TeachEngineering

Microcontroller-Based Instruments for Medical Use

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Microcontroller-Based Instruments for Medical Use

Part 1: Introduction to electrocardiogram (ECG) signals, heart rate, arrhythmia (tachycardia and bradycardia), and blood oxygen levels

Part 2: Understanding the Arduino microcontroller

Part 3: Introduction to the MAX30102 spectrometer, which measures heart sensor and oxygen level

Part 4: Program to get the heart rate and oxygen level on serial monitor

Part 5: Introduction to the AD8323 ECG sensor

Part 6: Program to capture the ECG signal

Part 1: Electrocardiogram (ECG) signal

An electrocardiogram (ECG or EKG) is a measure of how the electrical activity of the heart changes over time as action potentials propagate throughout the heart during each cardiac cycle.

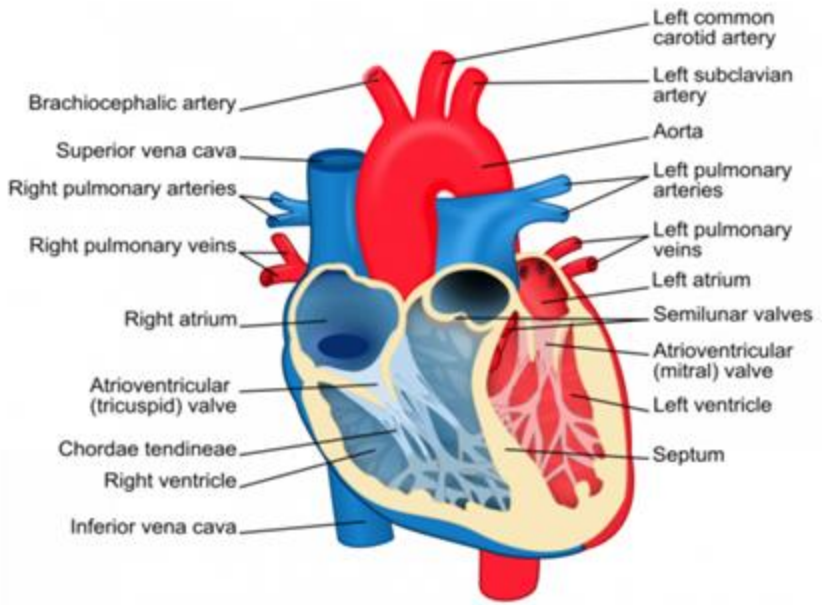
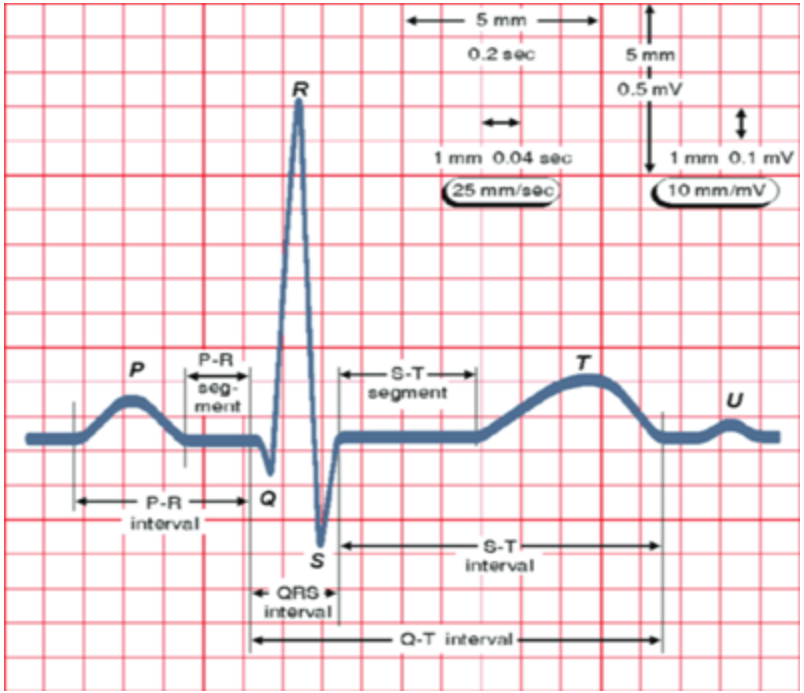
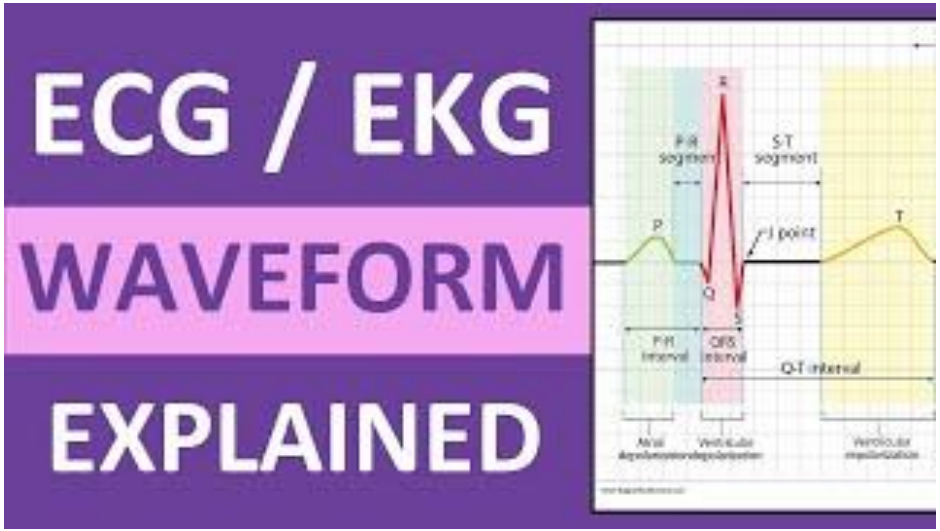


