KINE 648 Lab #4

Electrocardiography and the Prediction of VO_{2max} From Sub-max Data

<u>Equipment needed:</u>

Quinton ECG machines
Monarch 818 E ergometers
Handouts
Web page notes

Introduction to Electrocardiography (ECG, EKG)

- **<u>Electrocardiography</u>** - graphic recording of the electrical activity (potentials) produced by the conduction system and the myocardium of the heart during it depolarization / repolarization cycle.

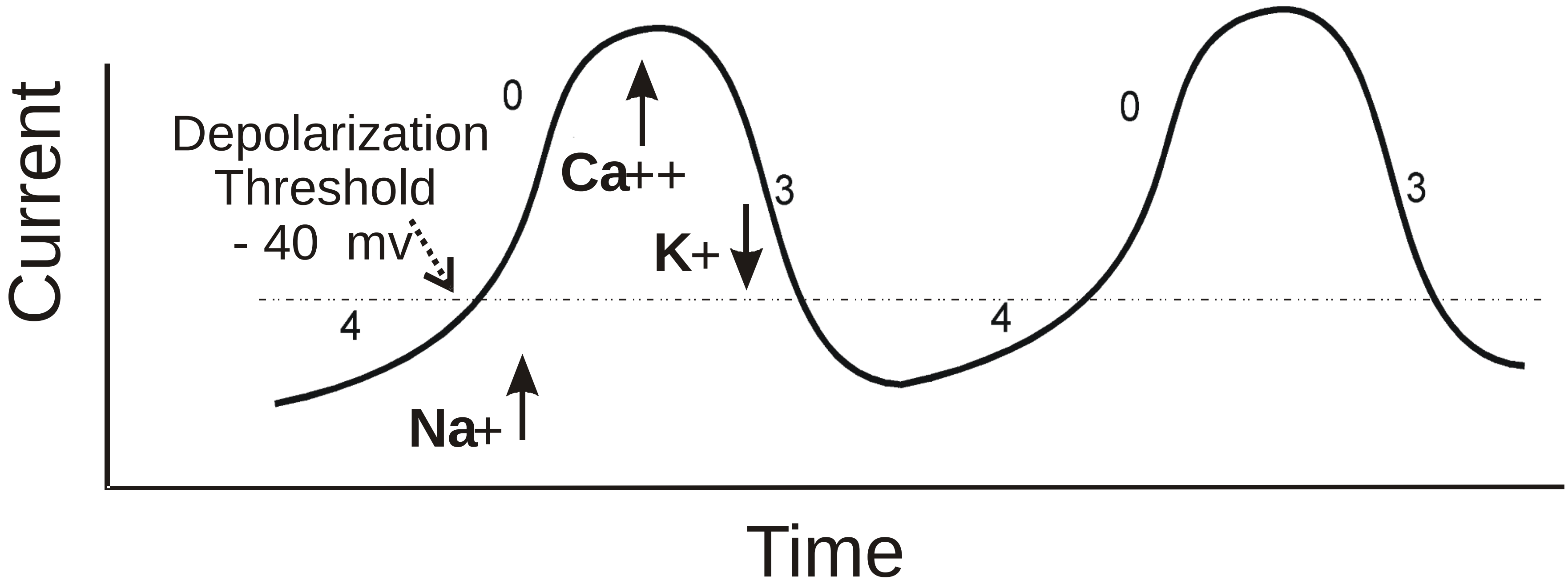
- During the late 1800's and early 1900's, Dutch physiologist Willem Einthoven developed the early electrocardiogram. He won the Nobel prize for its invention in 1924.

- Hubert Mann first uses the electrocardiogram to describe electrocardiographic changes associated with a heart attack in 1920.

- The science of electrocardiography is not exact. The <u>sensitivity</u> and <u>specificity</u> of the tool in relation to various diagnoses are relatively low

- Electrocardiograms must be viewed in the context of other clinical test correlates. They are especially useful when compared across time to see how the electrical activity of the heart has changed (perhaps as the result of some pathology).

