Family Name:. . . . . **Other Names:** . . . .

Student ID:. . . . . **Signature**. . . . .

ENGR 101: Exam

2023, June 12

Instructions

- Time allowed: **120 minutes**
- Attempt **all** the questions. There are **70 marks** in total.
- Brief Documentation is at the end of the examination script
- Write your answers in this exam paper and hand in all sheets.
- If you think some question is unclear, ask for clarification.
- You may use unmarked paper Chinese-English translation dictionaries.
- You may write notes and working on this paper, but make sure your answers are clear.

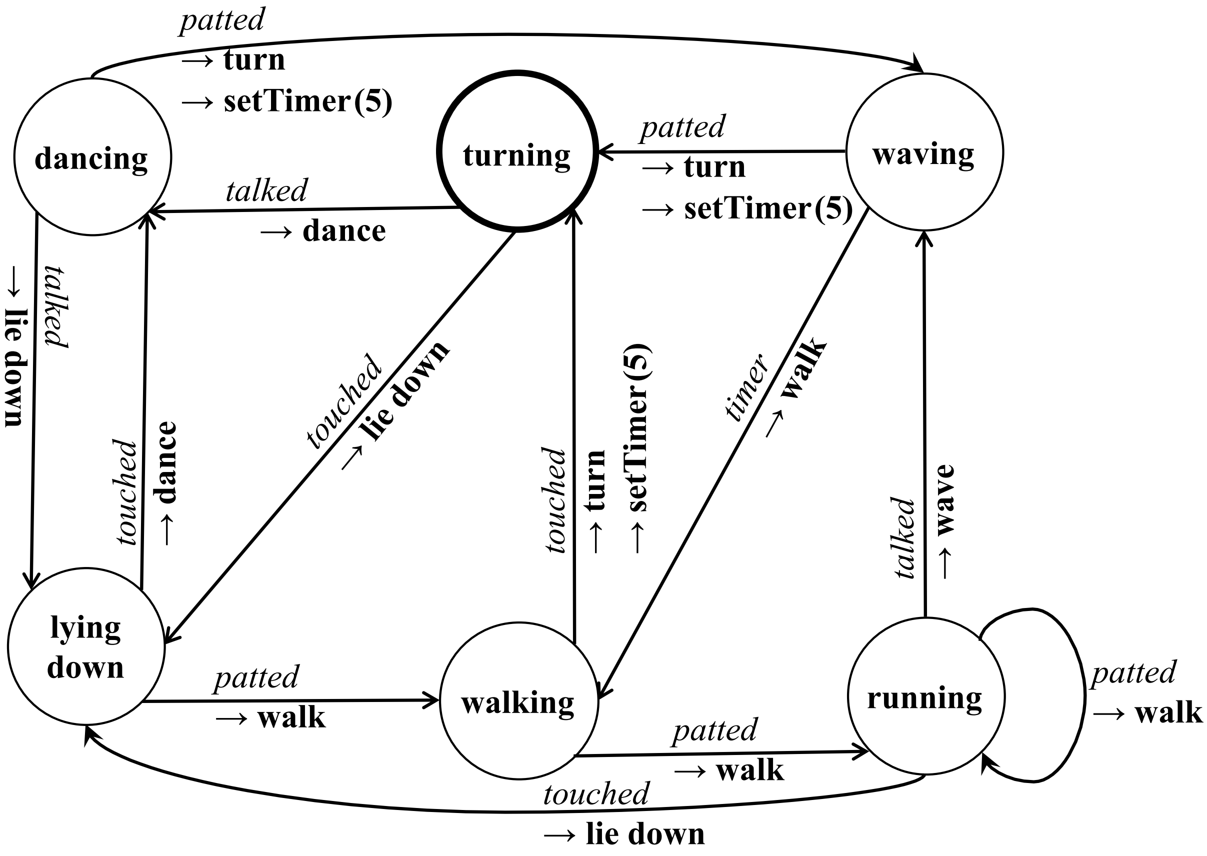
Questions		**Marks**	
1.	Finite State machines (FSM)	[28]	
2.	Arduino programming	[20]	
3.	Wiring up an Arduino	[12]	
4.	FSM and Arduino	[10]	
		TOTAL:	

SPARE PAGE FOR EXTRA ANSWERS

Cross out rough working that you do not want marked.
Specify the question number for work that you do want marked.

Question 1. FSM controllers **[28 marks]**

The diagram below shows a FSM controller robotic toy. You have seen this FSM controller in the lab.



It has the following sensors and actions:

Sensors	Actions
patted	→ walk
touched	→ dance
talked	→ wave
timer	→ lie down
	→ turn
	→ setTimer(5)

(a) **[6 marks]** If the controller starts in the state **turning** and gets this sequence of sensor values, what sequence of **states** will the controller go through?