Diagram of the heart. *Credit Wikipedia.org*



Electrocardiogram Signals Video

https://www.youtube.com/watch?v=ocSd7opNFD8 (4:12 minutes)



ECG Cycle Breakdown

- P Wave – Represents the movement of an electrical wave originating at the sinoatrial (SA) node and resulting in the depolarization of the left and right atria.

- P-R Segment – The pause in electrical activity caused by a delay in conduction of the electrical current at the atrioventricular (AV) node to allow blood to flow from the atria to the ventricles before ventricular contraction occurs.

- P-R Interval – The time between the beginning of atrial depolarization and the beginning of ventricle depolarization. A change in P-R interval is often an indicator of the activity of the parasympathetic nervous system on the heart.

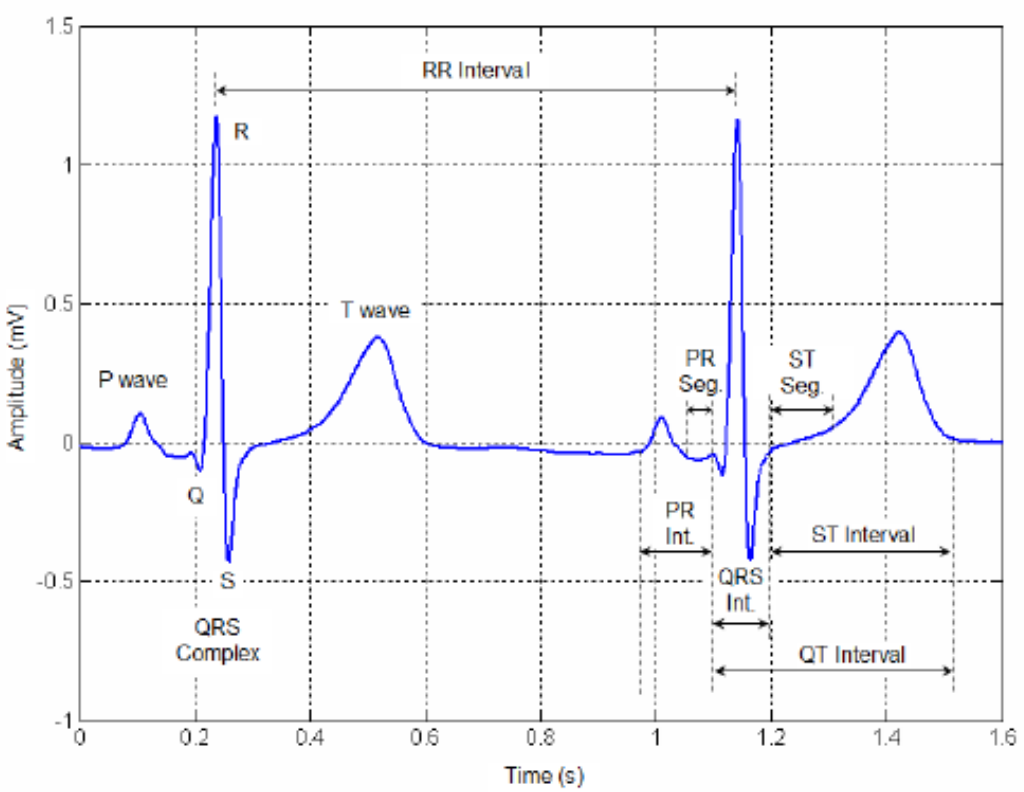
- QRS Complex – Represents the electrical activity from the beginning of the Q wave to the end of the S wave and the complete depolarization of the ventricles, leading to ventricular contraction and ejection of blood into the aorta and pulmonary arteries.