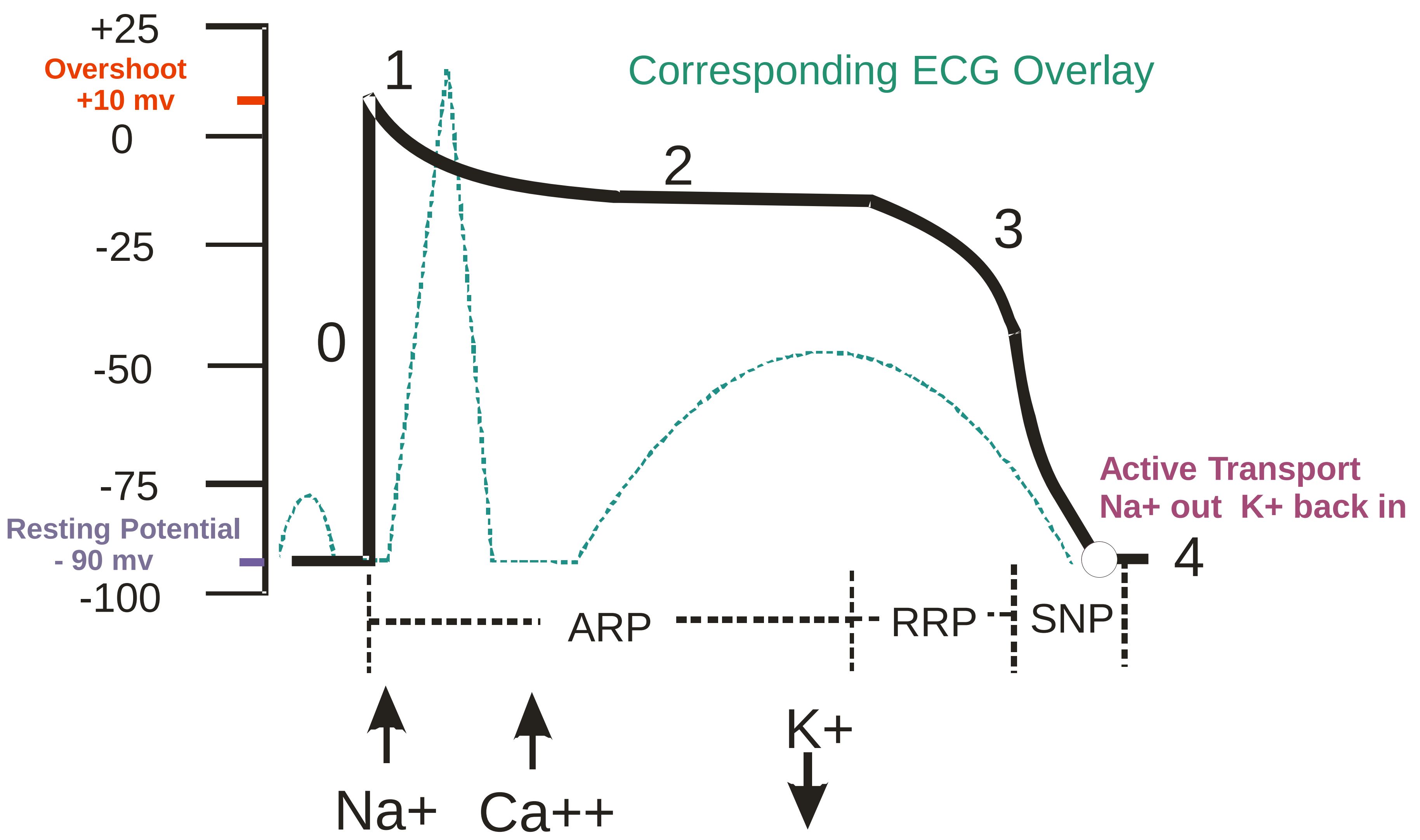
Atrial Muscle (Nodal) Action Potential




= inward ion movement (going into the cell)


= outward ion movement (exiting the cell)

