Knowledge domain: **Mechanical**
Unit: Calibration
Skill: Sphygmomanometer

Tools and Parts Required:

1) **Aneroid (Manual) sphygmomanometer**
2) **Stethoscope**
3) **Ruler**
4) **Marker**
5) **Water & wash bottle**
6) **Tubing**
7) **Y-shaped tubing (optional, can use from stethoscope)**
8) **Mercury sphygmomanometer (optional)**
9) **Needle nose or regular pliers**
10) **Adjustable Wrench**
11) **Small flathead screwdriver**

Introduction

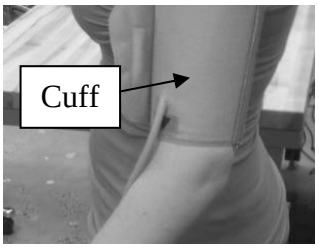
A blood pressure (BP) apparatus or sphygmomanometer is a medical device. A BP apparatus measures the vital sign of blood pressure. A BP apparatus has two parts: an inflatable cuff and a manometer. The inflatable cuff restricts blood flow to the arm. The manometer is aneroid or mercury. The manometer measures the pressure in the cuff. Blood pressure is measured in millimeters of mercury (mm Hg). A valve controls the pressure in the cuff. Close the valve to increase pressure. Open the valve to release the pressure.

Mercury manometer: A plastic or glass column connects to the cuff with rubber tubing. The tube is filled with mercury. The chemical abbreviation for mercury is “Hg”, so the unit for blood pressure is mm Hg (millimeters of mercury). The mercury height is between 0 millimeters and 300 mm Hg. The pressure reading equals the height of the mercury column.

Aneroid manometer: A circular dial displays blood pressures from 0 to 300 mm Hg. The needle on the dial points to the measured pressure.

A BP apparatus and a stethoscope are always used together. The operator of the BP apparatus uses the stethoscope to determine the blood pressure.

Introduction on How to Operate a BP Apparatus



1. Wrap the cuff snugly around the patient’s upper arm. Place the cuff at approximately the same height as the heart.

2. Turn the valve counterclockwise to close the valve

3. Use a stethoscope to listen to the patient’s pulse. Place the bell, or the circular end of the stethoscope, on the inside of the

elbow. You will hear the pulse from the brachial artery

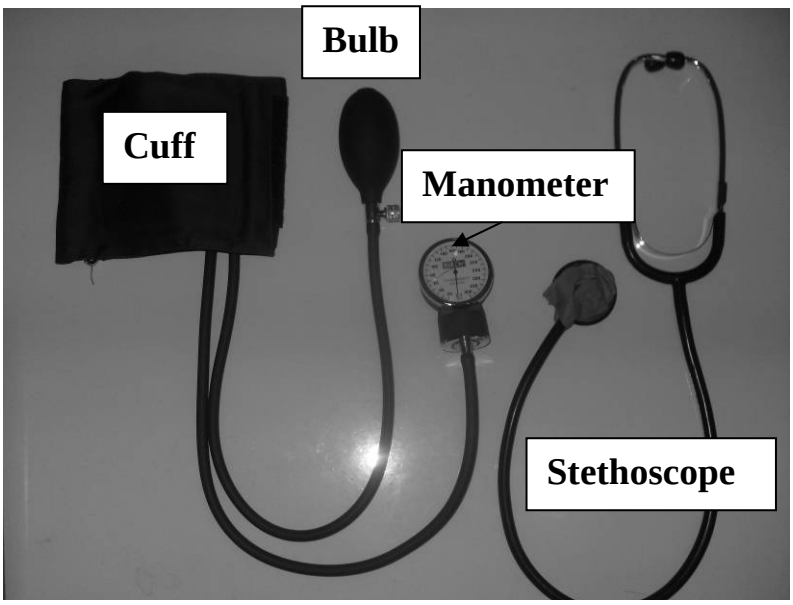
4. Squeeze the bulb repeatedly to inflate the cuff. The cuff will expand. Inflate the cuff completely to shut the artery.