ECG Cycle Breakdown (continued)

- S-T Segment – The pause in electrical activity after the complete depolarization of the ventricles to allow blood to flow out of the ventricles before ventricular relaxation begins and the heart fills for the next contraction.
- S-T Interval – The time between the end of ventricular depolarization (S wave) and the end of repolarization (T wave end).
- Q-T Interval – The time between the beginning of the ventricular depolarization (Q wave) and the end of repolarization (T wave end).
- T Wave – Represents the repolarization of the ventricles.

ECG Example

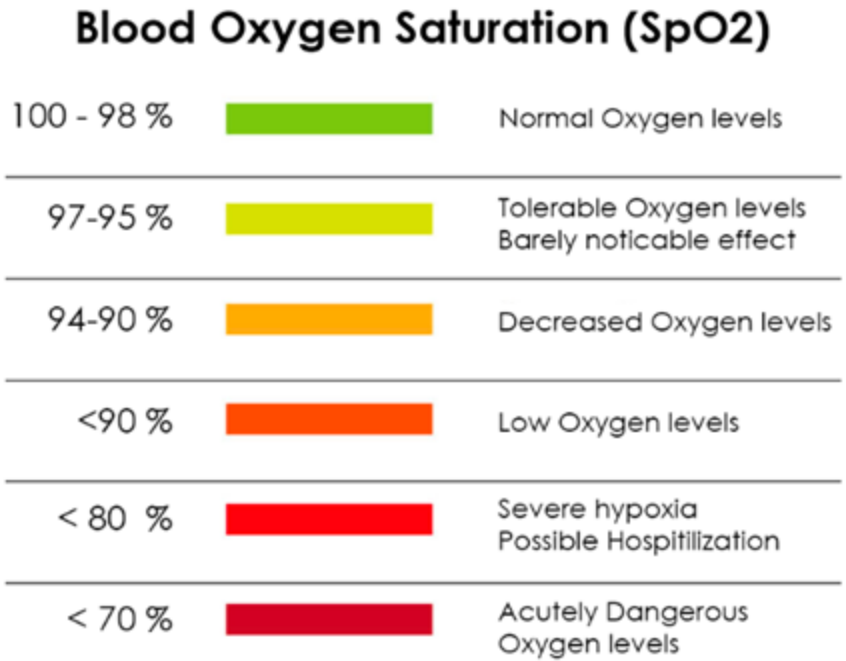
ECG time and voltage
ECG voltage: 0.5- 0.9 mv
ECG period is about 1sec
Normal heart rate: 60 – 120 BPM
Tachycardia: above 100 BPM
Bradycardia: below 60 BPM



