

CMPE242
Spring 2023

1/

Jan 25th (Wed), 2023

Organizational Meeting.

1° Class Syllabus; "Green sheet". Make a good use of the O.H. But it will expire by the end of the semester, By the end of the class. 3°.

San José State University
Computer Engineering Department
CMPE 242 Embedded Hardware Systems, Section 1, S2023 Lab

Room/Facility: Rm 268.
Access Form.

Course and Contact Information

Instructor:	Hua Harry Li, Ph.D.
Office Location:	Engineering Building, Rm 267A
Telephone:	(650) 400-1116 Text Message Only
Email:	hua.li@sjsu.edu
Office Hours:	<u>Mondays and Wednesdays 4:30 – 5:30 pm</u> Zoom link for the Office Hours Join Zoom Meeting https://us04web.zoom.us/j/9841607683? pwd=U1A3aEk1TnV4bjNLQk5CQkw0dDk4UT09 Meeting ID: 984 160 7683 Passcode: 121092
Class Days/Time:	<u>Monday and Wednesday 3:00 – 4:15 pm</u>
Classroom:	Engineering Build Room 325
Prerequisites:	CMPE 180A and 180D, classified standing, or instructor consent

Note: 4° Nature of the Class

Hardware: Target Platform Selection:
Software: { 1° Kernel Source Dist. Jot Pack;
2° Device Development, STI,
3° Python, C/C++
4° Github

NDA Jackson NAD
2gb/4gb.
Broadcom
R. Pie 3b+,
Pie 4.

Course Format

Technology Intensive, Hybrid, and Online Courses (Required if applicable)

This course requires use of computer/laptop, special microprocessor/ARM hardware for system prototyping, Python and/or C/C++ compiler for software programming. Students must have to participate in classroom activities and after class homework and projects assignment.

Faculty Web Page and MYSJSU Messaging (Optional)

Copies of the course reference materials such as datasheets, project references etc. can be found on line at <https://github.com/hualili/CMPE242-Embedded-Systems-> and/or SJSU CANVAS. Office hours Zoom link (during the Pandemic): Join Zoom Meeting [https://us04web.zoom.us/j/9841607683?](https://us04web.zoom.us/j/9841607683?pwd=U1A3aEk1TnV4bjNLQk5CQkw0dDk4UT09) Meeting ID: 984 160 7683 Passcode: 121092

Course Description (Required)

Advanced topics dealing with microprocessor and microcontroller hardware and firmware including processor architecture, advanced memory and I/O systems design, multilevel bus architecture, interrupt systems. Design project. Prerequisites: CMPE 180A and 180D, classified standing, or instructor consent.

Course Learning Outcomes (CLO) (Required)

Course Learning Objectives (CLO):

[hualili / CMPE242-Embedded-Systems-](https://github.com/hualili/CMPE242-Embedded-Systems-) Publi

Course Description/Nature: Hands-on,
Sound Theoretical Background, Coverage
of Theory. Note: Sensors, LSM303



Motors { Stepper motors, NEMA 17
3phase BLDC motor.
Automobile window wiper motor



3D Printer, CNC machines.



Robotics.

Required Texts/Readings (Required)

Note: Datasheets.

Textbook

1. S3C6410 RISC Processor datasheets, Samsung Electronics
https://github.com/hualili/CMPE244/blob/main/2021F-105-%230-cpu-arm11-2018S-29-CPU_S3C6410X.pdf and Development Board schematics
<https://github.com/hualili/CMPE244/blob/main/2021F-105b-%232018S-29-SCH-Tiny6410SDK-1111-PCB.pdf>
2. Nvidia Jetson NANO datasheets.
(a) Jetson Nano development kit document https://github.com/hualili/CMPE244/blob/main/2021F-108-%231NVIDIA_Jetson_Nano_Developer_Kit_User_Guide.pdf
(b) Jetson NANO System-on-Module
https://github.com/hualili/CMPE244/blob/main/2021F-108b-%23JetsonNano_DataSheet.pdf
(c) Optional (not used) SoC Park CPU reference https://github.com/hualili/CMPE244/blob/main/2021F-106-tx2-%23Parker_TRM_DP07821001p.pdf
3. Broadcom Raspberry Pie CPU datasheets, BCM2835 CPU
<https://github.com/hualili/CMPE244/blob/main/2021F-104-%230-cpu-pie-BCM2835-ARM-Peripherals.pdf> and https://github.com/hualili/CMPE244/blob/main/2021F-104d-simplifiedCPU-datasheet-%23rpi_DATA_CM_1p0.pdf

Other Readings

1. Professor Li's PPT, handout materials, lecture notes on line <https://github.com/hualili/CMPE242-Embedded-Systems->

Ref: on github, Lecture Notes.

