The Chinese University of Hong Kong
Department of Computer Science and Engineering
CENG2030 Fundamentals of Embedded System Design

Lab 7: Finite State Machine

Submission Instructions:

- You are required to submit **demo videos**, **answer sheet**, and **Arduino codes** to Blackboard.
- Create each Arduino project with a project name based on the lab and question numbers, e.g. **Lab7_Q1**.
- Answer all the questions in the .docx answer sheet
- Compress all the files to .zip file with your SID, e.g. **1155123456_Lab7.zip**
- Upload the .zip file to Blackboard before the deadline stated in Blackboard
- 10 marks will be deducted per day for late submission

For each question below, you are required to record a short mp4 **video** to demonstrate the answers. In the video, the following elements are required:

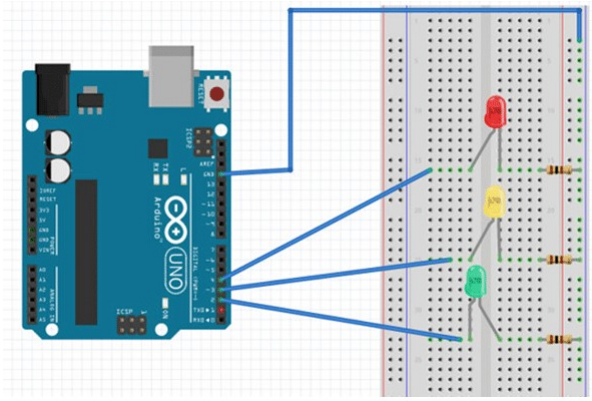
A. Show your full name and SID on a paper next to your circuit [8 marks]
B. Voice descriptions in English/Cantonese/Mandarin on what you are doing [8 marks]
C. Demonstrate your works by presenting all possible cases clearly [20 marks]

List of Components and Equipment:

- Arduino: 1x Arduino UNO Board with USB cable
- Breadboard: 1x Breadboard and Wires
- Resistors: 5x ~220Ω
- LED: 2x Red, 1x Yellow, 2x Green

1. Simple Traffic Light

To build a traffic light FSM, connect the LEDs and resistors on a breadboard to the Arduino UNO Board. For more information on the Arduino UNO Board, please visit https://store.arduino.cc/usa/arduino-uno-rev3



a. Hardware Connections
   i. Connect the anode (i.e. the positive terminal, and normally the longer leg) of the Green, Yellow, and Red LEDs to the digital output pins 2, 3, & 4 of the Arduino UNO Board respectively
   ii. Connect the cathode (i.e. the negative terminal, and normally the shorter leg) of all the LEDs to the corresponding resisters as shown in the picture above
   iii. Connect the other ends of the resisters to the GND pin of the Arduino UNO Board
   iv. Connect the Arduino UNO Board to your computer by using the USB cable
   v. Answer the questions on the answer sheet

b. Software Programming

i. On the desktop of your computer, double click the following Arduino icon to execute the Arduino IDE

ii. Create a new project by:

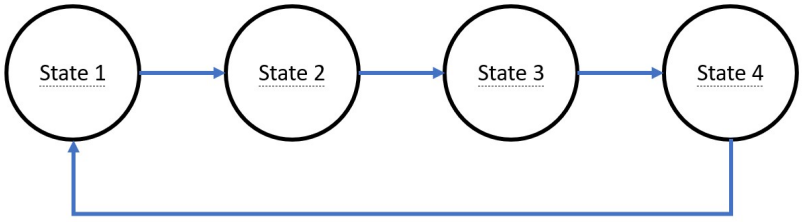
1. Click File > New, a new window will pop up
2. Copy the codes below

```
int green  = 2; // this number indicates the pin number of the Arduino board
int yellow = 3;
int red    = 4;

void setup() {
        pinMode(green, OUTPUT);
        pinMode(yellow, OUTPUT);
        pinMode(red, OUTPUT);
}

void loop() {
        // add FSM by calling state sub-routines here
}

void state_1() { // definition of State 1
        // add codes here to light up the LEDs and provide time delays
}

// add more states here
```

3. Paste the codes and replace everything in the new pop up window
4. Modify the codes to build the traffic light FSM. The FSM should include the following states in a sequential order:

State ID	Red	Yellow	Green	Duration
1	ON			5 sec.
2	ON	ON		3 sec.
3			ON	5 sec.
4		ON		3 sec.