Blood Oxygen Levels

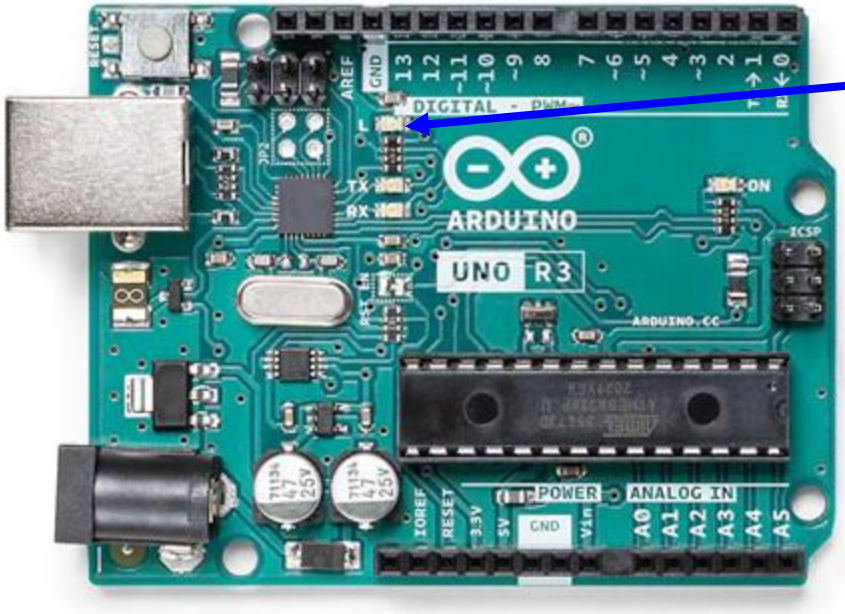
Blood oxygen levels refer to the amount of oxygen that is carried by hemoglobin in the red blood cells throughout the body. This oxygen is crucial for cellular metabolism and overall bodily functions.

Blood oxygen levels are typically measured using a device called a pulse oximeter, which provides a percentage value known as SpO2 (peripheral capillary oxygen saturation.)



Part 2: Understanding the Arduino Microcontroller

Data sheet in this pdf file: https://docs.arduino.cc/resources/datasheets/A000066-datasheet.pdf



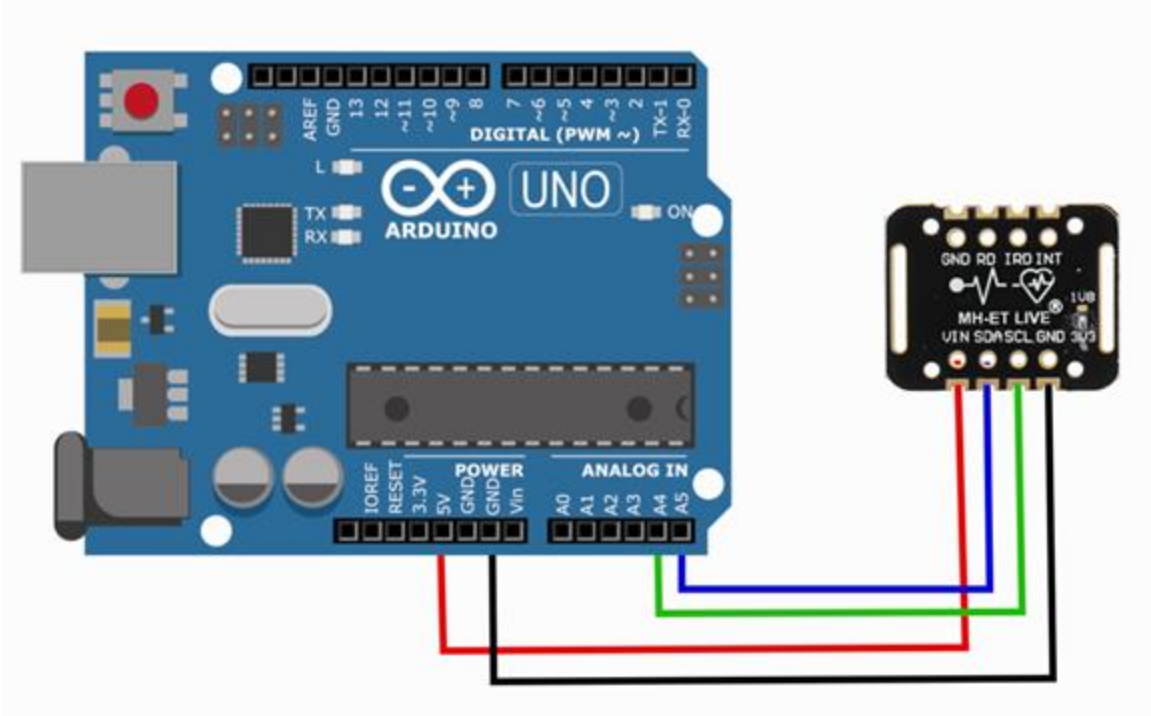
Digital pin LED_BUILTIN pin 13

Setting up and programming the Arduino

https://youtu.be/iSTZ8vNMpTM

Part 3: Understanding the MAX30102 Spectrometer

Circuit diagram of Arduino with pulse oximeter and heart rate sensor (MAX30102)