CMPE212 Spring 2023

Grading Information (Required)

Midterm Examination	30%
Homework and Projects	30%
Final Examination	40%

The examination grades are given based on the written answer in grades are given based on the work submitted, prototype system programming source code. The detailed rubrics for each homework assignment is given, check online both CANVAS and <https://git> project will be given to students for each submission with multiple learning. Rubrics examples for project 1 submission, for example software implementation counts 40%, report counts 20%, so the

Exams: In-Person, In-Class.

Submission To CANVAS.

Need Laptop & Prototype System in the Exam.

Alternative 1: Broadcom. Raspberry
Pie 3, 3B+, 4.

Determination of Grades

Jan 29 (Monday).

1. Homework, 0 pt. Honesty pledge.

Due this Wednesday, ON CANVAS.

Ref from the github

2022S-101-notes-cmpe242-3-14.pdf

Example: Selection of Target platform.

Build Selection matrix Below.

1. Architectural Aspects.

X86, ARM, MIPS
CISC, RISC, MIPS
for Server, 1982

2. User Basis, Market share.

3. OS Kernel Aspect: Linux/Unix.

4. Forward Looking: GPU →

GP GPU (general Purpose) →
AI/ML.

for Example: Jetson Nano

Quad CPU: ARM.
GPU (128 GPUs)

Quad ARM.

Discussion: I/O I/F for An Embedded

System: Tx/Rx/GND

1° UART (Serial Communication)

2° SPI. 100 Mbps

3° I2C, {SDA, SCK}

4° PWM

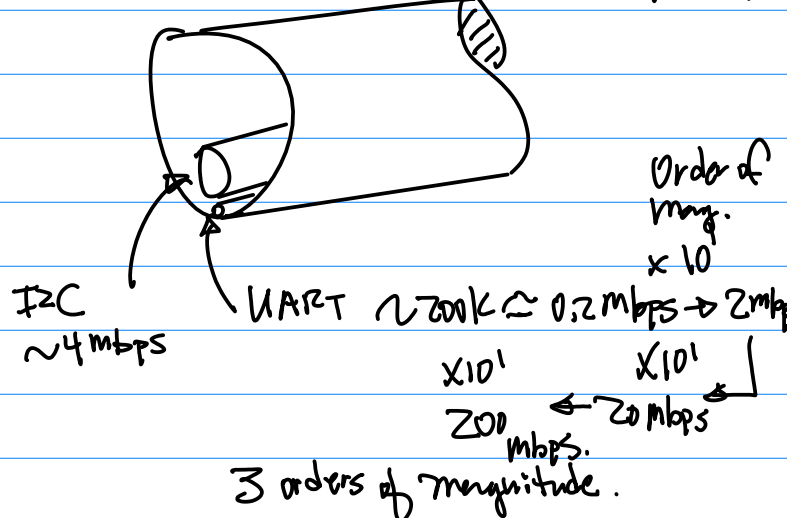
5° CAN

6° ADC

Mini Com/Putty
~1200 kbps Slow!

"3+1" {MOSI, MISO, SCK, nEN}

SPI Bit Rate
~100 Mbps.



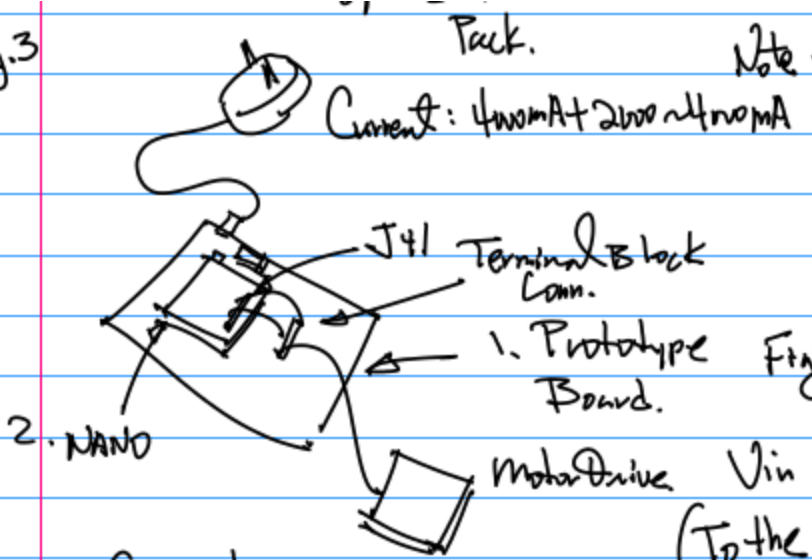
NANO, ~\$140
4gb.

Check zgb Towards the end
of Life.

Homework Preparation.

1° Build A Prototype Board. Ref. PP.3. Fig.3

Fig.3



Note: 1° Prototype Board. Dimension:
Feb 1. (Wednesday).

Note: 1. Target Board Selection
By today, Bring your
Target Together with the
Prototype Board to the Class
a week from today.