Sensor sequence: *talked, patted, timer, patted, touched, touched*

State:

(Question 1 continued on next page)

(Question 1 continued)

(b) **[12 marks]** If the controller starts in the state **walking** and gets this sequence of sensor values, what sequence of **actions** will the controller do, and what state will it end in?

Sensor sequence: *patted, talked, patted, talked, talked, touched , patted*

Actions:

Final State:

(c) **[10 marks]** Suppose the machine is in the state **running**. Give two different sequences of sensors that would make the machine go to the state **dancing**.

Sequence 1:

Sequence 2:

Question 2. C programming **[20 marks]**

(a) **[8 marks]** What will be the output of the following Arduino sketch?

```
void setup(){
    Serial.begin(9600);
    int num = 8;
    for (int i = 1; i <= num; i++) {
        if (i % 3 == 0) {
            Serial.print("Hop");
        } else {
            Serial.print(i);
        }
    }
}
void loop(){
}
```

Hint: *write the values of the variables in the boxes*

num: □

i: □

(b) **[4 marks]** Write an Arduino sketch to divide the numbers in variables num1 and num2 and display the result on the Serial Monitor?

```
double num1 = 2.5;
double num2 = 6.0;
void setup(){







}
void loop(){
}
```

(Question 2 continued on next page)

(Question 2 continued)

(c) **[8 marks]** Write an Arduino sketch to display all the numbers in the given array on the Serial Monitor? You must use a loop (for or while).

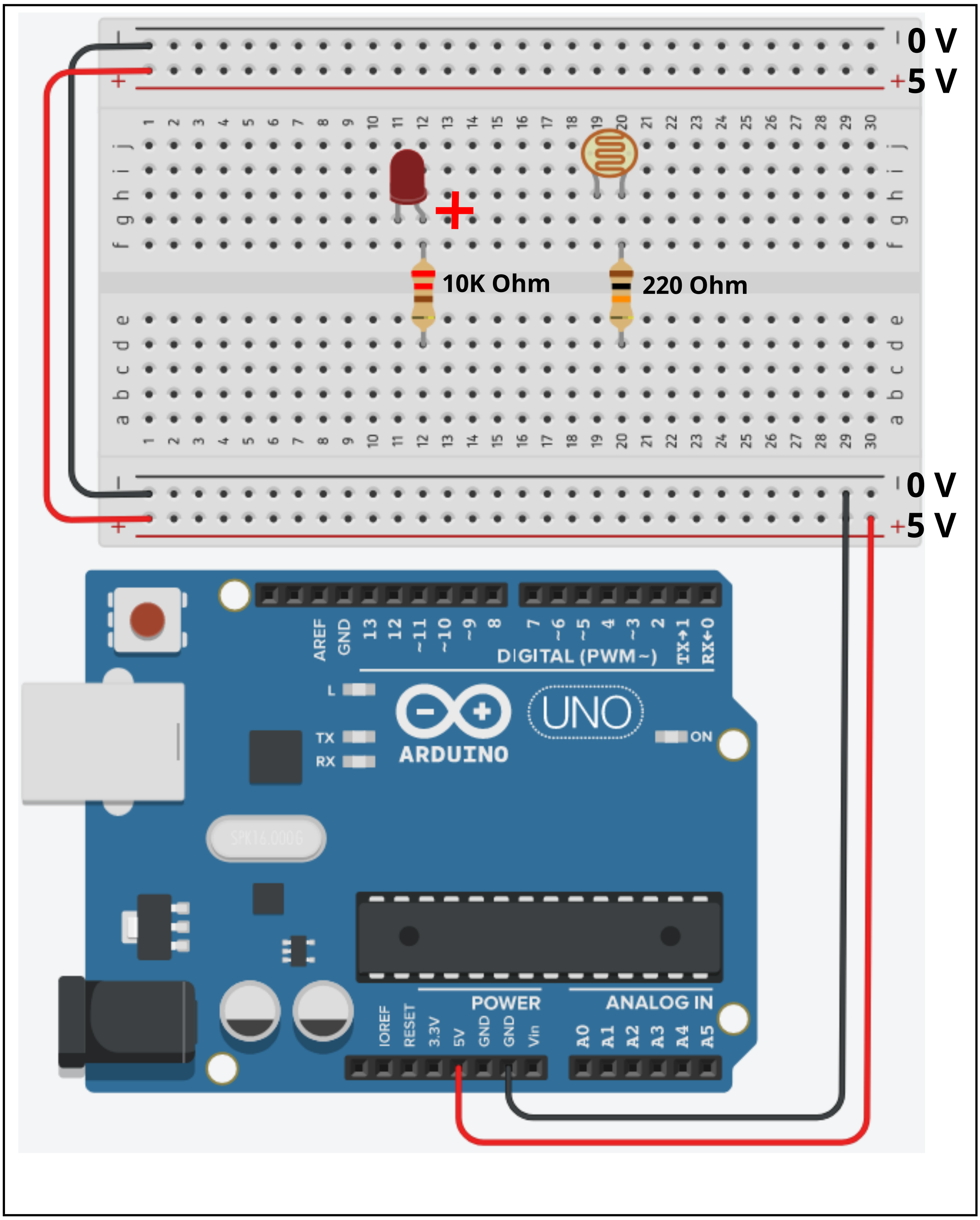
```
const int length = 12;
int arr[length] = { -4, 0, 2, 3, 7, 12, 8, 9, -10, 3, 1, 23 };
void setup() {
    Serial.begin(9600);











}
void loop(){
}
```

Question 3. Programming and Wiring up an Arduino **[12 marks]**

A photoresistor can be connected to an Arduino pin to turn an LED on or off.