See Reference Tutorial:
https://www.instructables.com/Guide-to-Using-MAX30102-Heart-Rate-and-Oxygen-Sens/
Image Permission:
lastminuteengineers.com

MAX30102 Sensor: Pulse Oximeter and Heart Rate Sensor

MAX30102 is a sensor that combines a pulse oximeter and a heart rate monitor. It's an optical sensor that measures the absorbance of pulsating blood through a photodetector after emitting two wavelengths of light from two LEDs, one red and one infrared. This particular LED color combination is designed to allow data to be read with the tip of one’s finger. The MAX30102 works by shining both lights onto the finger and measuring the amount of reflected light using a photodetector.

Measurement Principles

Heart Rate Measurement

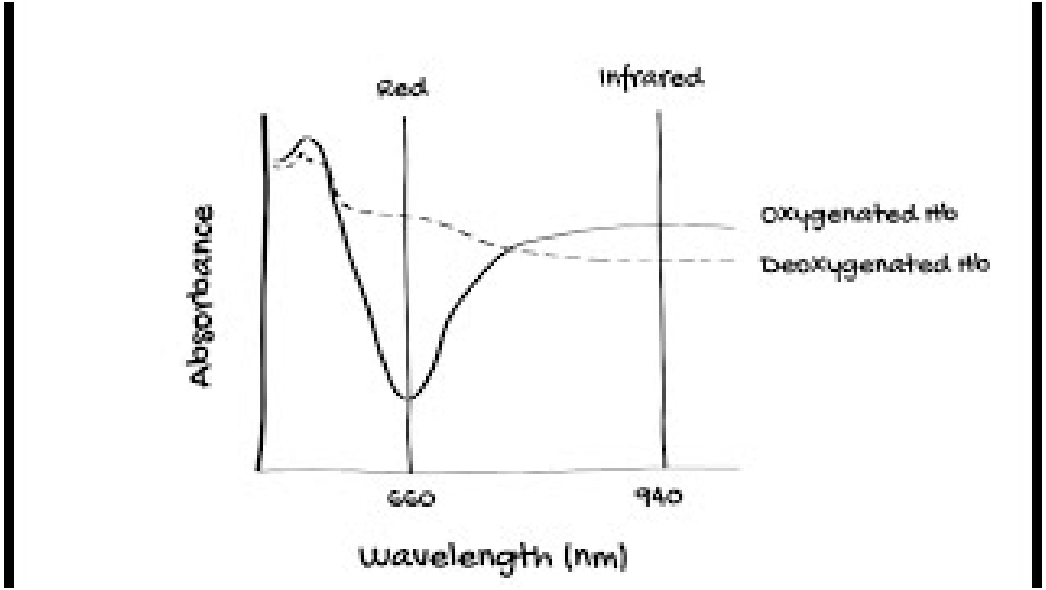
The oxygenated hemoglobin (HbO2) in the arterial blood has the characteristic of absorbing IR light. The redder the blood (the higher the hemoglobin), the more IR light is absorbed. As the blood is pumped through the finger with each heartbeat, the amount of reflected light changes, creating a changing waveform at the output of the photodetector. As you continue to shine light and take photodetector readings, you quickly start to get a heart-rate (HR) pulse reading.

Pulse Oximetry

Pulse oximetry is based on the principle that the amount of RED and IR light absorbed varies, depending on the amount of oxygen in your blood.

How does Pulse Oximetry work in MAX30102?

https://www.youtube.com/watch?v=MHPgamGQmDY



Programming MAX30102

1. The microcontroller program sheet includes Program 1 (Example 5) to get the heart rate (HR) and Program 2 to get both HR and oxygen level on serial monitor.

