Assignment - 1

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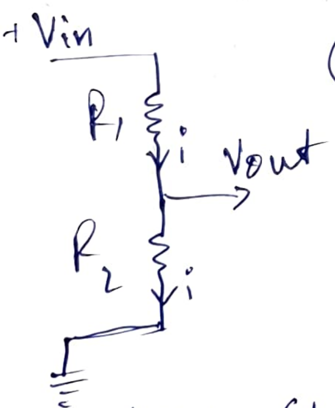
Y25 EE Student.

Introduction :

*) objectives :-> to study the circoits learnt in theory and practice applied engineering using tinkercad Simulated Circuits.
theory includes voltage dividers, RC circuits and ohmmeter used to measure unknown resistances.

Task A). A simple Voltage divider is needed in measurement systems to measure the voltages based on theory.. This is important because ~~some~~ measurement devices have limited ranges and sometimes we need to reduce the voltge.

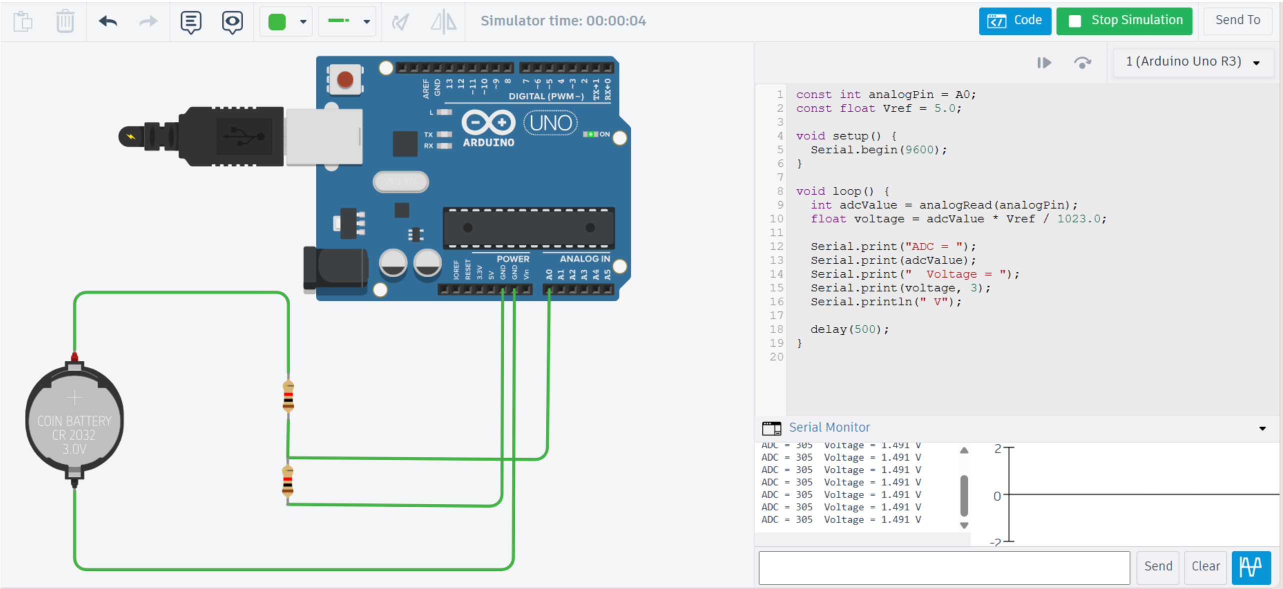


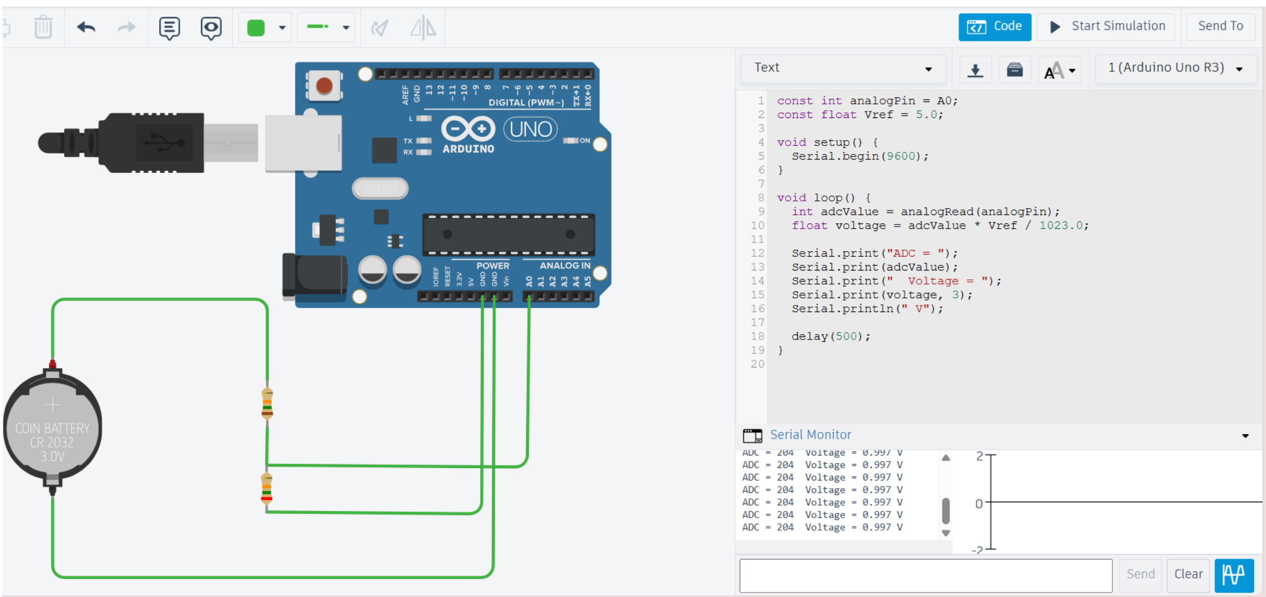
$$(\text{ohm's law})\ i = \frac{V_{in}}{R_1 + R_2}$$