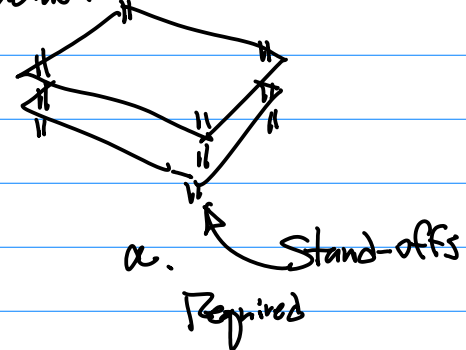
Example: to prepare the first Homework.

Note: 1° First Homework: "Hello, the
World" prototype System.
Python (Pycharm IDE) program
to flip LED. Turn ON/OFF LED.

2° Prototype Board.

Order online (Amazon) or
Local store, Anchor Electronics.
(Santa Clara.)

Dimension:



b. Connectors Encouraged/
Required;



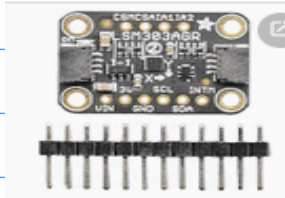
10pcs Upgraded Tiny Whoop JST-PH 2.0
Male and Female Connector Cable for
Battery JJRC H36 H67 Blade Inductrix
E010 E013

C. Bread Board for Quick Prototyping.

d. Right gauge of the prototyping wires, #28 or
higher (etc. 1 or 2 steps. Ref: 10mA)
~ up to 400mA

3. LED Assorted, Red, Yellow, etc.
Resistors.
Capacitors. 4.7µF (1~2PCS)

4° LSM303 (I2C, SPI)



Adafruit Industries
LLC 4413

This board/chip uses I2C 7-bit addresses 0x19 & 0x1E

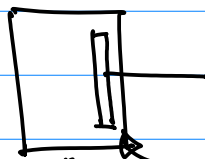
5° I2C Approximity Sensor.

Note: I2C Max for Multi-I2C Devices.

6° Design for the 1st Homework.

Hardware Design { I/P Testing { I.P. High
Software Design { O/P Testing { O.P. High → LED ON
O.P. Low → OFF

Note: Toggle SW to generate "High" or "Low" Input to the GPP of the NANO



Target CPU
NANO

J41, 40 pins connector / 2 Rows.
(Longest Connector)

Identify 3 pins { GND
Vcc
GPIO

Pin Assignment Table

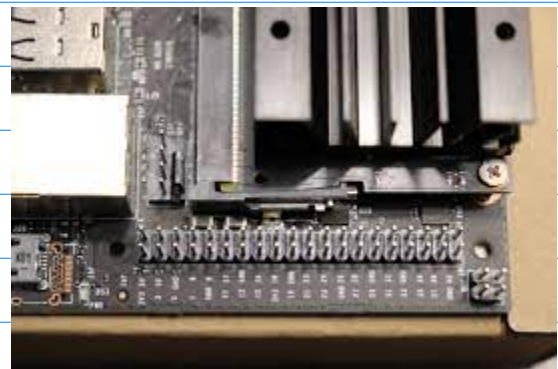
Pin	Description	Note
J41-1	3V3	
J41-2	5V	
J41-39	GND	
J41-12	GPIO	gpio79 Output
J41-40	GPIO	gpio78 Input



element14 Community

Jetson Nano Dev-Board Expansion Header

Alt Function	Linux(BCM)	Board Label	Board Label	Linux(BCM)
DAP4_DOUT	78(21)	D21	40 39	GND
DAP4_DIN	77(20)	D20	38 37	D26
UART2_CTS	51(16)	D16	36 35	D19
		GND	34 33	D13
LCD_BL_PWM	168(12)	D12	32 31	D6
		GND	30 29	D5
		D11/I0_SC	28 27	D0/I0_SD
SPI1_CS1	20(7)	D7	26 25	GND
SPI1_CS0	19(8)	D8	24 23	D11
SPI2_MISO	13(25)	D25	22 21	D9
		GND	20 19	D10
SPI2_CS0	15(24)	D24	18 17	3.3V
SPI2_CS1	232(23)	D23	16 15	D22
		GND	14 13	D27
DAP4_SCLK	79(18)	D18	12 11	D17
		RXD/D15	10 9	GND
		TXD/D14	8 7	D4
		GND	6 5	GND



Good Ref. Source

<https://jetsonhacks.com> > nvidia-jetson

NVIDIA Jetson Nano J41

Feb 6 (Monday).
Today's Topics: Design of
Prototype Board to Bring up the
target platform (NANO).