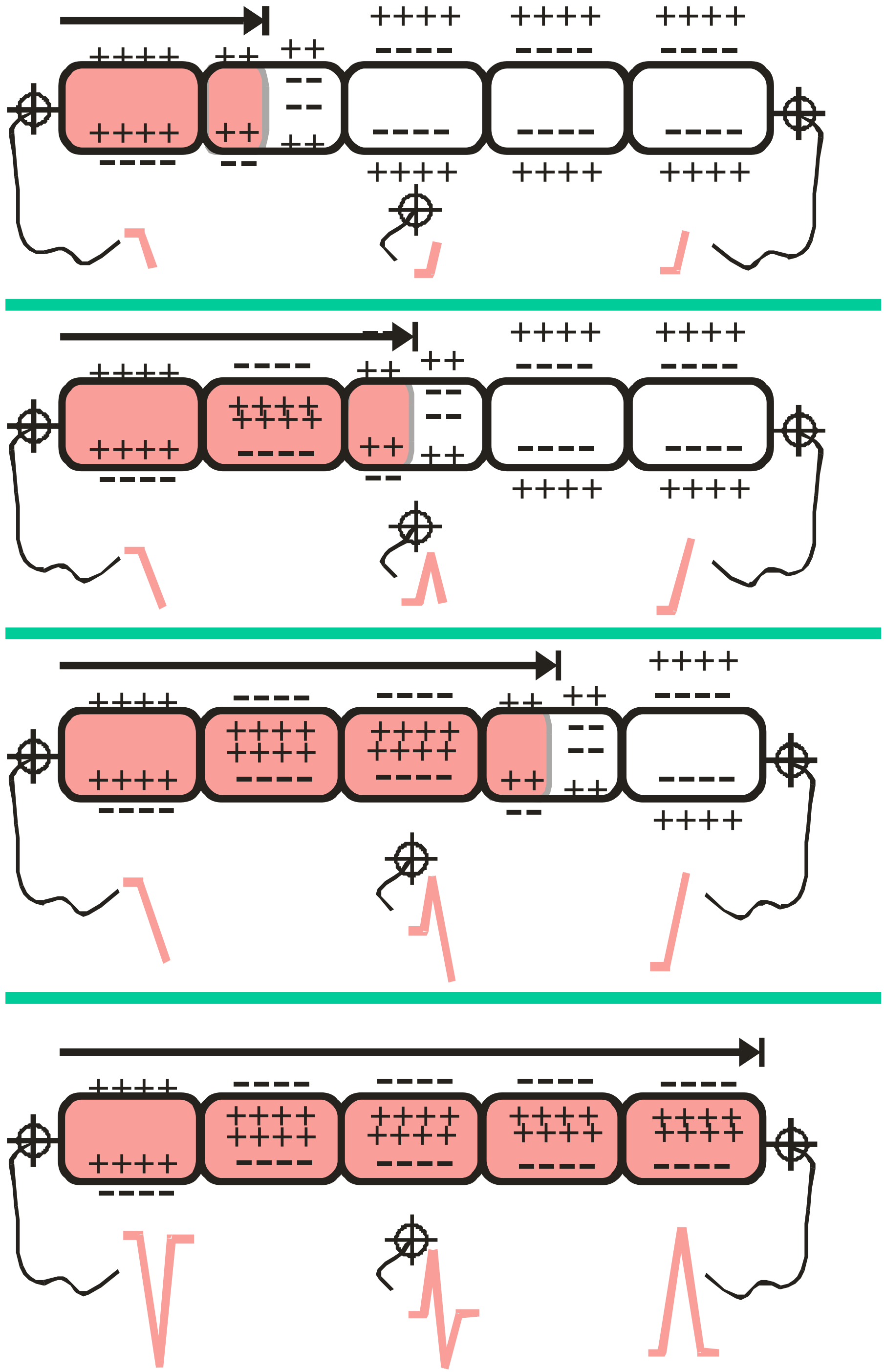
Action Potential of a Myocardial Cell



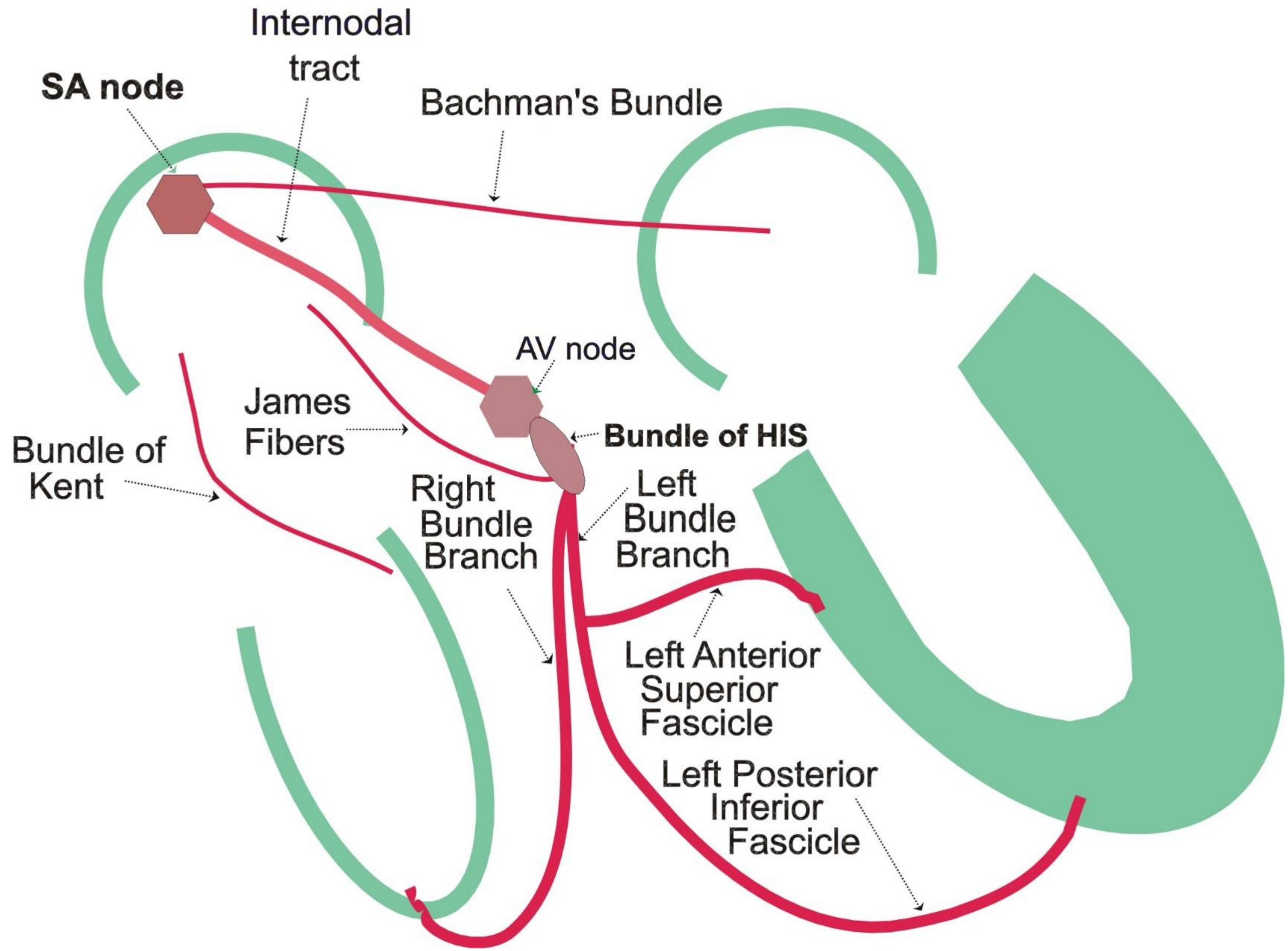
Generation of the ECG complexes

A wave of depolarization moving toward an electrode will cause an upward deflection on the ECG needle.

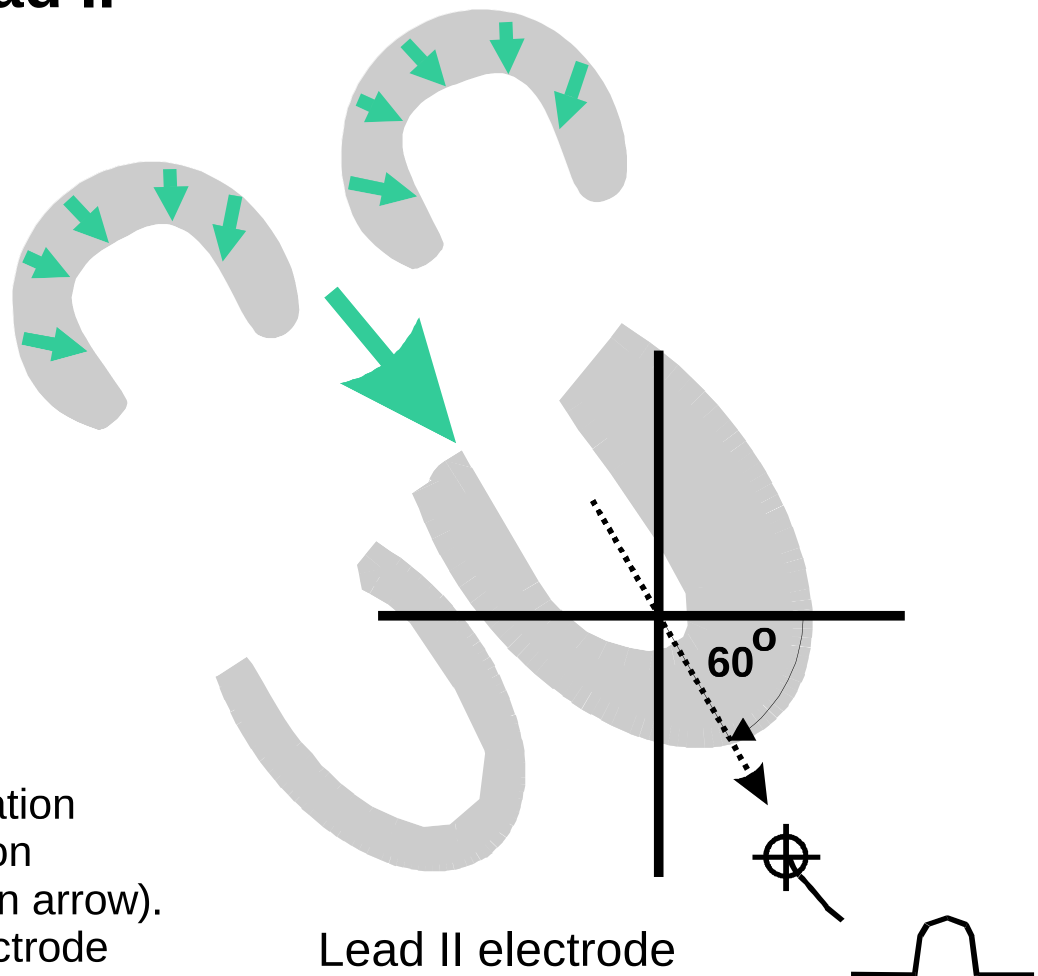
Corollaries ???



The Conduction System of the Heart



Visualization of the generation of the Atrial (P-wave) portion of the ECG complex in Lead II



1. Atrial depolarization proceeds from the top down in all directions

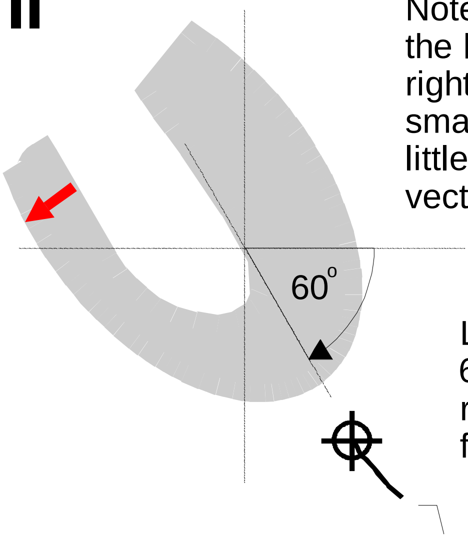
2. Summing these vectors of depolarization results in the main atrial depolarization vector oriented as shown (large green arrow). It is moving towards the positive electrode of the lead, resulting in an upward deflection of the ECG stylus.

