Rename your zoom name to your index number and surname, e.g., **18001234_Perera**

During the lecture we will ask you to put a message in the **chat** indicating your index number. You should respond within **5 minutes**.

Dr. Hiran Ekanayake

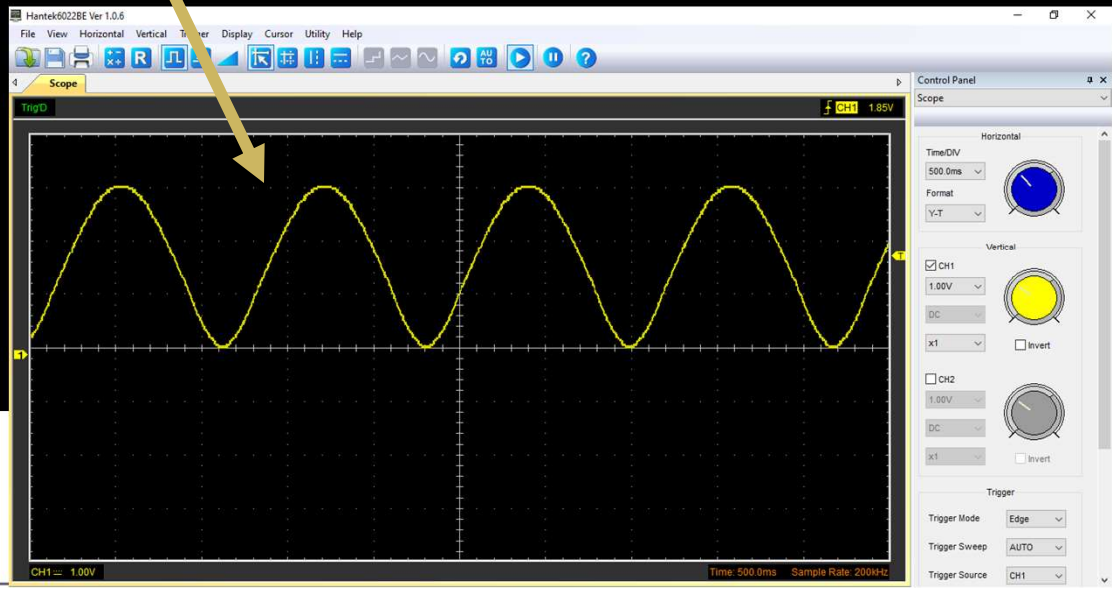
ANALOG OUTPUT

Generating a Sine Wave

What is this device?

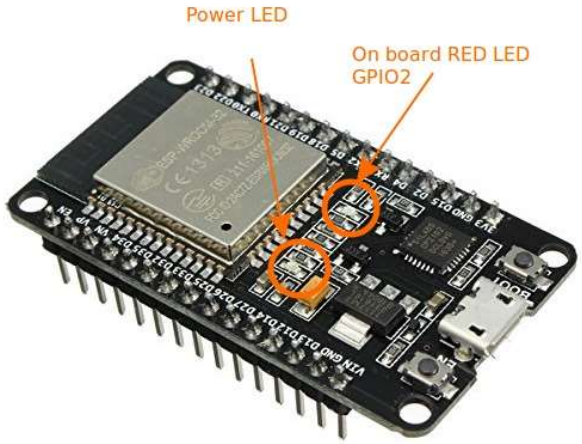
What is this oscilloscope?

```
int SineValues[256];

void setup() {
  Serial.begin(9600);
  float ConversionFactor=(2*PI)/256;
  float RadAngle;
  for(int MyAngle=0;MyAngle<256;MyAngle++) {
    RadAngle=MyAngle*ConversionFactor;
    SineValues[MyAngle]=(sin(RadAngle)*127)+128;
  }
}

void loop() {
  for(int i=0;i<256;i++) {
    Serial.println(SineValues[i]);
    dacWrite(25,SineValues[i]);
  }
}
```



ESP32

These are cheap Wi-Fi modules to develop DIY IoT projects



Why ESP32?

	Arduino Uno	Arduino Mega	ESP8266 (12E)	ESP32
MCU	ATmega328p 8-bit	ATmega2560 8-bit	Xtensa Single-core 32-bit L106	Xtensa Dual-Core 32-bit LX6 with 600 DMIPS
Operating Voltage / Current / Per Pin	5V	5V	3.3V (3.0-3.6V) / 80mA / 15mA	3.3V
Speed	16 MHz	16 MHz	80 MHz	Up to 240 MHz
Memory: Flash / SRAM / EEPROM	32kB / 2kB / 1kB	256kB / 8kB / 1kB	16MB / 160kB	16MB / 512kB / 448kB
IO: GPIO/PWM/ADC/DAC	14 / 6 / 6 / 0	54 / 14 / 16 / 0	17 / 8 / 1(10 bit) / 0	36 / 16 / 1 (12 bits) / 2
Wireless: Type / Wi-Fi / Bluetooth	No	No	STA / AP / STA + AP 802.11 b/g/n (HT20)	STA / AP / STA + AP 802.11 b/g/n (HT40) BT 4.2 / BLE
Wired: SPI / I2C / I2S / UART / CAN / Ethernet	0/1/0/1/0/0	0/1/0/4/0/0	2/1/2/2/0	4/2/2/2/1 Ethernet MAC
Networking: Protocols / Serial / Clients	1200 - 115200 bps	1200 - 115200 bps	IPv4/TCP/UDP/HTTP/FTP 110 - 921600 bps TCP Client 5	IPv4/TCP/UDP/HTTP/FTP 110 - 921600 bps TCP Client 5
Sensors	No	No	No	Touch, Temperature, Hall Effect
Security	No	No	WEP / WPA-PSK / WPA2-PSK	WEP / WPA-PSK / WPA2-PSK