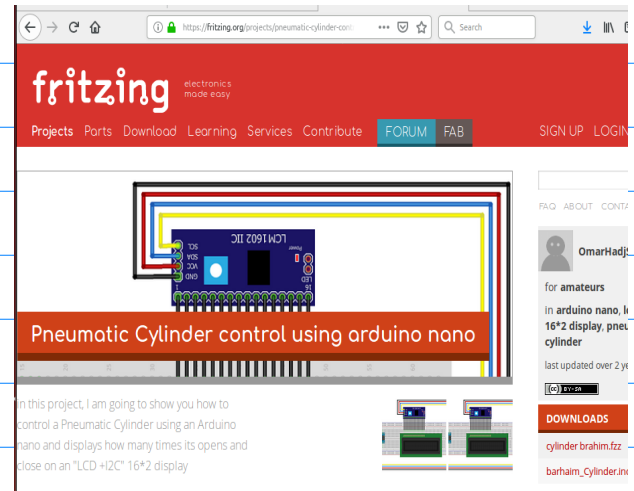
Ref: 1st Github

CMPE242-Embedded-Systems- / 2022S / 2022S-103-SDcard-source-distribution-tool-chain-
menuconfig-2021-10-8.pdf

2nd Github, Lecture Notes

/stems- / 2022S / 2022S-101-notes-cmpe242-3-14.pdf

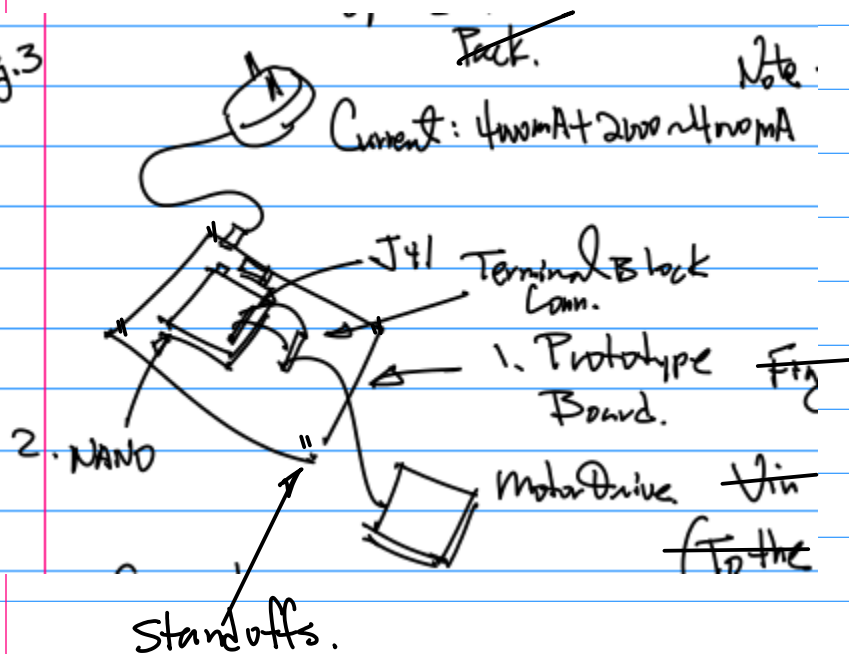
Note: Try to use on-line tool.



Note: Bring your target platform
to the Class for inspection
on Wednesday.

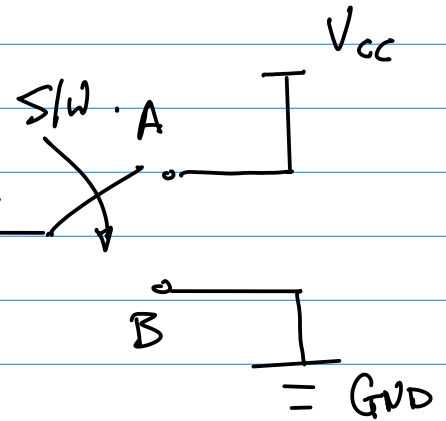
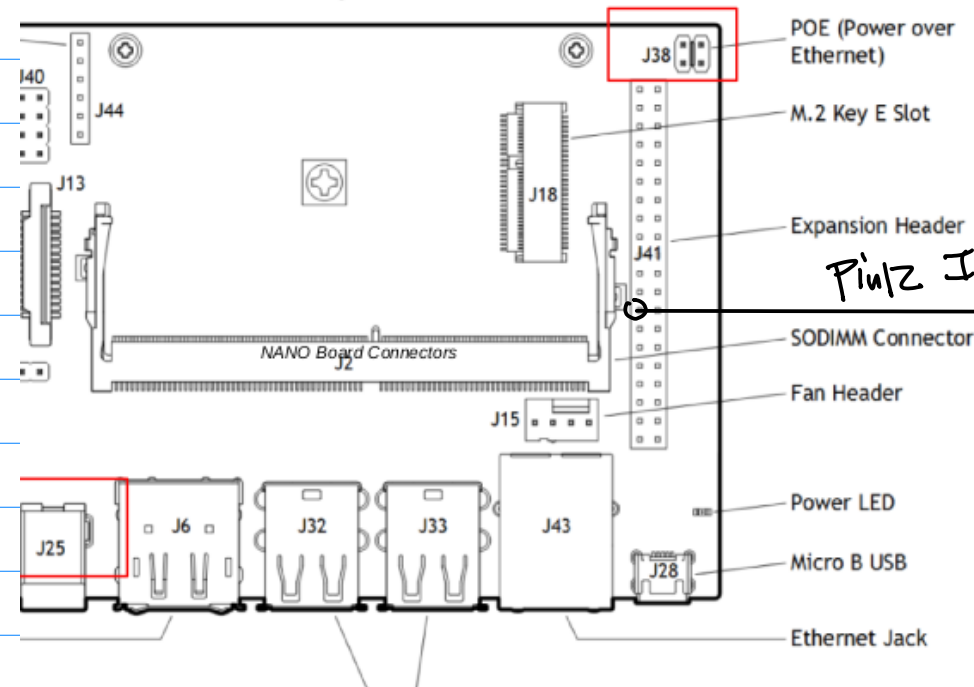
- a. Target platform.
- b. Work in progress.