Lead II electrode
60° downward
rotation angle
from the horizontal 0

Visualization of the generation of the Left Ventricular portion of the ECG complex in Lead II

(DEPOLARIATION)

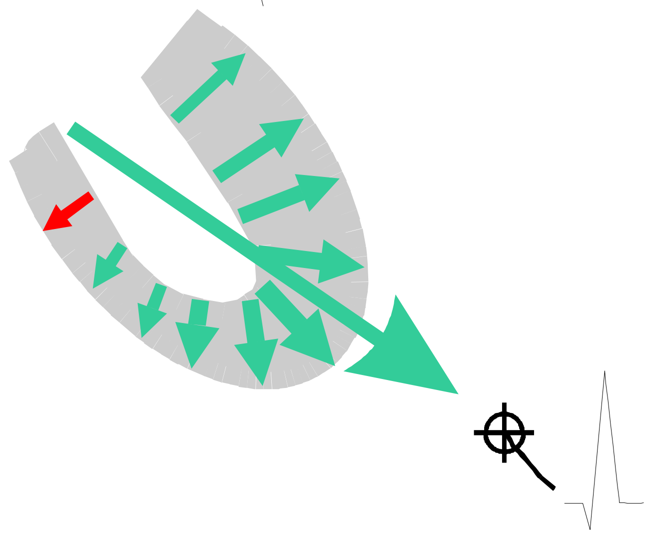
Note: compared to the left ventricle, the right ventricle is much smaller and contributes little to the overall main vector of depolarization



Lead II electrode 60° downward rotation angle from the horizontal 0°

1. Septum depolarizes from the inside out and the resulting depolarization wave moves away from the electrode recording Lead II

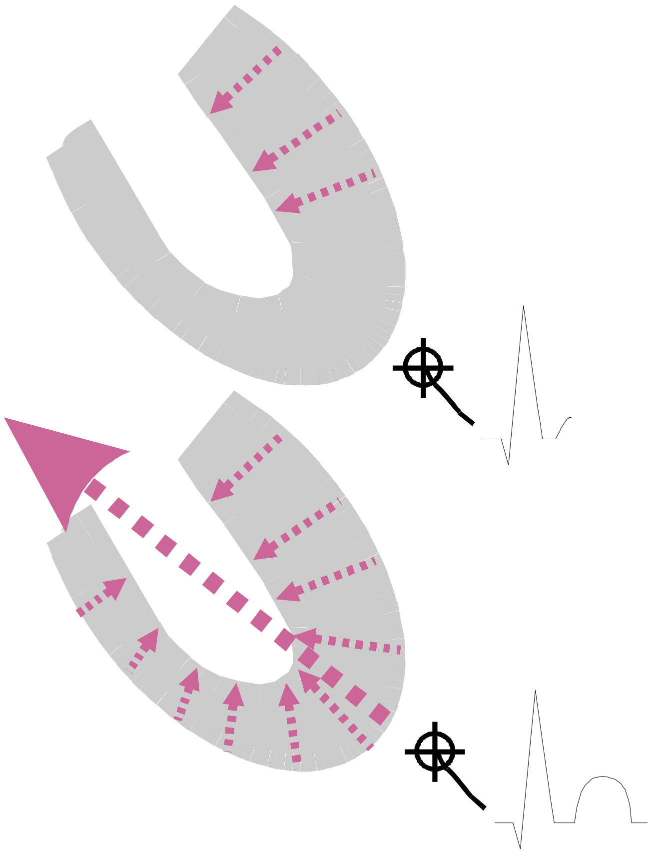
2. The rest of the ventricle depolarizes counter-clockwise from the inside out and creates the **main cardac vector** (large arrow) which is essentially, the algebraic sum of all of the small depolarization vectors. This vector is, in a normal heart, almost always moving directly toward Lead II, generating a mostly positive QRS complex



Visualization of the generation of the Left Ventricular portion of the ECG complex in Lead II (REPOLARIATION)

3. Repolarization can be thought of as beginning where depolarization left off and proceeding clockwise from the lateral wall back to the septum..

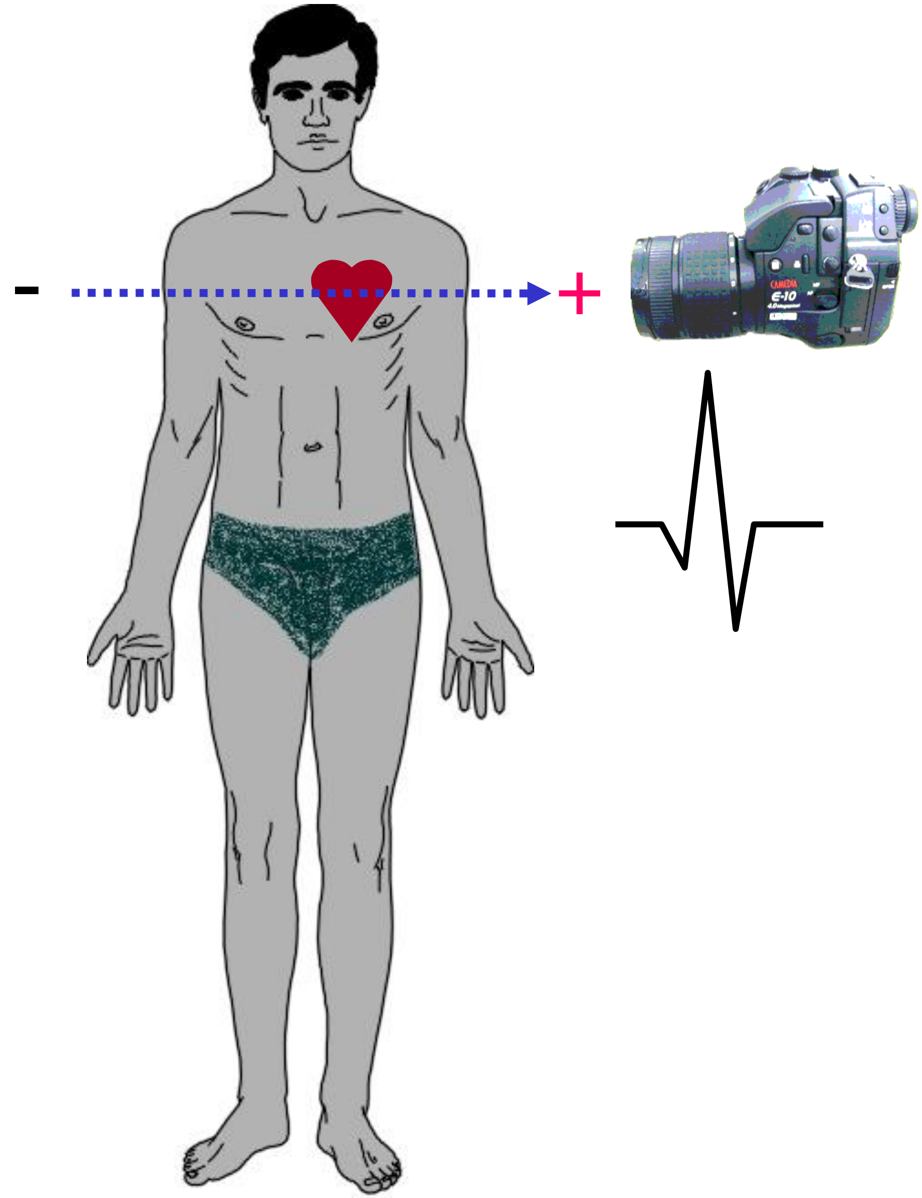
4. The repolarization process proceeds at a much slower rate than depolarization so the wave inscribed (T-wave) is wide and rounded. The repolarization vector is moving away from the Lead II electrode so the inscribed T-wave is always positive