ESP32 Development Boards

DOIT DEVKIT V1

ESP32 DevKit

ESP-32S NodeMCU

ESP32 Thing

WEMOS LOLIN32

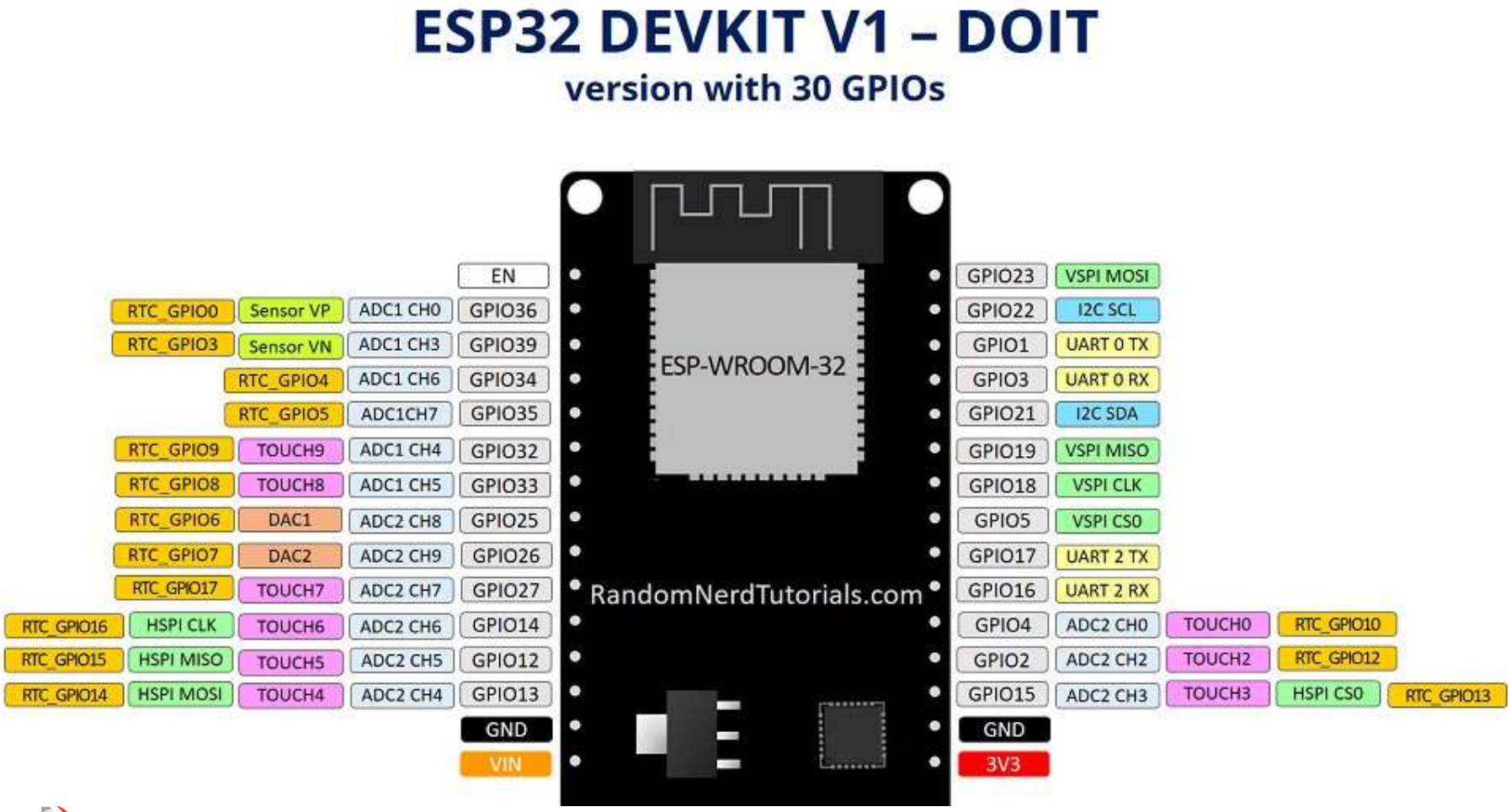
"WeMos" OLED

HUZZAH32

Others

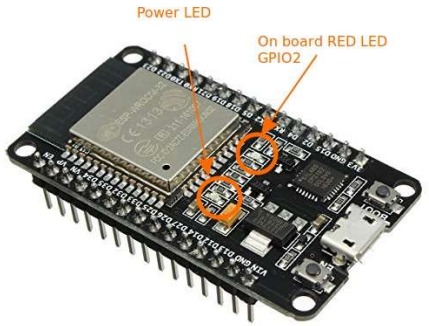
(...)