Fig.3



Example: Continuation ON GPIO I/F
Design.
Design for the Input Testing.

Top View



↓ modify the Design to Add R_1

Let $I_1 = 10 \text{ mA}$, find R_1 .

$$V_{cc} - R_1 I_1 = V_{in}$$

where $I_1 = 10 \text{ mA}$, $V_{in} = 0 \text{ V}$.

$$V_{cc} - R_1 \times 10 \times 10^{-3} = 0, R_1 = \frac{V_{cc}}{10^{-2}} = \frac{3.3}{10^{-2}} = 3.3 \times 10^2 \Omega = 330 \Omega$$

Next, update the Design to add R_2 to Regulate I_2 .

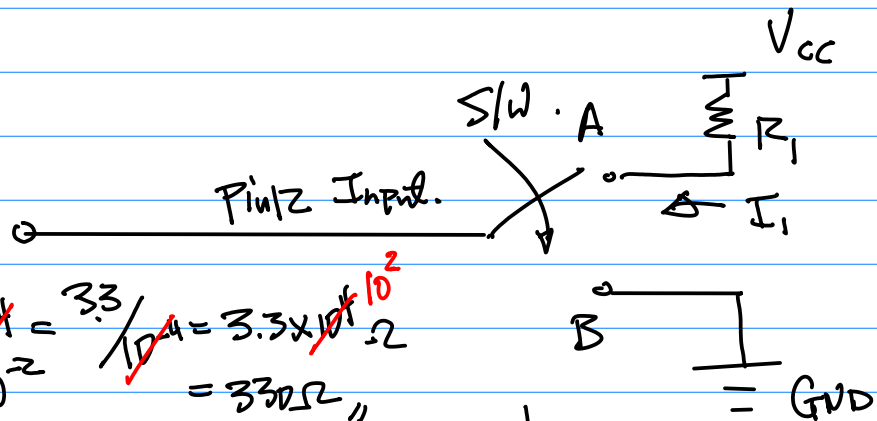
Make $I_2 = 10 \times 10^{-3} \text{ A}$

Assume $V_{12} = V_{cc} = 3.3 \text{ V}$.