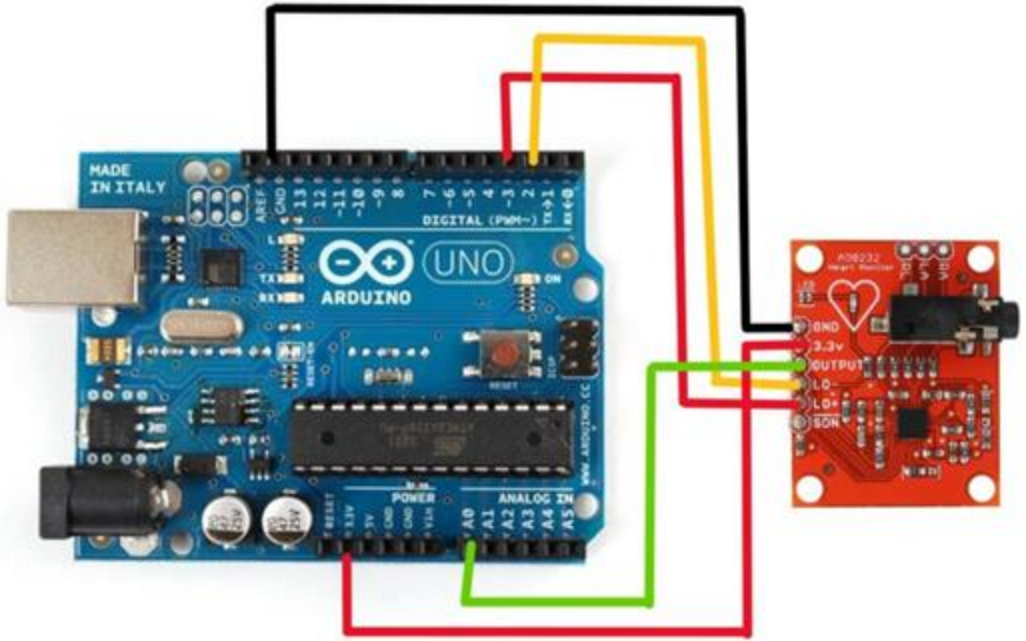
2. Watch the video at https://www.youtube.com/watch?v=V5UvNVQsUsY&t=2s to install the SparkFun library from tools⇒ manage library⇒ search for MAX30102 ⇒ install.

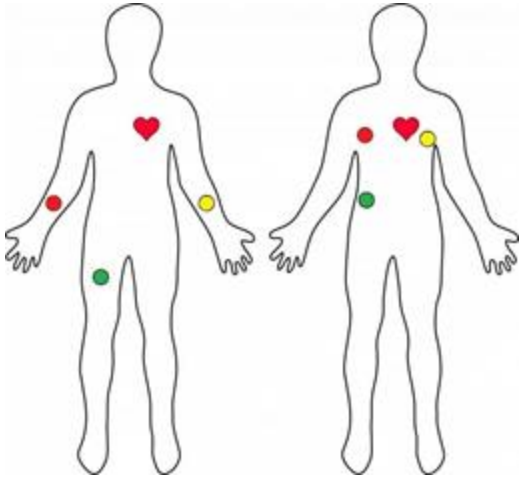
3. Then choose file⇒ examples⇒ sparkfun max30102⇒ example 5, compile and run.

4. Choose serial monitor from tools to capture the HR.

5. Copy & paste Program 2 from the program sheet to capture oxygen level and heart rate measurements. (Note: You need to put your finger on the sensor!)

