your hand, just 2-3 cm above the brachial artery.with the tube facing downwordand toword the inside of your arm.
4. The cuff should be wrapped directly to your skin.
5. Relax for 10-20 minuts before measurment.
6. Remain still and do not talk during measurement.
7. Blood pressure is varied by many factor, a single measurement does not reflect your true blood pressure. Take and record several readings over a period of time.
8. Wait atleast 5 minuts between successive measurements.
9. For listening the korotcoff sound place the Phonocardiogram sensor just over the brachial artery (just) below the cuff.

Error During the measurement:

If the error occurs during the measurement, the cuff deflates rapidly and stops measurement. The **"**Err" is displayed on the LCD screen.

Troubleshooting:

If an error occurs during measurement the operation is discontinued, an error code is displayed with 4 short beeps, follow the below recommended action and press start button again to initiate another measurement.

Error code	Possible cause(s)	Recommended Action
Err1	The cuff is suddenly unwrapped during measurement	A measurement can be stopped at any time by pressing Start button
Err2	Talk or move during measurement	Remain very still and quiet during the measurement
Err3	Air leakage	Contact the dealer for repair
Err4	The cuff is wrapped too loose or too tight	Wrape the arm cuff snugly at correct position
Err5	Squeeze the cuff during deflation	Do not the cuff during measurement

1.2 HOW to CONDUCT THE EXPERIMENT

Meanings of various symbols appearing during measurement



Measurement in progress



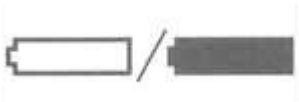
Irregular Heart beat



Inflation



Deflation



System not activated /activated

Figure 12

1.2 HOW to CONDUCT THE EXPERIMENT

Experiment 1

Objective: Measurement of systolic and diastolic blood pressure values of Human heart.

Equipments Needed:

1. **SCIENTECH 2358** Blood Pressure Measurement (Oscillometric)

Procedure:

1. Connect one end of the power supply to **SCIENTECH 2358** while other end to mains power supply
2. Switch ON the Mains power supply, then **SCIENTECH 2358**
3. Tie the cuff to your left arm just 2-3 cm above your elbow joint
4. Connect the cuff tube to the **SCIENTECH 2358**
5. Press the start button of the **SCIENTECH 2358**
6. Wait for some time while system shows the correct values of the blood pressure
7. See the values of systolic and diastolic pressure in the LCD screen

   Note: You can also see the waveform of the signals at output of different blocks in the Oscilloscope.

Observation Table:

S. No	Pressure	1	2	3	4	5
1	Systolic					
2	Diastolic					
3	Average					

Result: Average value of Systolic and diastolic pressures are

Systolic…….

Diastolic……

Questions:

1. How many types of valves regulate the blood flow through heart?
2. How is the blood pressure measurement done?

1.2 HOW to CONDUCT THE EXPERIMENT

Experiment 2

Objective: Observation (listening) of the Korotcoff sound waveforms during blood pressure measurement

Equipments Needed:

1. **SCIENTECH 2358** Blood Pressure Measurement (Oscillometric)
2. Phonocardiograph sensor
3. Oscilloscope
4. Head phone

Procedure:

1. Connect one end of the power supply to **SCIENTECH 2358** while other end to mains power supply
2. Switch ON the Mains power supply, then **SCIENTECH 2358**
3. Occlude the cuff to your left arm just 2-3 cm. above elbow joint
4. Connect the phonocardiograph sensor **SCIENTECH 2358**
5. Place the phonocardiograph sensor just over your brachial Artery
6. Connect Head phone to the Techbook kit
7. Press the start button of kit
8. Wait for some time while pressure is increasing up to systolic pressure
9. Listen the korotcoff sound in head phone very carefully when pressure is decresing below the systolic pressure value
10. Also see the sound waveform in oscilloscope

Observation Table:

S. No	Pressure	1	2	3	4	5
1	Systolic					
2	Diastolic					
3	Average					

Result: Average value of Systolic and diastolic pressures are

Systolic…….

Diastolic……

Questions:

1. What is first Korotkoff sounds?
2. What is fourth heart sound?

1.3 FREQUENTLY ASKED QUESTIONS

1. What is the function of heart?

The heart is a hollow, muscular organ about the size of a fist. It is responsible for pumping blood through the blood vessels by repeated, rhythmic contractions. The heart is composed of cardiac muscle, an involuntary muscle tissue that is found only within this organ. The term "cardiac" (as in cardiology) means "related to the heart" and comes from the Greek word kardia, for "heart."