Pin Description



“Hello World” with ESP32

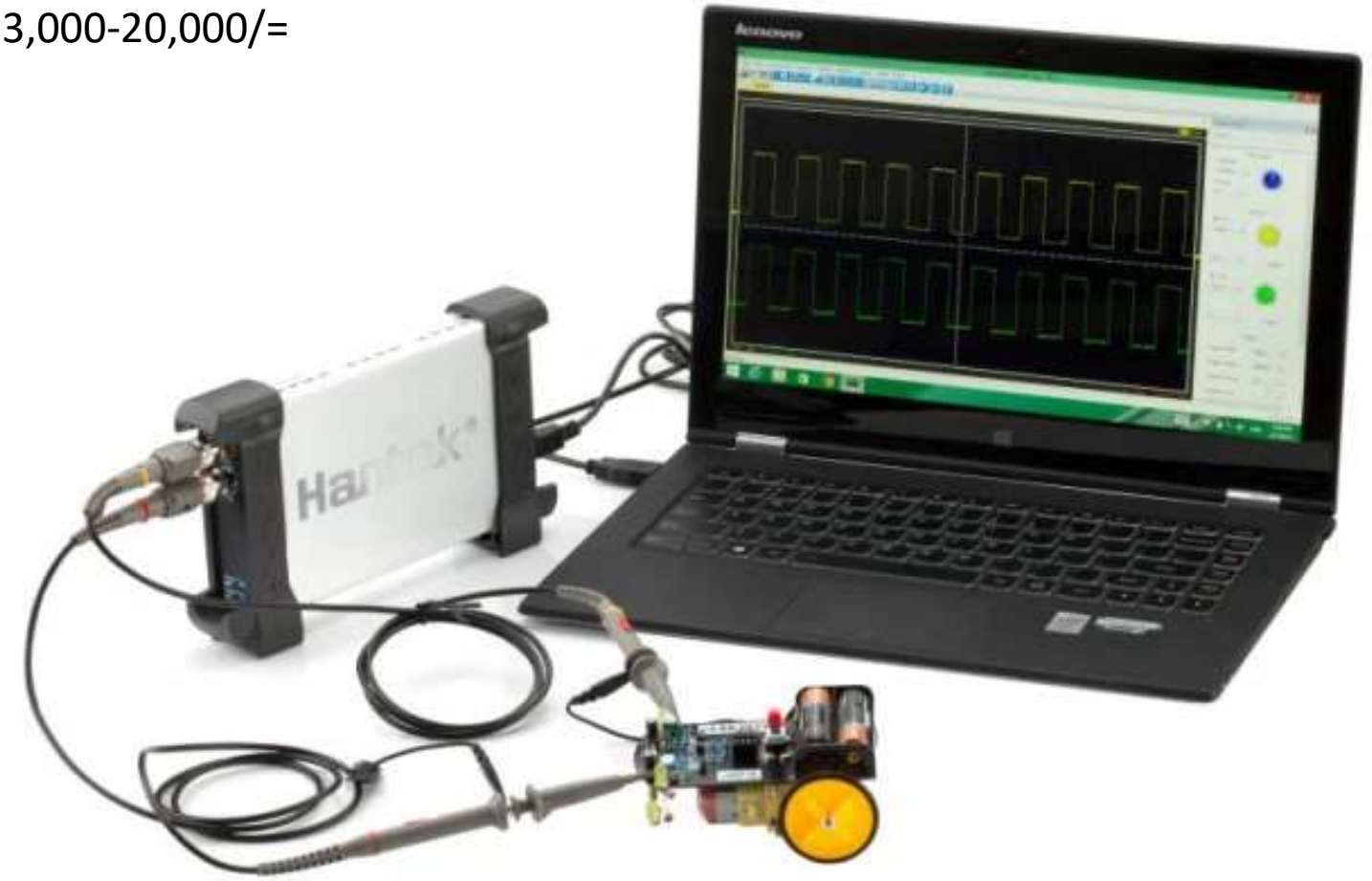
- Under File> Preferences add https://dl.espressif.com/dl/package_esp32_index.json into the “Additional Board Manager URLs” (use comma to add to existing)
- Go to Tools > Board > Boards Manager… search ESP32 … and install
- Select DOIT ESP32 DEVKIT V1 as the board and correct port
- Press upload in Arduino while holding down the BOOT button on ESP until “Connecting…” succeeds
- Press ENABLE button to reset & test




```
#define LED 2

void setup() {
  pinMode(LED,OUTPUT);
}

void loop() {
  delay(500);
  digitalWrite(LED,HIGH);
  delay(500);
  digitalWrite(LED,LOW);
}
```

Hantek 6022BL PC Based USB Digital Portable Oscilloscope + 16 CHs Logic Analyzer, 48MS/s Real-time Sampling, 20MHz Bandwidth

Local: Rs. 13,000-20,000/=



DSO138 DIY Oscilloscope

Vertical

- Number of Channel: 1
- Analog Bandwidth: 0 - 200KHz
- Sensitivity: 10mV/Div - 5V/Div
- Sensitivity error: < 5%
- Resolution: 12-bit
- Input Impedance: 1M ohm
- Maximum Input voltage: 50Vpk
- Coupling: DC, AC, GND

Horizontal

- Max Real-time Sampling Rate: 1Msps
- Timebase: 10us/Div - 500s/Div
- Record Length: 1024

Trigger

- Trigger Modes: Auto, Normal, Single
- Trigger Types: Rising/falling edge
- Trigger Position: 1/2 of buffer size fixed

Display

- 2.4-inch color TFT LCD with 320 x 240 r soluti

Power Supply

- 9V DC (8 - 12V acceptable)
- Supply Current: 120mA

Physical

- Dimension: 117mm X 76mm X 15mm
- Weight: 70 gram (not including cables)