5. Slowly open the valve to release the pressure gradually. While the pressure in the cuff decreases, you may hear a repeated rhythmic sound. These sounds are very difficult to hear. Practice is required to hear the sounds. The “systolic blood pressure” is the pressure value on the manometer when you first hear the rhythmic sound.

6. Slowly release the pressure in the cuff until you do not hear the rhythmic sound. The “diastolic pressure” is the pressure value on the manometer when the rhythmic sound first ceases.

7. Record the blood pressure. The blood pressure is “(systolic blood pressure measurement) over (diastolic blood pressure measurement).” For example, a nurse might say, “your blood pressure is 120 over 80.” Normal systolic blood pressure values are 110-140 mmHg. Normal diastolic blood pressure values are 60-90 mmHg. If you do not hear the sounds, it does not mean the system is broken. The sounds may be very difficult to hear.

Example
Below is a picture of a manual blood pressure apparatus.



Identification and Diagnosis

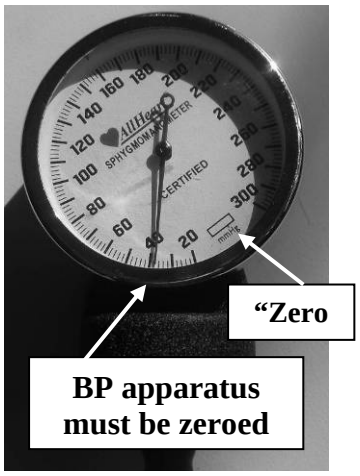
BP apparatuses need to be repaired if they are 1) leaking air or 2) not zeroed. A BP apparatus is leaking air if the manometer’s pressure decreases rapidly when the valve

is closed. A BP apparatus is not zeroed if the manometer does not read zero when at rest. Follow the instructions below to accurately test for these problems and repair the BP apparatus.

Procedure

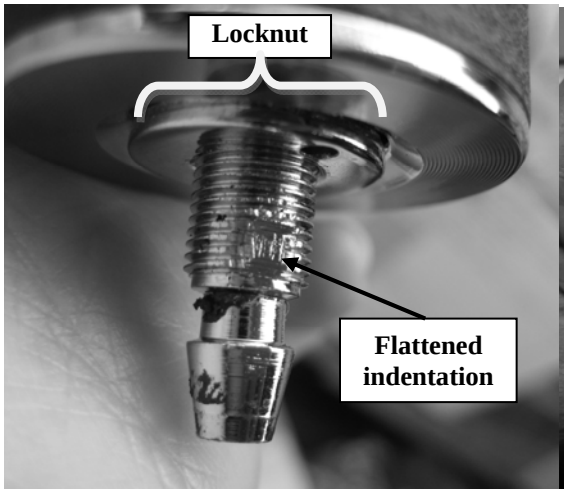
Aneroid manometer:

1. Check if there are any leaks
    - Wrap the cuff around a hard, cylindrical object. For example, metal water bottles, PVC pipes, table legs are appropriate objects.
    - Close the valve. Squeeze the bulb repeatedly. Inflate the cuff completely. If the pressure value decreases slowly (<5 mmHg per minute), there are no leaks in the tubing. If the pressure decreases faster than 5 mmHg per minute, check for leaks in the rubber tubing or cuff.
    - Close the valve. Squeeze the bulb repeatedly. Inflate the cuff completely. Open the valve slightly. The pressure should decrease slowly and consistently. If the pressure decreases quickly and inconsistently, check for leaks in the rubber tubing.
    - Repair any leaks. Refer to the skills in *Plumbing-Leaking*.

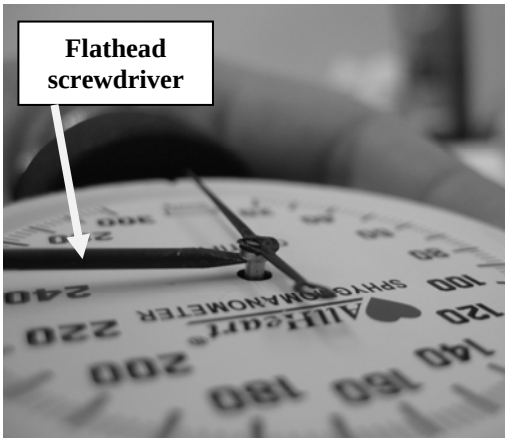


2. Check if the BP apparatus is zeroed at rest
    - When the cuff is not inflated, the needle should point to the rectangular box. The rectangular box may be labeled "ZERO." If the needle does not point within the box, the manometer must be zeroed. If the needle is within the box, skip step 4.