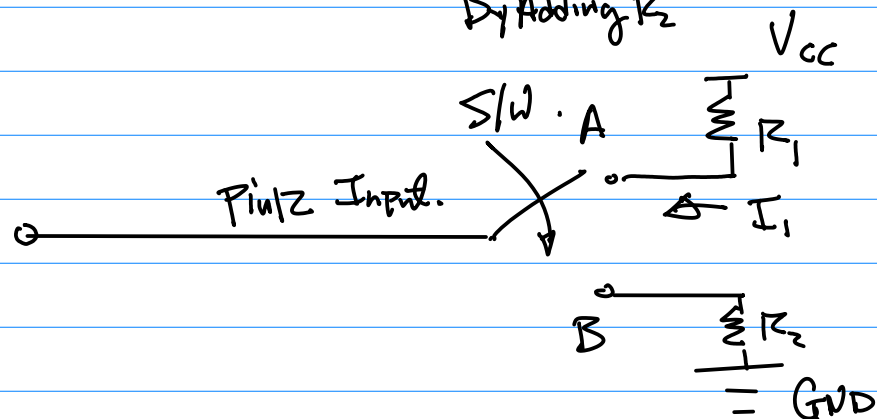
$$V_{12} - I_2 R_2 = 0, \text{ hence}$$

$$V_{cc} = I_2 R_2 \quad | \quad I_2 = 10 \times 10^{-3}$$

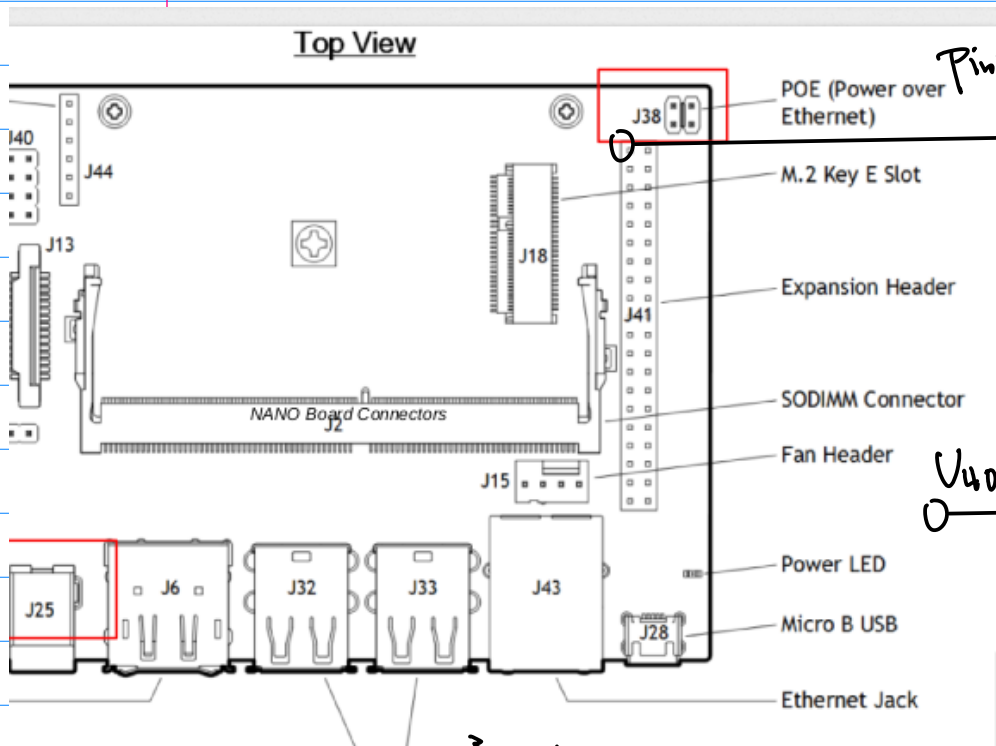
$$\therefore R_2 = \frac{V_{cc}}{I_2} = \frac{3.3}{10^{-2}} = 330 \Omega$$



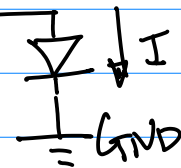
↓ modify the Design By Adding R_2



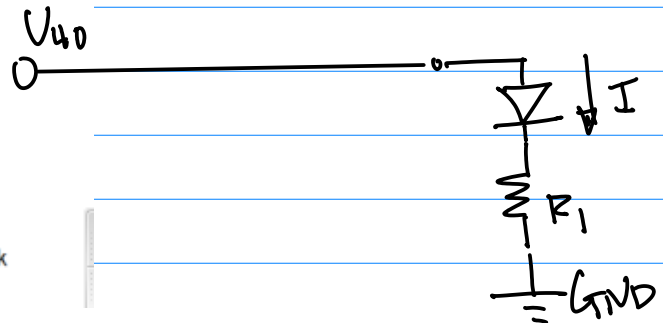
Output Testing Circuit.



Pin40 Output



↓ Add R_1 to Regulate The Current I .



Let $I \approx 10 \times 10^{-3}$. find R_1 .

$$V_{40} - IR_1 = 0, \quad R_1 = V_{40} / I \quad \left| \begin{array}{l} V_{40} = V_{CC} = 3.3V. \\ I = 10 \times 10^{-3} \end{array} \right. = 3.3 / 10^{-2} = 330 \Omega.$$

20225-103-SDcard-source-distribution-tool-chain-menuconfigu-2021-10-8.pdf

Software Design:

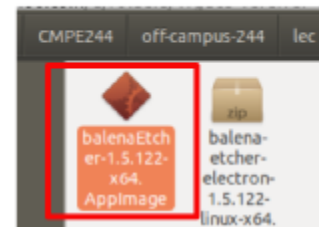
Step 1. Prepare microSD Card, 16GB
or 32GB (for Additional App.).
Download Pre-Compiled/Built
Kernel Image from the Nvidia
Site

<https://developer.nvidia.com/embedded/learn/get-started-jetson-nano-devkit#write>

Step 2. Download the software "Etcher"
to your host machine in order to write
the kernel image to your microSD
Card.

(2.1) for Linux host, Download, install, and launch Etcher.

<https://www.balena.io/etcher/>



Step 3. Take the microSD, insert it
to your target platform.