The Concept of a "Lead"

Lead I

• The directional flow of electricity from Lead I can be viewed as flowing from the RA toward the LA and passing through the heart. Also, it is useful to imagine a camera lens taking an "electrical picture" of the heart with the lead as its line of sight

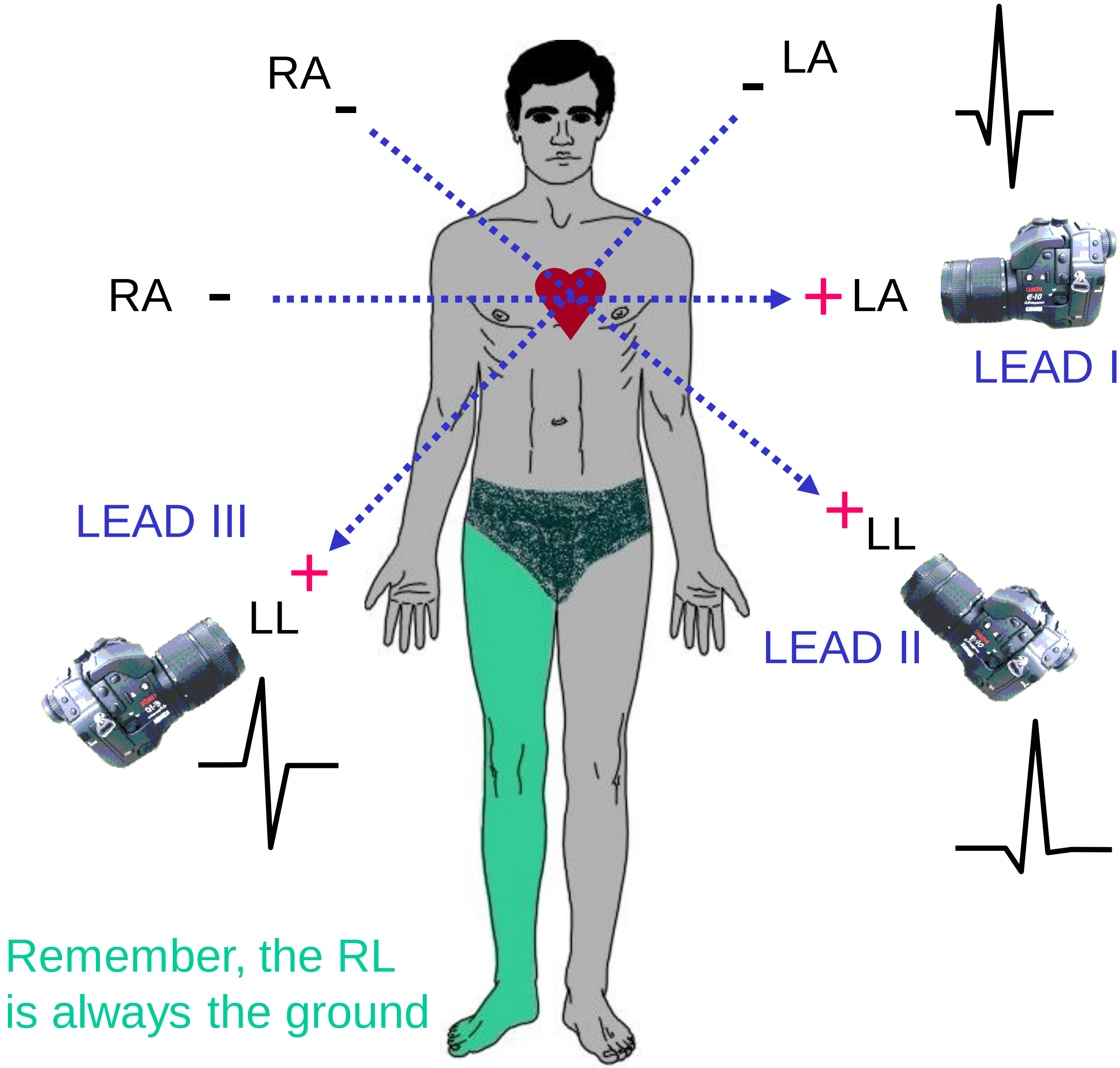


The Concept of a "Lead"

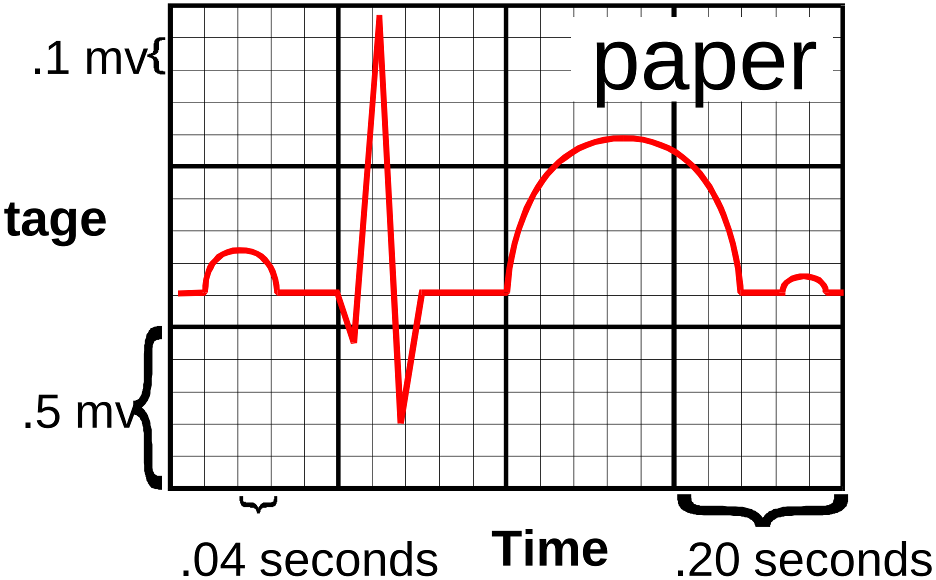
Leads I II III

• By changing the arrangement of which arms or legs are positive or negative, two other leads (II & III) can be created and we have two more "pictures" of the heart's electrical activity from different angles.