2. Give the constructional details of heart?

It has a four-chambered, double pump and is located in the thoracic cavity between the lungs. The cardiac muscle is self-exciting, meaning it has its own conduction system. This is in contrast with skeletal muscle, which requires either conscious or reflex nervous stimuli. The heart's rhythmic contractions occur spontaneously, although the frequency or heart rate can be changed by nervous or hormonal influence.

3. What is Atrium?

There are two atria on either side of the heart. On the right side is the atrium that contains blood which is poor in oxygen. The left atrium contains blood which has been oxygenated and is ready to be sent to the body. The right atrium receives de-oxygenated blood from the superior vena cava and inferior vena cava. The left atrium receives oxygenated blood from the left and right pulmonary veins.

4. What is the function of Ventricles?

The ventricle is a heart chamber which collects blood from an atrium and pumps it out of the heart. There are two ventricles: the right ventricle pumps blood into the pulmonary circulation for the lungs, and the left ventricle pumps blood into the systemic circulation for the rest of the body. Ventricles have thicker walls than the atria, and thus can create the higher blood pressure. Comparing the left and right ventricle, the left ventricle has thicker walls because it needs to pump blood to the whole body. This leads to the common misconception.

5. How many types of valves regulate blood flow through heart?

Four types of valves regulate blood flow through heart:

- The tricuspid valve regulates blood flow between the right atrium and right ventricle.
- The pulmonary valve controls blood flow from the right ventricle into the pulmonary arteries, which carry blood to your lungs to pick up oxygen.
- The mitral valve lets oxygen-rich blood from your lungs pass from the left atrium into the left ventricle.
- The aortic valve opens the way for oxygen-rich blood to pass from the left ventricle into the aorta, your body's largest artery, where it is delivered to the rest of your body.

1.3 FREQUENTLY ASKED QUESTIONS

6. What is the Conduction pathway of Blood?

Blood | Heart → Aorta → Arteries → Arterioles → Capillaries → Venules → Veins → Vena cava → Heart → Pulmonary arteries → Lungs → Pulmonary vein

7. How many types of capillaries are there in heart?

There are three types Capillaries which are as follows:

- **Continuous:** Continuous capillaries have a sealed epithelium and only allow small molecules, water and ions to diffuse.
- **Fenestrated:** Fenestrated capillaries have openings that allow larger molecules to diffuse.
- **Sinusoidal:** Sinusoidal capillaries are special forms of fenestrated capillaries that have larger opening allowing RBCs and serum proteins to enter.

8. What is blood pressure?

The pressure of the circulating blood decreases as blood moves through arteries, arterioles, capillaries, and veins; the term blood pressure generally refers to arterial blood pressure, i.e., the pressure in the larger arteries, arteries being the blood vessels which take blood away from the heart.

9. What is first Korotkoff sounds?

When blood just starts to flow in the artery, the turbulent flow creates a "whooshing" or pounding sound (first Korotkoff sounds). The pressure at which this sound is first heard is the systolic blood pressure.

10. What is fourth heart sound?

The rare fourth heart sound S4 is sometimes audible in healthy children, but when audible in an adult is called a pre systolic gallop. This gallop is a sign of a pathologic state, usually a failing left ventricle. This sound occurs just after atrial contraction ("atrial kick") and is the sound of blood being forced into a stiff/hypertrophic.

Glossary

Aorta: the largest of the arteries in the systemic circuit.

Aortic Valve: lies between the left ventricle and the aorta.

Antidiuretic hormone: Produced in the posterior pituitary ADH (vasopressin), major function is to regulate blood pressure by water retention by the kidneys.

Arteriole: a small diameter blood vessel that extends and branches out from an artery and leads to capillaries.

Atrioventricular Node (abbreviated AV node): the tissue between the atria and the ventricles of the heart, which conducts the normal electrical impulse from the atria to the ventricles.

Atrioventricular valves: large, multi-cusped valves that prevent backflow from the ventricles into the atria during systole.

AV Bundle: collection of heart muscle cells specialized for electrical conduction that transmits the electrical impulses from the AV node.

Blood Pressure: the pressure exerted by the blood on the walls of the blood vessels.

Capillaries: the smallest of a body's vessels, they connect arteries and veins.