(a) **[5 marks]** Use the provided components in the picture below to draw a circuit for an Arduino project that uses a photoresistor as an input and an LED as an output.

The circuit should turn on the LED when Pin 8 is set to HIGH, and the photoresistor should send varying voltages based on the light density to Pin A5.



(Question 3 continued on next page)

(Question 3 continued)

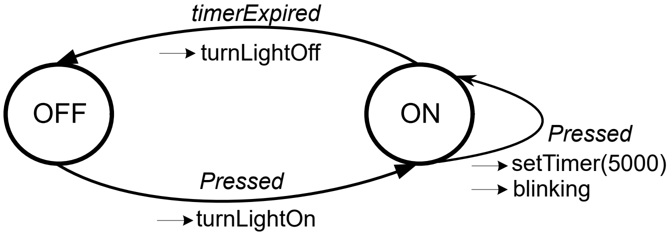
(b) **[7 marks]** Write an Arduino sketch that turns on an LED when the value reading from a photoresistor is greater than or equal to a specified threshold, and turns off the LED when the value reading is less than the threshold.

Note: The photoresistor is connected to analog pin A5 and the LED is connected to digital pin 8. The threshold value is set to 500.

```
const int lightPin = A5;          // define photoresistor pin
const int ledPin = 8;             // define LED pin
const int threshold = 500;        // Set darkness threshold
void setup(){
    // Set up the pins







}
void loop(){
    // Read the pin and perform actions

















}
```

Question 4. FSM and Arduino **[10 marks]**

Consider the following event-driven Finite State Machine controller for a simple Arduino device.



The Arduino device has two states and three transitions

- The device sends the signal Pressed and timerExpired to the controller.
- The controller can perform four different actions on the device: turnLightOn(), turnLightOff(), blinking(), and setTimer(n) where n is milliseconds.

Part of the code for the controller is on the facing page:

- The state variable contains the current state of the device.
- The pressed() function returns HIGH if a user pushes the button,
- The checkTimer() function checks if a timer has expired. If the timer has expired, it sets timerExpired variable to True.

(Question 4 continued on next page)

(Question 4 continued)

```
String state  = "OFF"; // Stores the current state of the FSM
bool timerExpired = false;

void setup(){
    pinMode(Light, OUTPUT); // Set pin as an output
}

void loop(){
    checkTimer();
    int pressed = pressed(); // returns HIGH if the user has pushed the button

    // actions and transitions
    if(state ==                    ){
        if(                         ){





        }
    } else if(state ==                    ){
        if(                         ){




        }else if(                         ){




        }
    }

    if(timerExpired = true){ // Reset the timer
        timerExpired = false;
    }
}
/** Check if timer expired */
void checkTimer() {
    if ( millis () − timerStart > timerEnd) {
        timerEnd = 0;
        timerExpired = true;    // tell the controller that the timer ran out.
    }
}
```

* * * * * * * * * * * * * * *

Documentation

Brief, simplified specifications of some relevant Arduino functions.

Serial

```
Serial . begin(speed)                     // opens serial port, sets data rate to speed bps
Serial . print (anything val)             // Prints val with no newline
Serial . println (anything val)           // Prints val and newline
Serial . println ()                       // Prints a newline
```

Digital I/O

```
void pinMode(int pin, int mode)           // Configures the specified pin as INPUT or OUTPUT
void digitalWrite ( int pin, int value)   // Write a HIGH or a LOW value to a digital pin.
int digitalRead ( int pin)                // read HIGH or LOW from the input pin
```

Analog I/O

```
int analogRead(int pin)                     // Reads the value from the specified analog pin.
                                            // The return value is between 0 and 1023.
void analogWrite( int pin, int value)       // Writes an analog value (PWM wave) to a pin.
```

Time

```
void delay(unsigned long ms)                  // Pauses the program for the amount of time (in milliseconds )
void delayMicroseconds(unsigned int us)       // Pauses the program for the amount of time (in microseconds)
```

Random Numbers

```
long random(long min, long max)             // The random function generates pseudo-random numbers.
void randomSeed(unsigned long)              //  Initializes the pseudo-random number generator
```

SPARE PAGE FOR EXTRA ANSWERS

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