• We can also arrange other electrodes & voltages so that we can obtain many other leads. For our purposes we will use a 12-lead system



ECG basics – Paper Speed & Heart Rate



Paper speed = 25mm / second

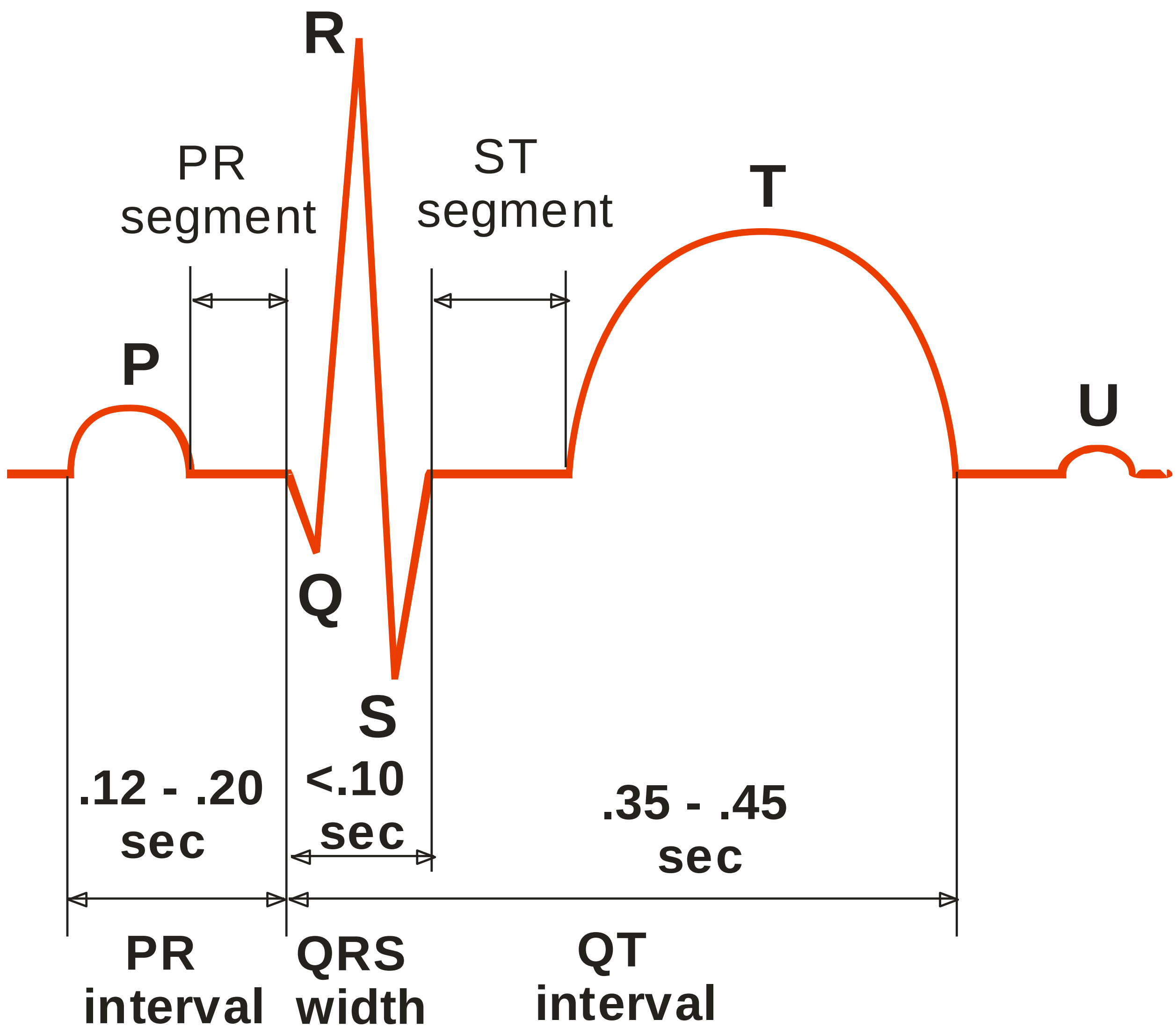
Heart Rate = number of R-waves in a 6 second strip divided by 10

= 1500 divided by the number of small boxes between consecutive R-waves

= large square estimation counts (300 - 150 - 100 - 75 - 60 - 50 - 43)

ECG Basics - the ECG Complex

- By examining the different leads, and the shape, time intervals, contour, frequency, and type of the ECG complexes, we can, among other things, diagnose cardiac illnesses, suggest whether or not the heart is receiving enough oxygen, determine if the person has suffered a heart attack, and get an idea as to the size and performance of the main pumping chamber (left ventricle)



ECG Electrode Placement

Standard Configuration

Right Arm (white)

Left Arm (black)