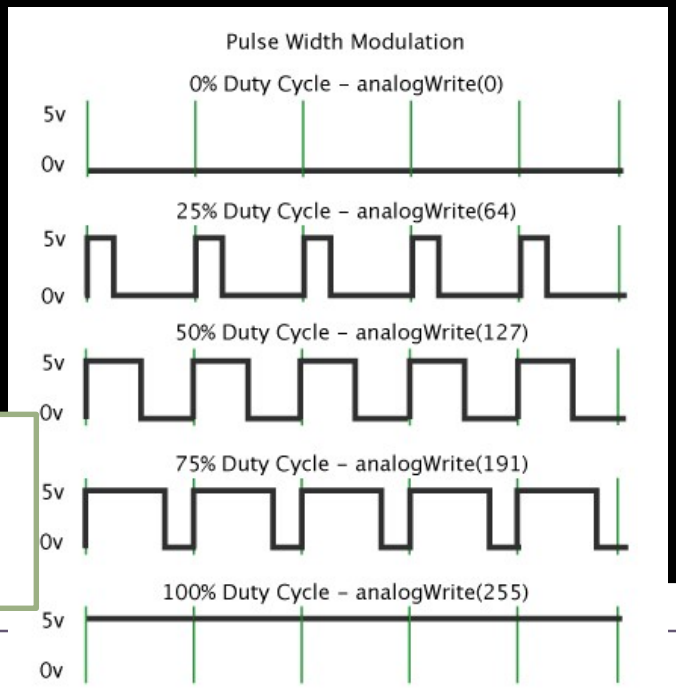
Local: Rs. 4000-8000/=

By JYE Tech based on Cortex-M3 ARM processor (STM32F103C8)
https://jyetech.com/dso-138-oscilloscope-diy-kit/

Analog Out in ESP32: LED

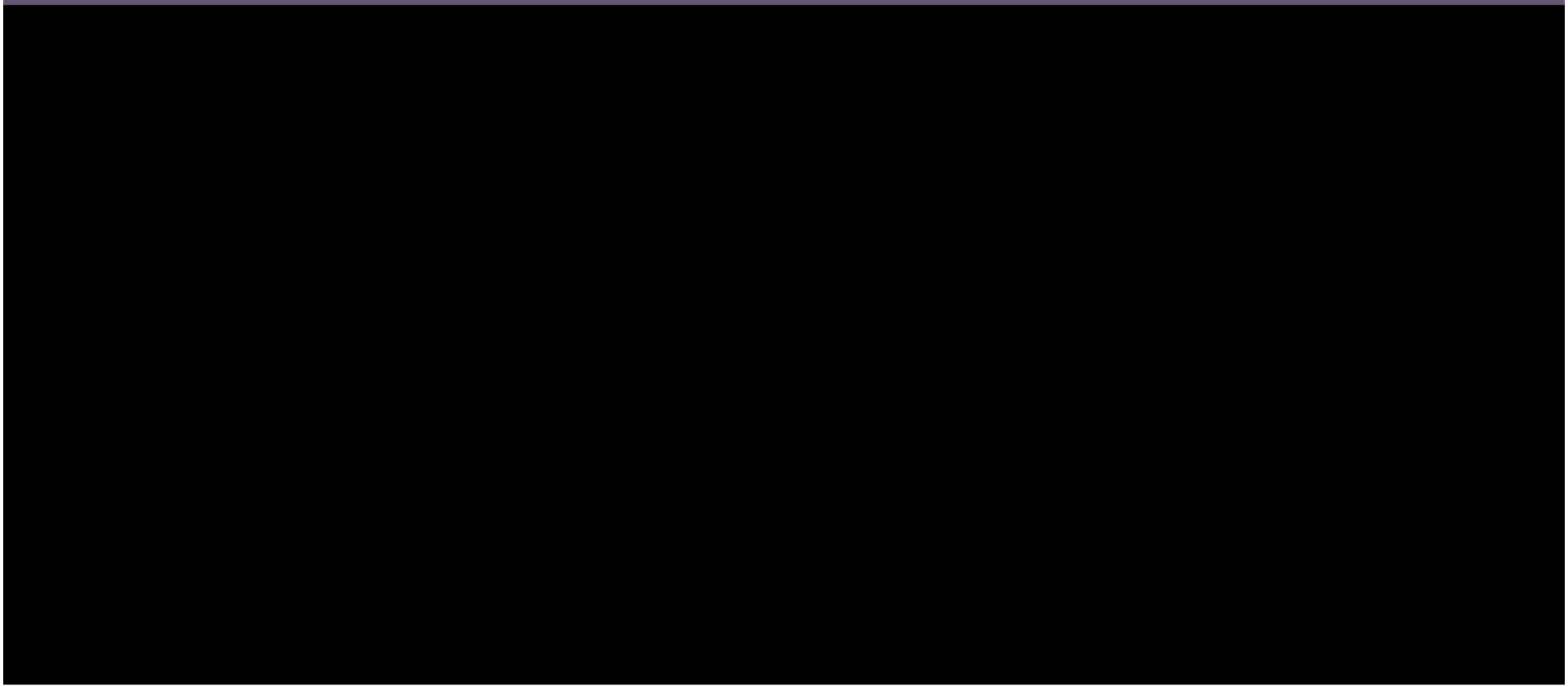
Analog Out in Arduino: LED

```
void setup() {
  Serial.begin(9600);
  pinMode(3,OUTPUT);
}

void loop() {
  for (int i=0; i<255; i+=10) {
    analogWrite(3, i);
    Serial.println(i);
    delay(30);
  }
  for (int i=255; i>0; i-=10) {
    analogWrite(3, i);
    Serial.println(i);
    delay(30);
  }
}
```