Cardiac Cycle: term used to describe the sequence of events that occur as a heart works to pump blood through the body.

Chordae Tendinae: cord-like tendons that connect the papillary muscles to the tricuspid valve and the mitral valve in the heart.

Coronary Arteries: blood vessels that supply blood to, and remove blood from, the heart muscle itself.

Diastole: period of time when the heart relaxes after contraction in preparation for refilling with circulating blood.

Diastolic Pressure: lowest point in blood pressure where the heart relaxes.

Edema: The swelling that forms when too much tissue fluid forms or not enough taken away.

Electrocardiogram: the recording of the heart's electrical activity as a graph.

Fibrous Pericardium: a dense connective tissue that protects the heart, anchoring it to the surrounding walls, and preventing it from overfilling with blood.

Heart Rate: term used to describe the frequency of the cardiac cycle.

Hepatic Veins: blood vessels that drain de-oxygenated blood from the liver and blood cleaned by the liver (from the stomach, pancreas, small intestine and colon) into the inferior vena cava.

Hypertension or High Blood Pressure: medical condition wherein the blood pressure is chronically elevated.

Inferior Vena Cava (or IVC): a large vein that carries de-oxygenated blood from the lower half of the body into the heart.

Intraventricular Septum: the stout wall separating the lower chambers (the ventricles) of the heart from one another.

Left Atrium: receives oxygenated blood from the left and right pulmonary veins.

Lub-Dub: first heart tone, or S1; caused by the closure of the atrioventricular valves, mitral and tricuspid, at the beginning of ventricular contraction, or systole.

Lumen: hollow internal cavity in which the blood flows.

Lymph: originates as blood plasma that leaks from the capillaries of the circulatory system, becoming interstitial fluid, filling the space between individual cells of tissue.

Mitral valve: also known as the bicuspid valve; prevents blood flowing from the left ventricle into the left atrium.

Myocardium: the muscular tissue of the heart.

Pacemaker Cells: cells that create these rhythmical impulses of the heart.

Pulmonary Valve: lies between the right ventricle and the pulmonary artery; prevents back-flow of blood into the ventricle.

Pulse: the number of heartbeats per minute.

Purkinje Fibers (or Purkinje tissue) : located in the inner ventricular walls of the heart, just beneath the endocardium; specialized myocardial fibers that conduct an electrical stimulus or impulse that enables the heart to contract in a coordinated fashion.

Right Atrium: receives de-oxygenated blood from the superior vena cava and inferior vena cava.

Semilunar Valves: positioned on the pulmonary artery and the aorta.

Sinoatrial Node: (abbreviated SA node or SAN, also called the sinus node): the impulse generating (pacemaker) tissue located in the right atrium of the heart.

Sinusoidal Capillaries: special forms of fenestrated capillaries that have larger opening allowing RBCs and serum proteins to enter.

Systole: contraction of the heart.

Systolic Pressure: the highest point in blood pressure when the blood is being pumped out of the left ventricle into the aorta during ventricular systole.

Superior Vena Cava (SVC): a large but short vein that carries de-oxygenated blood from the upper half of the body to the heart's right atrium.

Thrombus: a blood clot in an intact blood vessel.

Tricuspid Valve: on the right side of the heart, between the right atrium and the right ventricle; allows blood to flow from the right atrium into the right ventricle when the heart is relaxed during diastole.

Vasoconstriction: the constriction of blood vessels.

Vasodilation: the dilation of blood vessels.

Veins: carry de-oxygenated blood from the capillary blood vessels to the right part of the heart.

Ventricle: a heart chamber which collects blood from an atrium.

Venule: a small blood vessel that allows deoxygenated blood to return from the capillary beds to the larger blood vessels called.

Scientech 2358

Technical Specifications

Display	:	Large screen crystal digital display
Inflation	:	Automatic with built in pump
Technology	:	Oscillometric method monitor attached arm Cuff
Deflation	:	Automatic rapid air release method
Sensor	:	Pressure detection mechanical capacitance Pressure sensor
Measurement range	:	30-280 mmHg
Accuracy	:	Blood pressure: ± 4mmHg
Test Point	:	8 nos.
Dimensions (mm)	:	W 326 x D 252 x H 52
Power supply	:	110V - 260V AC, 50/60Hz
Weight	:	1.5 Kg. (approximately)
Operating Condition	:	$0\text{-}40^{0}$ C, 85% RH
Learning Material	:	Online on www.ScientechLearning.com