3. Zero the BP
    - There are two ways to zero the BP apparatus.
    - <u>First Method</u>: Remove the tubing from the manometer. You should see a metal hose barb with threads. The threads have two flattened indentations. Use pliers on the indentations to turn the hose barb. The needle should move with the hose barb. Turn the hose barb until the needle is in the "ZERO" box. If you are unable to turn the hose barb, use a wrench or needle-nose pliers to loosen the locknut. The locknut is above the hose barb (see picture). After you adjust the hose barb, retighten the locknut. DO NOT pull the hose barb all the way out – you will ruin the manometer.



- <u>Second Method</u>: Remove the clear cover to the sphygmomanometer. Sometimes you can twist the cover off. Sometimes you will need to "pop off" the lid with a flathead screwdriver. Using a small flathead screwdriver, gently "pop off" the needle. Twist the needle so that it points to the "ZERO" box. Snap the needle back on.

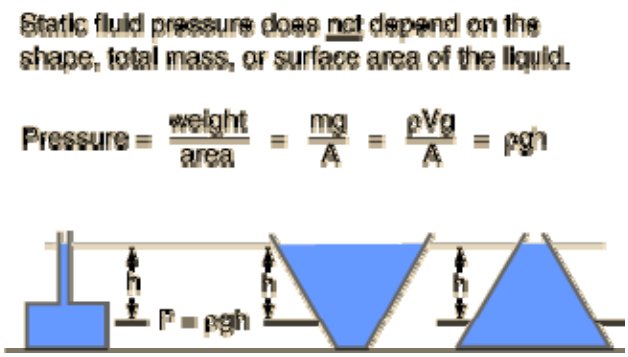


4. Check the calibration with a mercury sphygmomanometer
    - Even if the needle is in the "ZERO" box, the manometer is not necessarily calibrated. The box is very wide. Your manometer's reading may be slightly high or low.
    - Mercury columns are the standard for measuring pressure. Use clean and zeroed mercury sphygmomanometers to calibrate your aneroid manometer.
    - Find a Y-shaped rubber tubing. You can often find one on a stethoscope. Connect one end to your aneroid manometer. Connect the second end to the mercury manometer. Connect the third end to a blood pressure cuff. You may need an adapter piece.

- Wrap the cuff around a hard, cylindrical object. Close the valve. Inflate the cuff. Record several values of the pressure.

Hg BP Pressure (mm Hg)	***Aneroid BP Pressure (mmHg)***
0	0

5. Check the calibration with water
   - If you do not have a mercury column or a Y-piece, you can use a water column instead.
   - A fluid's pressure only depends on the fluid's depth (height) and density, not on the surface area or shape of the liquid. Therefore, you can use a water column to test the accuracy of a BP apparatus.



Water Pressure = Mercury Pressure

$\rho gh = \rho gh$

$\rho h = \rho h$

(H_2O density)(H_2O height) = (Hg density) (Hg height)

H_2O height = (Hg density) (Hg height) / (H_2O density)

How high should your water column be to create 50 mm Hg of pressure?