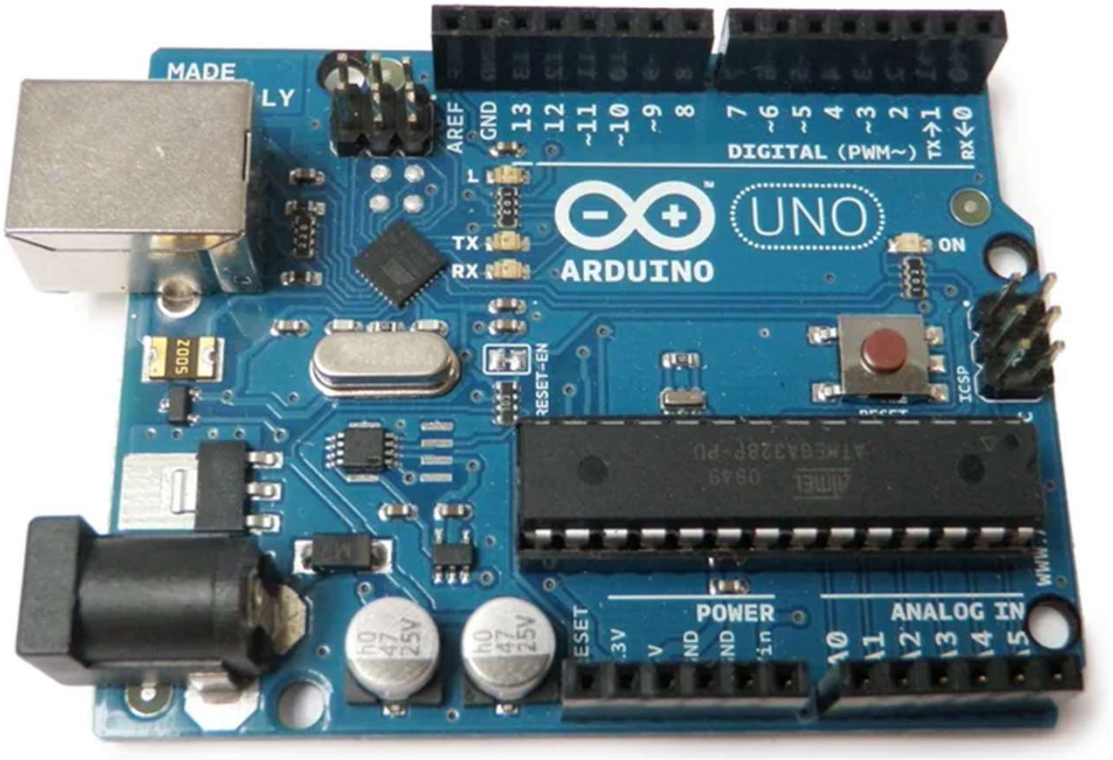


PWM for creating a pseudo analog voltage
Duty Cycle – 20% => duty cycle within 1 sec.
period = ON for 200 m.sec.

Which Pins in Arduino Uno Provides PWM?



Which Pins in Arduino Uno Provides PWM?