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the power up the NAND Board,
Config the Board by following the
prompt.

Note: It is recommended to
use 4 Amps Power Adaptor.

Step 4. Init & Config. for GPIO
Driver.

Ref.

Feb 8 (Wed). Wednesday
Homework. Due Feb 15th. (GPIO Homework)

1^o Written Requirements for the Homework
Will be posted on CANVAS.

2^o Submission ON CANVAS. No E-mail
Submission.

3^o Target platform with Prototype
Board

20225-104-gpio-systemLevel-and-c-#2021F-114-gpio-nano-v3-hl-2021-10-20.pdf

T.P.Z. Note: a. Website, Ref. Sources.

Pi and NANO are pin to pin compatible

Jetson Nano GPIO - JetsonHacks <https://www.jetsonhacks.com> ... > GPIO/2C
Jun 7, 2019 — As you may have heard, the GPIO pin layout on the Jetson Nano
is compatible with the 40 pin layout of a Raspberry Pi (RPi).

b. → 40 pin Connector is Compatible
With Raspberry Pi.

c. By Default, the Kernel Image (O.S.)
has already configured GPIO
Driver, so, use Command Line
to Turn ON/OFF LED As follows.

```
$ echo 79 > /sys/class/gpio/export
```

← Connect to the GPIO
Driver.

```
$ echo out > /sys/class/gpio/gpio79/direction
```

← Config the
GPIO As An
Output

```
$ echo 1 > /sys/class/gpio/gpio79/value
```

```
$ echo 0 > /sys/class/gpio/gpio79/value
```

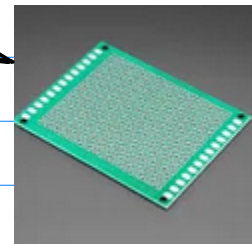
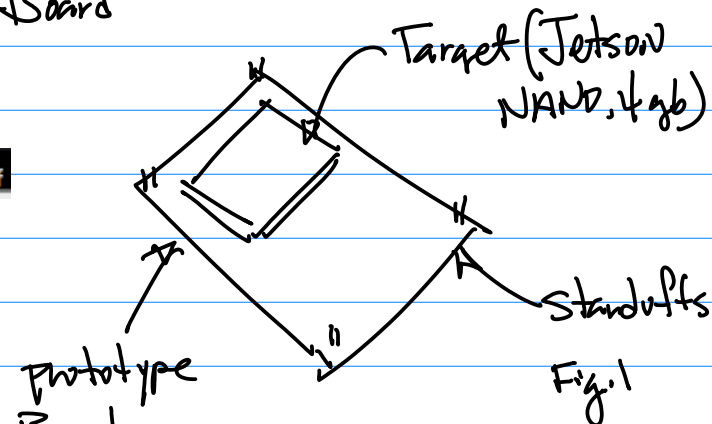
```
$ echo 79 /sys/class/gpio/unexport
```

```
$ cat /sys/kernel/debug/gpio
```

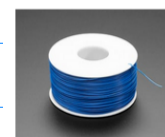
Set output = "1"
Set input = "0"
Release GPIO

Homework : GPIO Testing. Due A Feb.
Week from Today.

Bring the Board to Class for Demo.



Note: Bread Board for this Homework
is OK, But for the Rest of the
Homework, We must use
Prototype Board.
2^o Standoffs.
3^o Wire for prototyping should
be in the Range of 28 AWG ~ 32
AWG



"Wire Wrap" Thin Prototyping & Repair
Wire - 200m 30AWG Blue

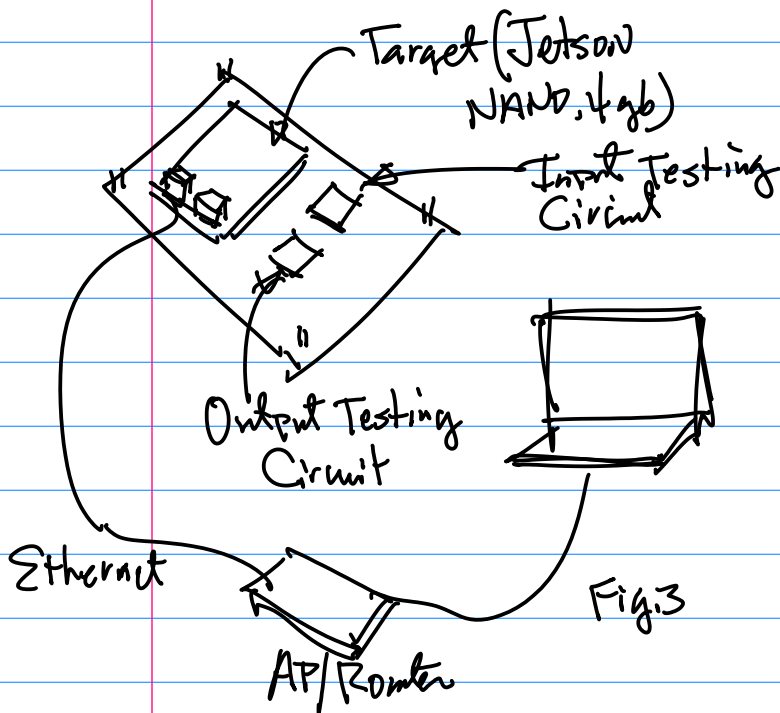
PRODUCT ID: 1446

Add to Cart

\$7.50
In stock

Fig. 2

4^o Input/Output Testing Circuit
has to be included,
please take photos of
(a) Entire System.