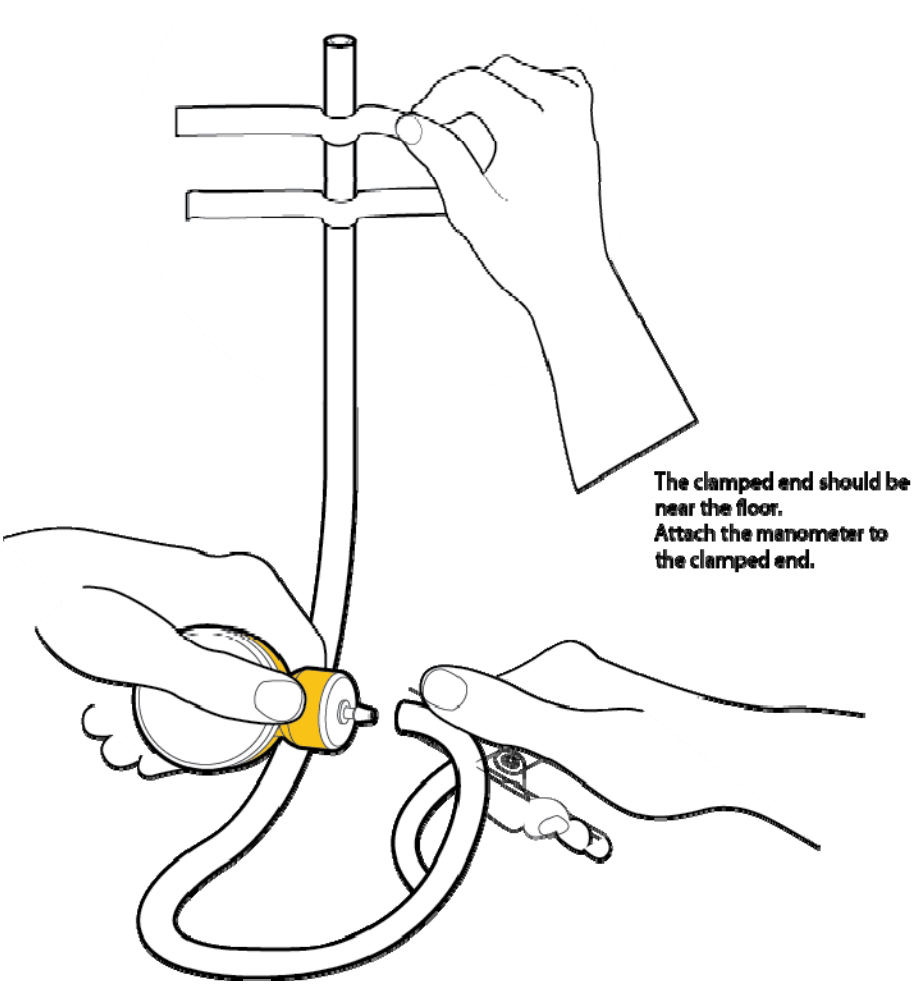
H_2O height = (Hg density) (Hg height) / (H_2O density)

= ($13.53 g/cm^3$) (_____mm Hg) / ($1 g/cm^3$)

=_____mm

= _____cm

- Cut a long rubber or plastic tube to at least 280cm
- From one end of the tube, measure and mark the tube at 68cm, 136 cm and 271 cm.
- Tape the tube to the wall vertically, with "zero" at the bottom.
- Attach the sphygmomanometer to the bottom of the tube.
- Fill the tube to 68cm with water.


The clamped end should be near the floor.
Attach the manometer to the clamped end.

- Read the manometer. Record the reading in the table below.
- Repeat with other water heights.
- The manometer should be accurate within 1 to 3 mm Hg. If the pressure is inaccurate by more than 3 mm Hg, the manometer should be calibrated. (Step 5)

Water Height (cm)	***Pressure (mm Hg)***	***Actual Pressure (mmHg)***
0	0	0
68	50	
136	100	
271	200	

6. Look at your pressure readings. They should all be too high, too low, or accurate. Adjust your manometer accordingly, using the method in step 3. Test your manometer again at multiple pressures. If some readings are too high and others are too low, your manometer's rate of change is inaccurate and cannot be calibrated.

Exercise

Your instructor will give you a BP apparatus. Inspect the BP apparatus. Predict if the BP apparatus will display accurate blood pressures. Check the accuracy of the BP apparatus. Use the column of water technique described above. Compare the BP apparatus with a mercury sphygmomanometer. Calibrate the BP apparatus if you obtain inaccurate measurements. Your instructor must verify your work before you continue.

Preventative Maintenance and Calibration

Always calibrate every medical device before returning it to use.