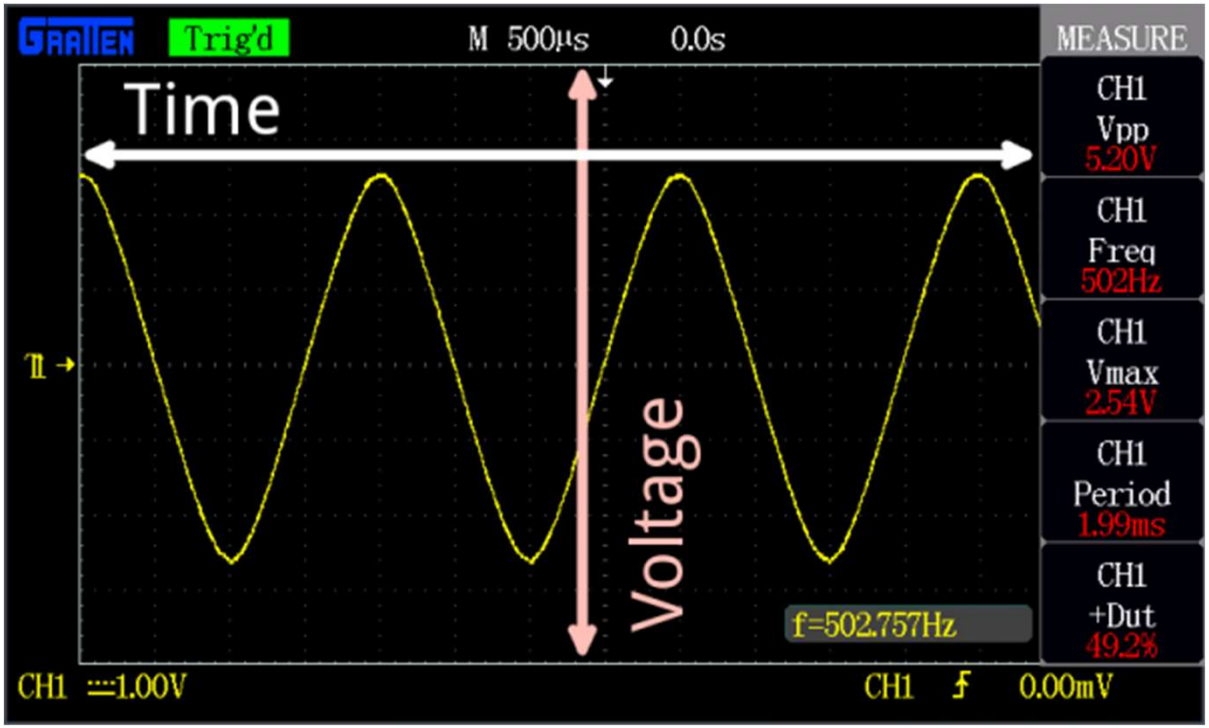
Attention

- Put a chat message indicating your index number and 111, e.g.,
  - **18001234_111**

How to Use an Oscilloscope?

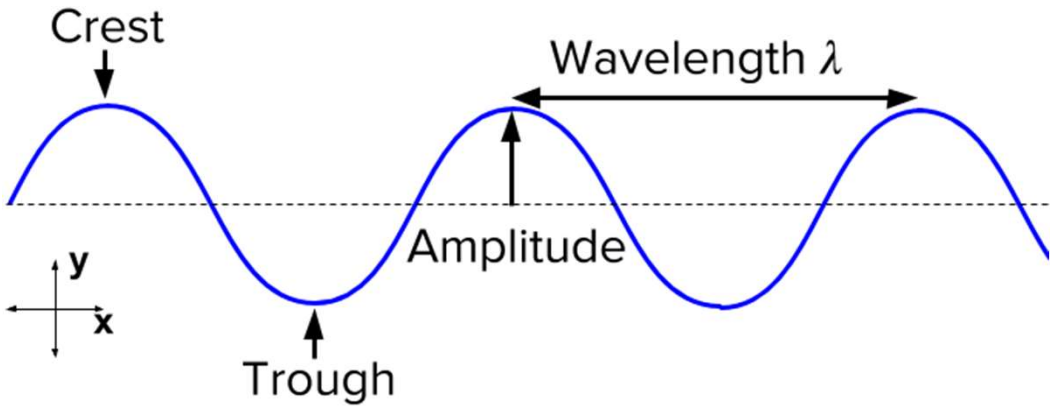
https://learn.sparkfun.com/tutorials/how-to-use-an-oscilloscope/all

- Purpose:
  - To graph an electrical signal as it varies over time
- Controls:
  - To zoom in and zoom out the horizontal and vertical axes
  - Trigger to stabilize the display