(b) I/P, O/P circuit of
the Board. "Closed-In"
View.

5^o README file ~1 page.

6^o Screen Capture of the
Program Execution & Result.

Make sure the Screen Captures
have your personal identifier.

7^o Source code Listing.

a. "Template"
Name of the program:
Coded by:
Date:
Version: { Release
Debug

Purpose:

Copyright:

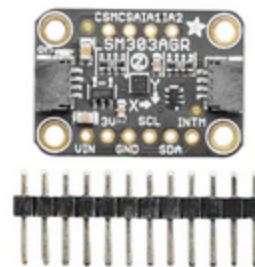
Note:

8^o Short Video Clips, Not exceeding 15~30 Sec.

Options: { github for the class.
for your work.
Video Clip(s). Youtube.

Bill of material Needed for the
Coming homework and lectures.

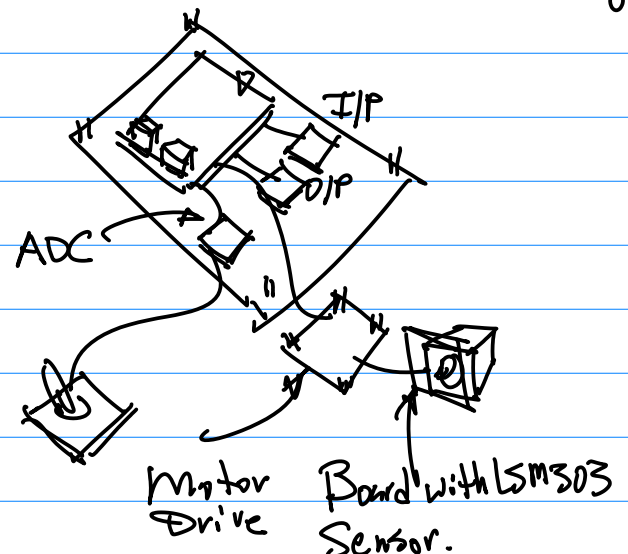
1. LSM303 Sensor \$12.95 from digikey.



Please Bring it to
the class Next
Monday.

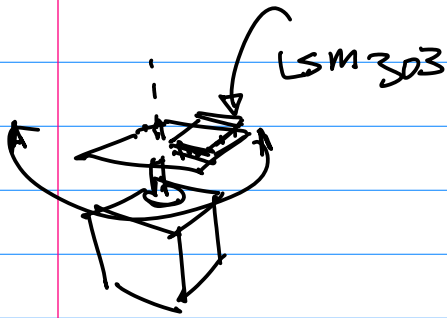
Fig.4

Fig.5



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2. Motor.

Option 1. Stepper motor
NEMA 17



[Adafruit Industries LLC](#)
[324 Bipolar Stepper](#)
[Motor Hybrid Frame Size](#)
[17 200 Step 350mA](#)

[\\$14.00](#)
[Digi-Key](#)



[4 Axis Nema23 Stepper](#)
[Motor 270oz-in 76mm](#)
[3A Dual Shaft+TB6560](#)
[MD430 Driver CNC](#)

[\\$178.00](#)
[Amazon.com](#)
[Free shipping](#)



Option 2. Motor for E.V.

BLDC (Brushless D.C. motor)

for Scooters, eBike, or \$50 ~ \$200



Option 3. Motors from Automobile Industry,
from Amazon. \$35 ~ \$200



Note: please form 2 person
Team By Next week.

Human Control Interface

Devices . Hand Bar Controller
for Scooters .



\$12.

Ads · Shop adc i2c pie

Datasheet



adafruit-ADS1015
12-Bit ADC - 4
\$9.95
Adafruit Industries

Python Reference
Code is
Available
as well.

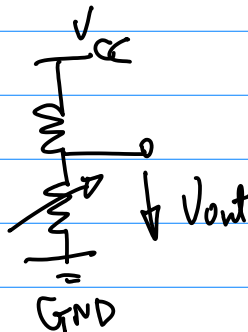
Wireless Game Console Controller.



~\$199.

DualSense Edge
wireless controller -

Or: Potential meter.



Bourns Inc.
PDB181-
\$1.47
Digi-Key