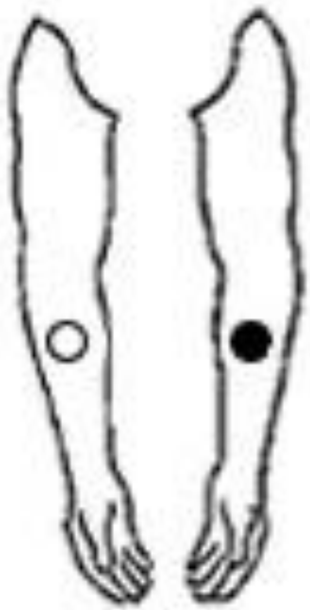
Exercise Configuration

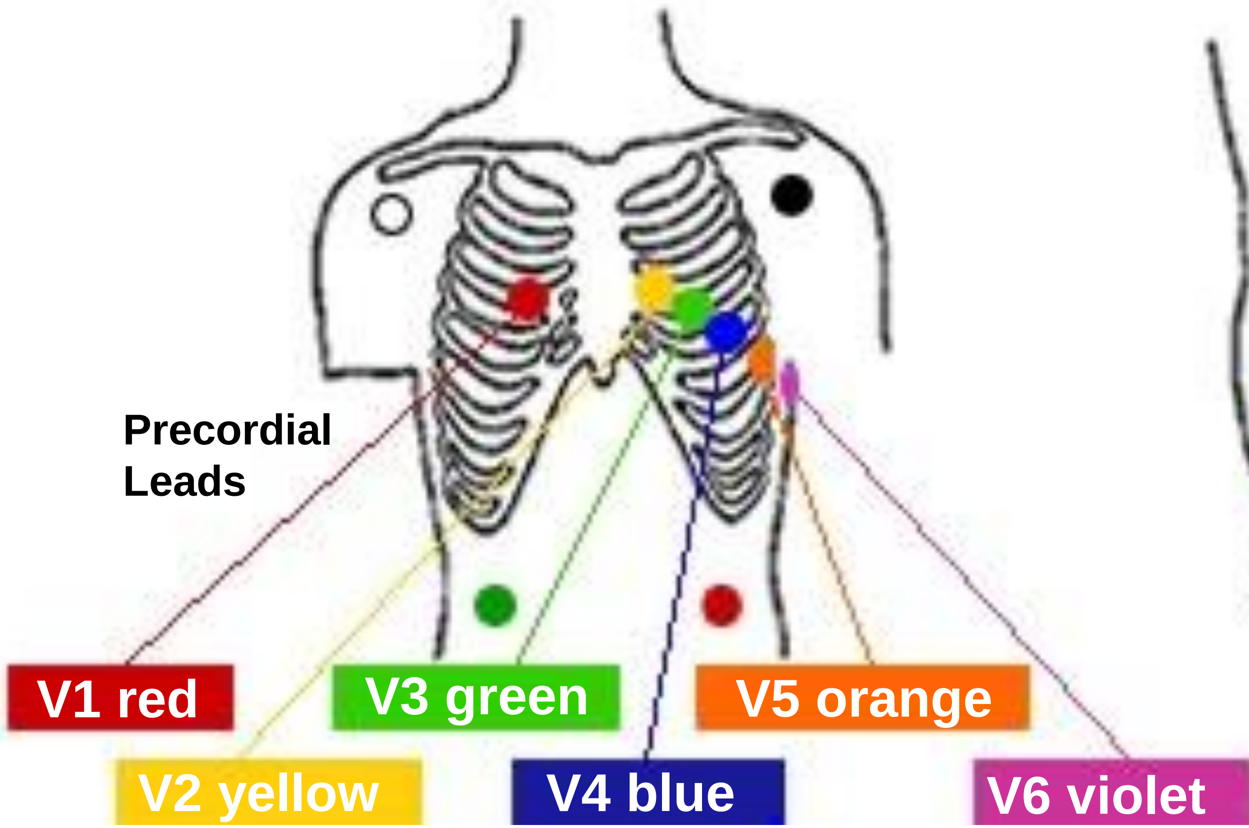
The right & left arm electrodes are transferred to the upper torso while the leg electrodes are transferred to the lower torso

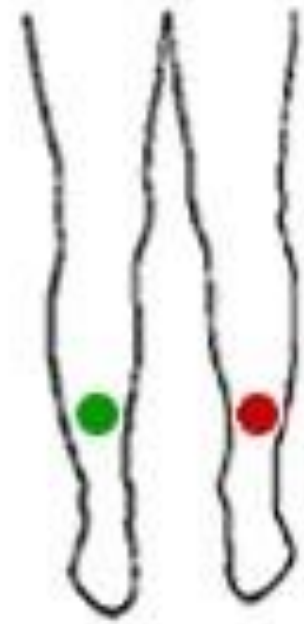
Standard Configuration

Right Leg (green - ground)

Left Leg (red)

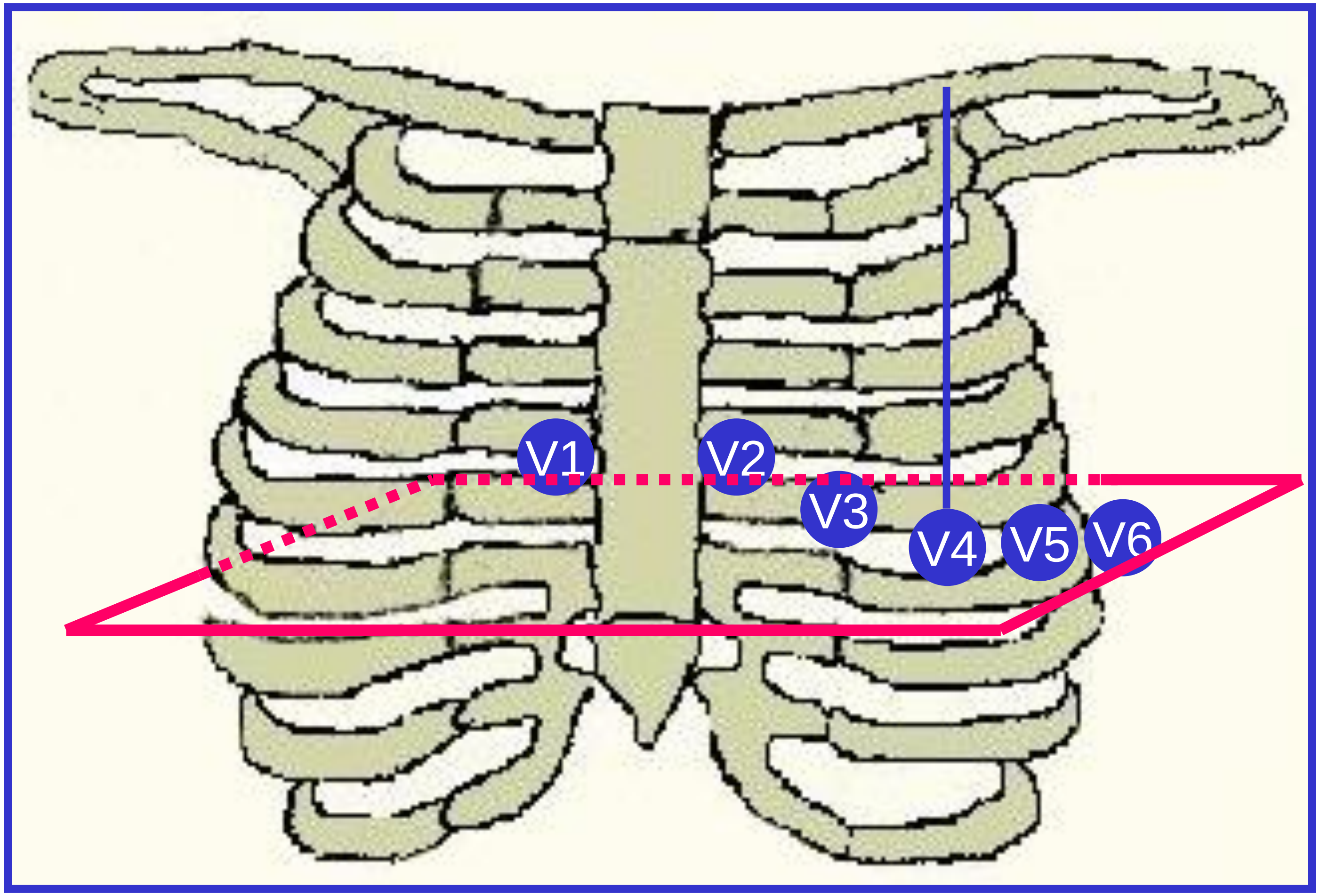






- Each of the precordial leads is unipolar (1 electrode constitutes a lead) and is designed to view the electrical activity of the heart in the **horizontal** or **transverse plane**