The state diagram of the FSM is shown below:



5. Click Sketch > Verify/Compile, change the name of the folder/program and Save
6. If the codes are compiled correctly without error, “Done compiling.” will be shown

iii. Check the following Arduino settings:
1. Click and choose Tools > Boards: “Arduino/Genuino Uno”
2. Click and choose Tools > Port > COM??? (other than COM1 normally)

iv. Compile and upload the program to the Arduino
1. Click Sketch > Upload
2. If there is no error, “Done uploading.” will be shown

v. Answer the questions on the answer sheet

2. Traffic Light with Pedestrian Light

Keeping the circuit of Question 1 connected. Add two more LED and resistor pairs for the pedestrians, they are red and green LEDs, namely PRed and PGreen respectively.

a. Hardware Connections
i. Modify the circuit to incorporate two more sets of LEDs and resistors
ii. Connect the Arduino UNO Board to your computer by using the USB cable
iii. Answer the questions on the answer sheet

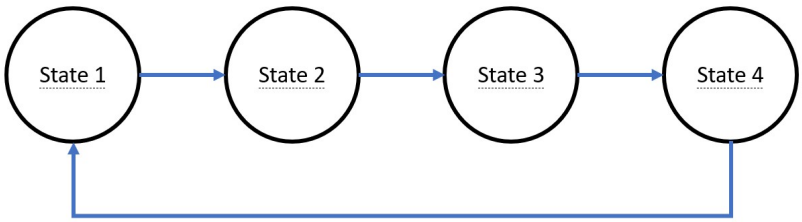
b. Software Programming
i. On the desktop of your computer, double click the following Arduino icon to execute the Arduino IDE

ii. Create a new project by:
1. Click File > New, a new window will pop up
2. Copy and modify the codes in Question 1 to build a new traffic light FSM. The FSM should include the following states in a sequential order:

State ID	Red	Yellow	Green	PRed	PGreen	Duration
1	ON				ON	5 sec.
2	ON	ON			Flash*	3 sec.
3			ON	ON		5 sec.
4		ON		ON		3 sec.

* Flash = ON for 0.5 sec. and OFF for 0.5 sec. and so on.

The state diagram of the FSM is shown below:



3. Click Sketch > Verify/Compile, change the name of the folder/program and Save
4. If the codes are compiled correctly without error, “Done compiling.” will be shown

iii. Check the following Arduino settings:
1. Click and choose Tools > Boards: “Arduino/Genuino Uno”
2. Click and choose Tools > Port > COM??? (other than COM1 normally)

iv. Compile and upload the program to the Arduino
1. Click Sketch > Upload
2. If there is no error, “Done uploading.” will be shown

v. Answer the questions on the answer sheet

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Answer Sheet

Demo Video **[36%]**

1. Simple Traffic Light **[32%]**

a. Hardware Connections

How many digit I/O pins are used?

_____

In total, how many digit I/O pins are available on Arduino UNO board?

_____

b. Software Programming

What is the total number of states in the FSM?

_____

What kind of event triggers the transitions between different states?

_____

2. Traffic Light with Pedestrian Light **[32%]**

a. Hardware Connections

At each digit I/O pins of Arduino UNO board, what is the DC current available?

_____

In total, how many **analog input** pins are available on Arduino UNO board?

_____

b. Software Programming

In State 2, how many times will the PGreen light flashing before transiting to State 3?

_____

What kind of programming statement is required to accomplish the flashing?

_____

THE END