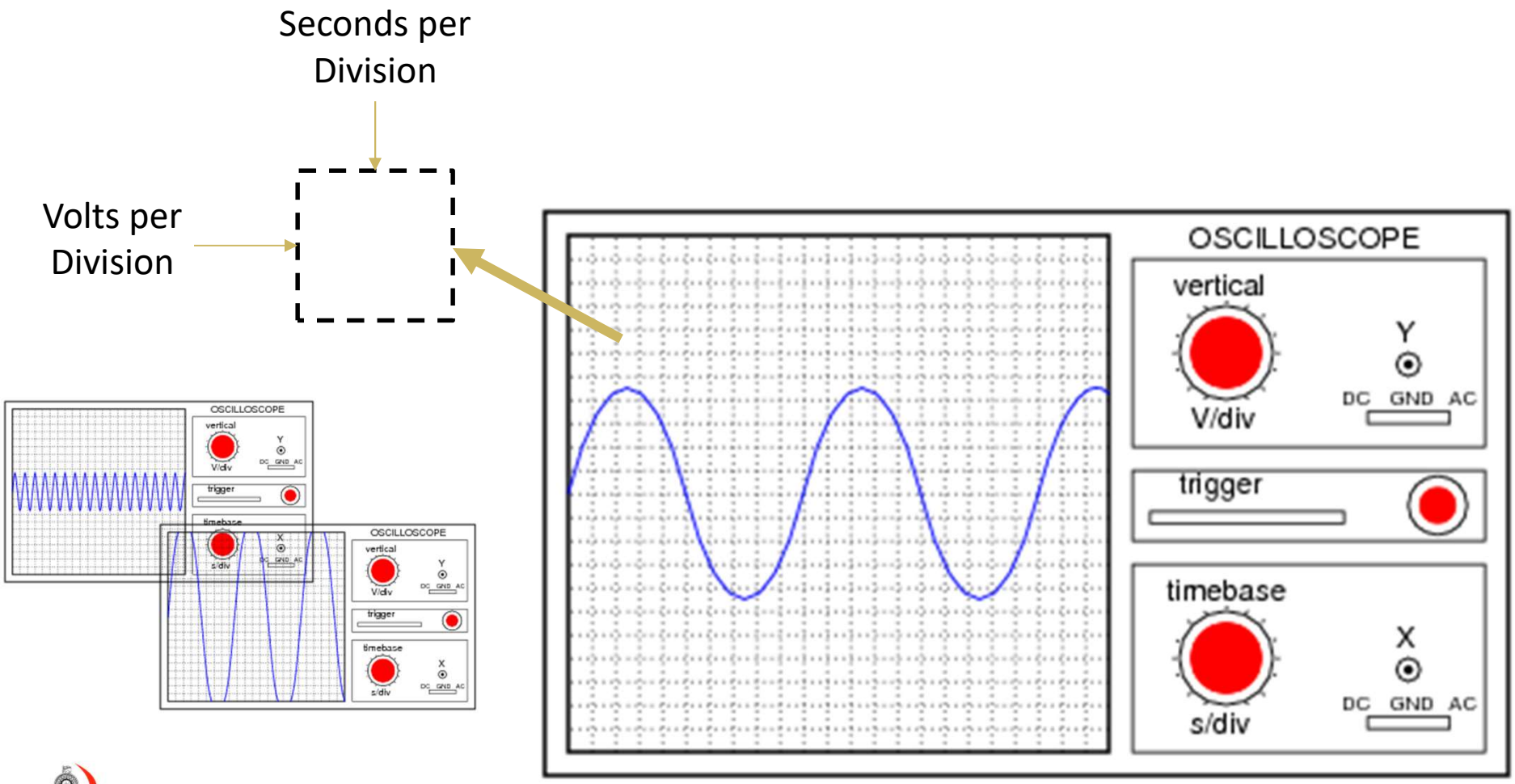


What Can O-Scopes Measures?

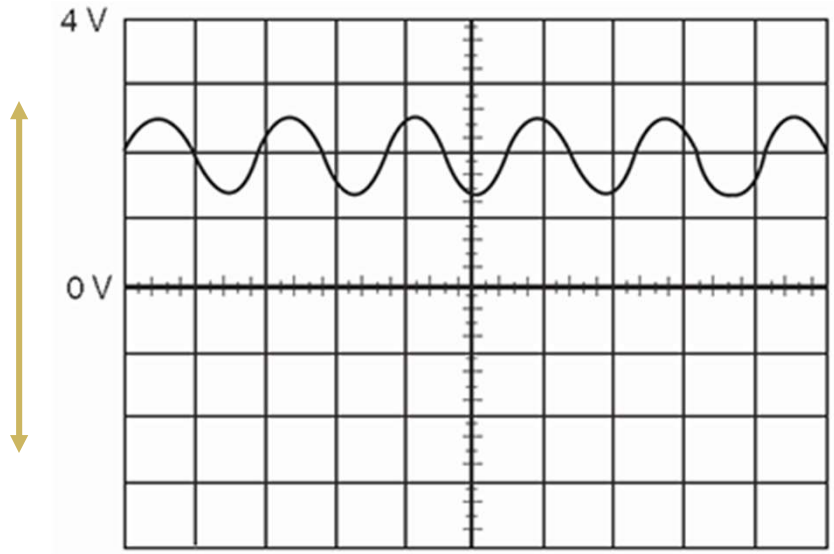
- Both voltage-based and time-based characteristics
- Voltage-based
  - Amplitude, peak-to-peak, min, max, average, etc.
- Time-based
  - Frequency, period/wavelength, duty cycle, rise/fall time, etc.
- Other
  - Shape of wave, phase, compare waves, noise, etc.