- V1 - 4th intercostal space - right margin of sternum
- V2 - 4th intercostal space - left margin of sternum
- V3 - linear midpoint between V2 and V4
- V4 - 5th intercostal space at the mid clavicular line
- V5 - horizontally adjacent to V4 at anterior axillary line
- V6 - horizontally adjacent to V5 at mid-axillary line



Anatomical Placement of Electrodes

Electrode	Anatomical Location
Right Arm (RA)	The base of the right shoulder against the deltoid border about 2 cm below the clavicle but above the border of pectoralis (in deltoid fossa).
Left Arm (LA)	The base of the left shoulder against the deltoid border about 2 cm below the clavicle but above border of pectoralis (in deltoid fossa).
Right Leg (RL)	Right anterior axillary line a few centimeters above the umbilicus
Left Leg (LL)	Left anterior axillary line a few centimeters above the umbilicus
V_1	Fourth intercostal space at right sternal border.
V_2	Fourth intercostal space at left sternal border.
V_3	Midway between positions for V_2 and V_4.
V_4	Fifth intercostal space at left midclavicular line.
V_5	Horizontal level of V_4 at left anterior axillary line.
V^6	Horizontal level of V_4 at left midaxillary line.

Skin Preparation and Placement of Electrodes

This is an <u>essential</u> step for recording high quality ECG's during exercise. Failure to prepare the skin properly and consistently for an exercise test will result in an ECG signal that cannot be continuously monitored or accurately interpreted because of artifact.

a. Have the patient disrobe to the waist and lie down, face up on the prep table. (Women will need to wear two piece bathing suit top or jog bra)

b. Identify the general areas to be used for electrode placement

c. Shave the area where the electrodes are to be applied if necessary. Use the clippers and dry razors to remove as much hair as possible. Next, in order to remove oil from the skin, wipe the area down with a gauze pad soaked in alcohol.

d. remove a small amount of "one step quick prep" sand paper tape and wrap it over your finger. Scratch the placement site 4-6 times with light pressure. This removes the keritinized top layer of the skin epithelium and allows electricity to optimally flow into the electrode. Do not press hard as you will cause pain, remove the skin, and cause bleeding

e. Apply patient electrodes. Electrolyte gel at center of electrode should be placed directly over the area abraded with the sandpaper. Smooth the adhesive part of the electrode with your finger to insure proper adhesion to the skin: Do not press on the center of the electrode.

f. The skin resistance should be reduced to 5000 ohms or less. The ohm meter should be set to RX1K. Connect the red wire to the bottom right input and the black wire to the bottom left input. Cross connect the testing stems and use the "OHMS ADJUST" control to zero out the reading. (The ohms are read on the green scale, multiplying the indicated number by 1000). Check the skin resistance by testing each electrode against the right leg electrode. If the resistance is greater than 5000 ohms, remove the electrode and repeat the skin preparation.

g. Attach the lead wires from the ECG recorder to the patient electrodes. Caution: Be sure to connect the lead wires to the proper electrode, otherwise faulty inaccurate signals may be recorded.

Lab Assignment for Data Collection #4

Directions: Students should work in groups of 2 with each student serving as both a subject and a data collector. Each student will complete the assignment using his partner's data.

1. **Prepare your subject and equipment** Place a bike on the treadmill belt, turn on the ECG machine, and make sure the MANUAL protocol is selected. Place the ECG electrodes on the subject as per instruction. Adjust the bike seat so that at pedal extension, the knee is at a 160^{o} angle (almost straight) and have your subject sit on the bike. Push the "3 lead" button on the ECG machine to obtain 10 seconds of continuous ECG tracing. Push the same button to stop recording.

2. **Execute the exercise protocol:** Have the subject begin pedaling at the 60 RPM (set metronome to 120 and have subject down-stroke every beep). When the client feels comfortable and is able to maintain the proper RPM, push START EXERCISE button on the ECG machine and increase the tension on the belt to 1 kg of resistance by turning blue knob below handlebars clockwise. Maintain this workload for 3 minutes. At 2:30 into the stage, take and record the subjects blood pressure and push the "12 lead" button to obtain an ECG (blood pressure can be written on the ECG or entered via the keyboard before the end of each stage). At the end of the first 3 minute stage, increase the resistance to 1.5 kg and repeat data collection at 2:30 into the stage. Repeat data collection for 2, 2.5, and 3 kg of resistance (you should have an ECG tracing and BP reading for each of the 5 stages: 1kg, 1.5kg, 2.0kg, 2.5kg, and 3kg) After recording data for the last stage, release the tension on the belt by turning the blue knob counterclockwise back to 1 kg and allow the subject to cool down to 2 minutes. Take a final BP and ECG recording, then disconnect the subject from the machine.

Lab Write-up for Assignment #4

1. In lead II, measure and record the PR interval, the width of the QRS complex, QT interval, and the height of the R-wave of the resting ECG tracing and the tracing recorded at 3 kg @ 60 rpm. Describe any differences between the 2 tracings with respect to these measurements. Also, note any recognizable abnormalities on the subject's ECG. Include a copy of each of the resting and exercise ECG's with your lab write-up.

2. Using the regression tool in Microsoft EXCEL, calculate what the subjects oxygen consumption would be at their estimated maximum heart rate (estimate their max HR as 220 – age). To illustrate this, construct a plot graph with heart rate as the independent variable (x-axis) and oxygen consumption for each workload (as estimated by the equations) as the dependent variable. Have EXCEL place a trend line in the plot. How did the subject's estimated VO2max compare with their actual VO2max as measured in Lab number 3? What could cause possible discrepancies?

3. What changes on the ECG indicate that the heart may not be receiving enough oxygen? What changes indicate an ongoing (acute) heart attack? An old heart attack?

4. A heart attack (myocardial infarction) results in the destruction of part of the heart muscle (usually that of the left ventricle, the main pumping chamber). How might a severe heart attack in which the patient looses 65-75 percent of their heart muscle alter circulatory hemodynamics (heart rates, systolic and diastolic blood pressures, cardiac outputs, end diastolic pressures, left atrial pressures, pulmonary artery pressures, etc.) at rest and during exercise? How would it alter maximum oxygen consumption?