Part 4: Understanding the AD8323 ECG Sensor

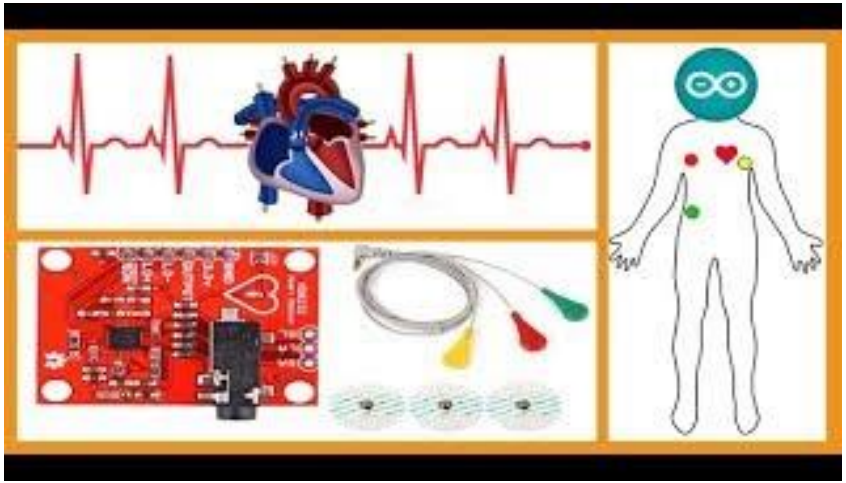




https://www.youtube.com/watch?v=01y_Vu_sAQU&t=463s

Programming AD8323

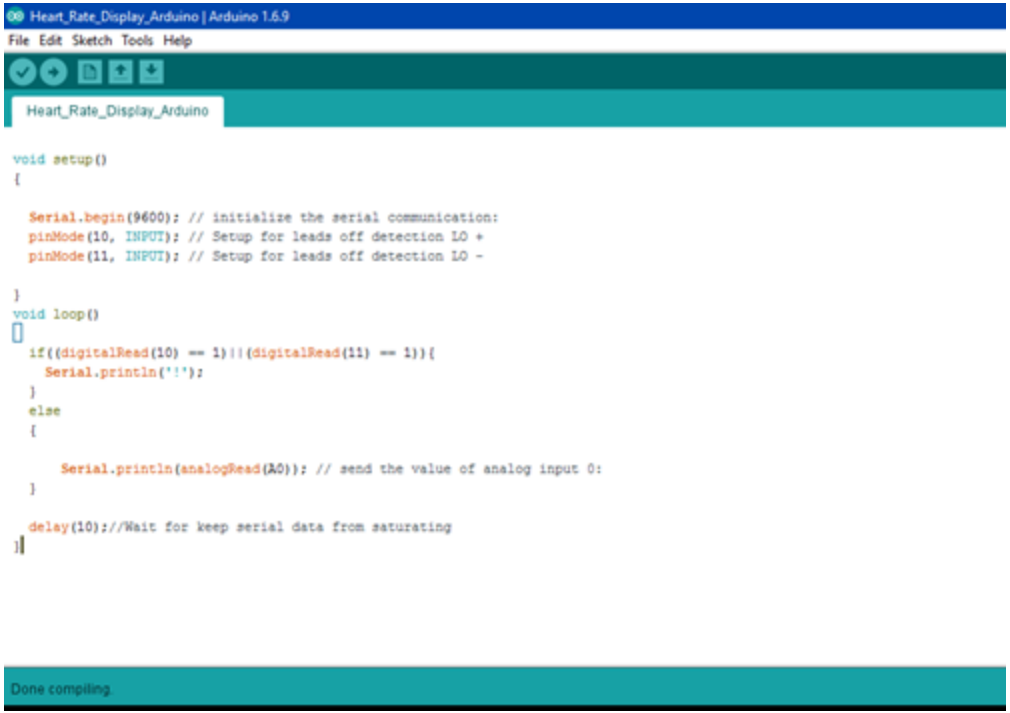
1. Watch this video.
2. Connect the AD8323 sensor to the Arduino as in the video.
3. Copy and paste the program in Slide 18.
4. Compile and run.
5. Choose serial plotter to capture ECG.
6. Place the leads on the right position as in the video.
7. Compute the peaks for 15 seconds.



https://www.youtube.com/watch?v=01y_Vu_sAQU&t=463s

ECG Code: Program to Capture the ECG Signal

(Note: You can see the values on serial monitor or see the ECG signal on serial plotter by choosing that from the toolbar in the IDE.)




```
void setup() {
Serial.begin(9600);
pinMode(10,INPUT);
pinMode(11,INPUT);
}
void loop() {
if((digitalRead(10)==1)||(digitalRead(11)==1))
{
Serial.println(":D");
}
else{
Serial.println(analogRead(A0));
}
delay(10);
}
```

Sample of the output on serial plotter and monitor/Arduino