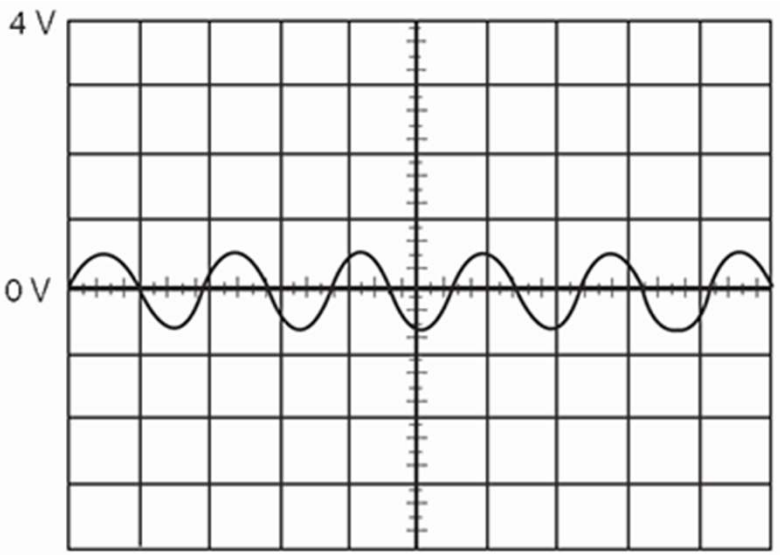


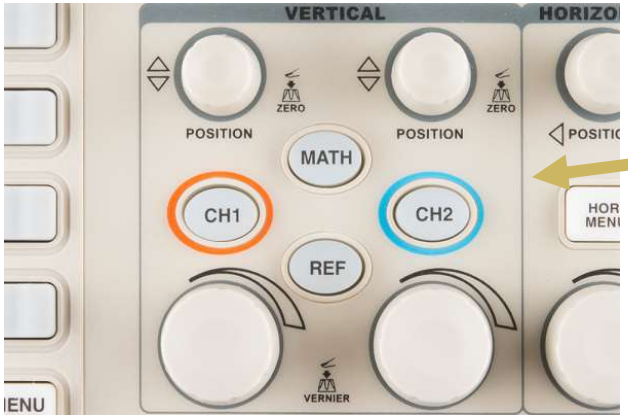
O-Scope Display



Vertical Position





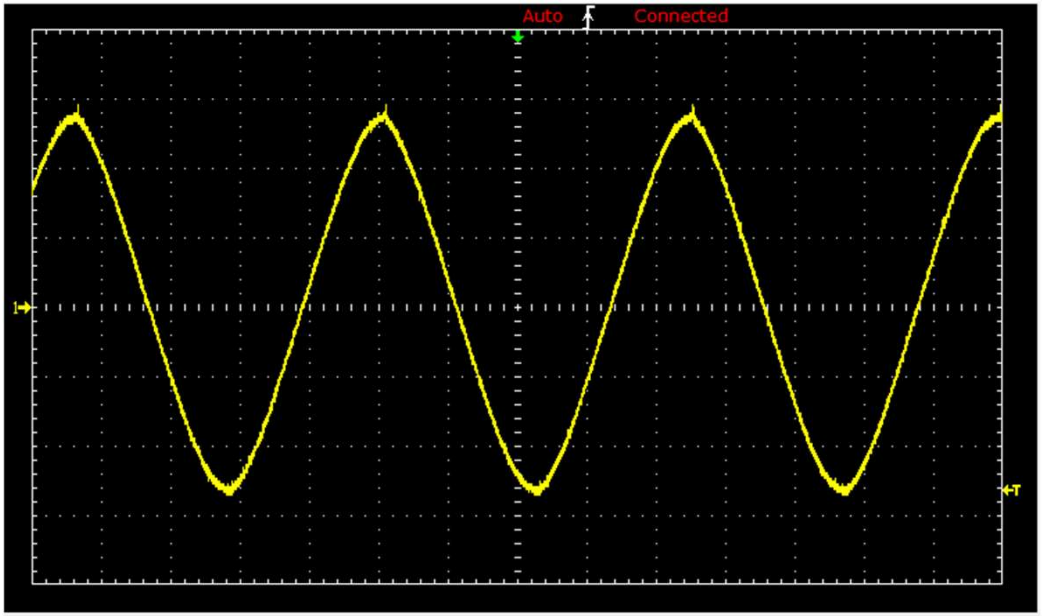


Controls the Vertical (Voltage) Scale

Horizontal Scale

Trigger

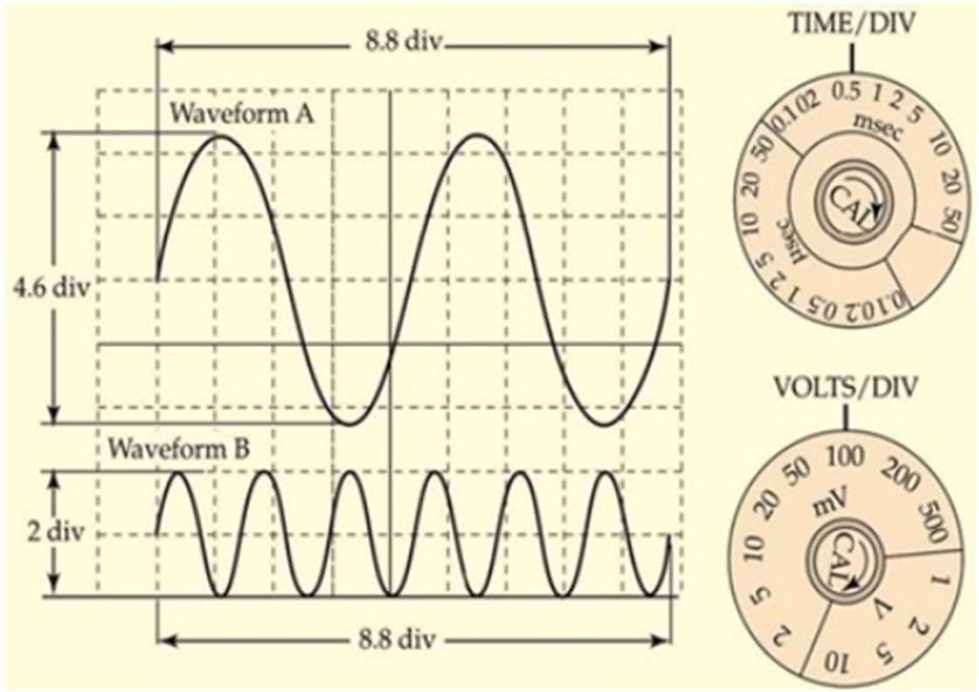
No/Improper Trigger



Exercise

- Calculate the frequencies of the two waveforms (A&B).

TIME/DIV= 0.5ms/DIV
VOLTS/DIV= 100mV/DIV = 0.1V/DIV



Waveform A:

$V_{p\text{-}p}$ = 0.1*4.6 = 0.46V

T= 0.5*(8.8/2) = 2.2 ms

f = 1/T = 454.5 Hz

Waveform B:

$V_{p\text{-}p}$ = 0.1*2 = 0.2V

T= 0.5*(8.8/6) = 0.733 ms

f = 1/T = 1.36 kHz.

Attention

- Put a chat message indicating your index number and 125, e.g.,
  - **18001234_125**

Exercise

```
int led = 3;

void setup() {
  pinMode(led,OUTPUT);
}

void loop() {
  analogWrite(led, 64);
}
```