$$V_{out} = iR_2 = V_{in}\left(\frac{R_2}{R_1 + R_2}\right)$$

ADC (Arduino) is used to measure the Vout in the circuit, conversion formula :

$$V_{out} = (\text{ADC reading}) \times \frac{5}{1023}$$


Simulator time: 00:00:04
Code
Stop Simulation
Send To
1 (Arduino Uno R3)
const int analogPin = A0;
const float Vref = 5.0;
void setup() {
Serial.begin(9600);
}
void loop() {
int adcValue = analogRead(analogPin);
float voltage = adcValue * Vref / 1023.0;
Serial.print("ADC = ");
Serial.print(adcValue);
Serial.print(" Voltage = ");
Serial.print(voltage, 3);
Serial.println(" V");
delay(500);
}
Serial Monitor
ADC = 305 Voltage = 1.491 V
ADC = 305 Voltage = 1.491 V
ADC = 305 Voltage = 1.491 V
ADC = 305 Voltage = 1.491 V
ADC = 305 Voltage = 1.491 V
ADC = 305 Voltage = 1.491 V
ADC = 305 Voltage = 1.491 V
Send
Clear
COIN BATTERY
CR 2032
3.0V
ARDUINO
UNO
DIGITAL (PWM~)
POWER
ANALOG IN


Code
Start Simulation
Send To
Text
1 (Arduino Uno R3)
const int analogPin = A0;
const float Vref = 5.0;
void setup() {
Serial.begin(9600);
}
void loop() {
int adcValue = analogRead(analogPin);
float voltage = adcValue * Vref / 1023.0;
Serial.print("ADC = ");
Serial.print(adcValue);
Serial.print(" Voltage = ");
Serial.print(voltage, 3);
Serial.println(" V");
delay(500);
}
Serial Monitor
ADC = 204 Voltage = 0.997 V
ADC = 204 Voltage = 0.997 V
ADC = 204 Voltage = 0.997 V
ADC = 204 Voltage = 0.997 V
ADC = 204 Voltage = 0.997 V
ADC = 204 Voltage = 0.997 V
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Send
Clear
COIN BATTERY
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ARDUINO
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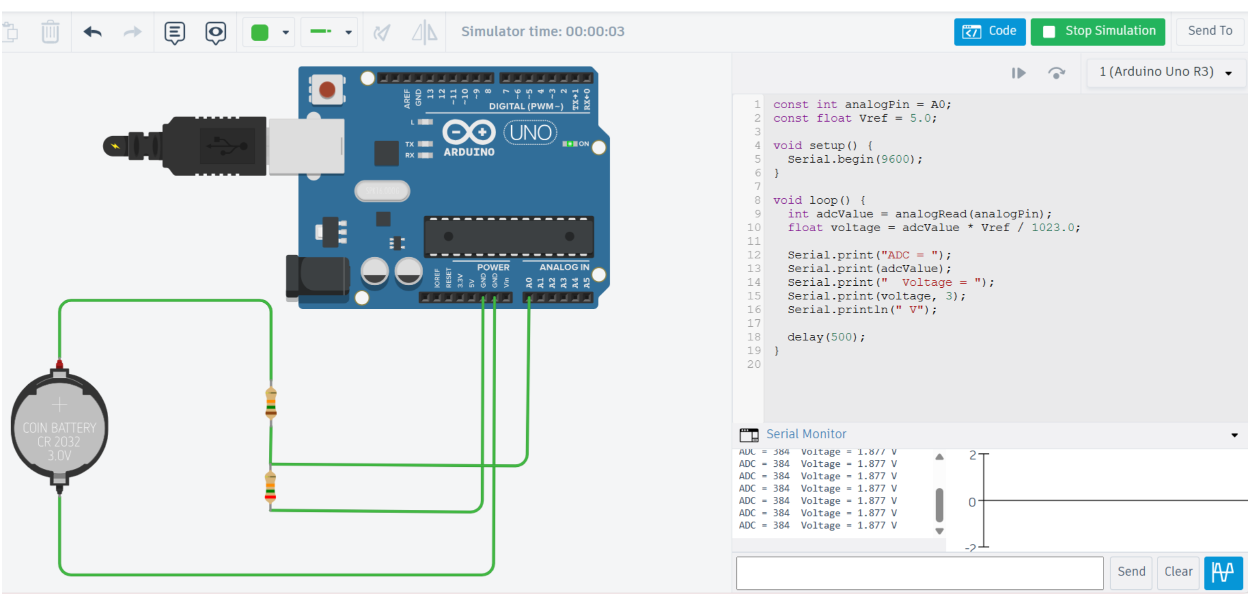

Simulator time: 00:00:03
Code
Stop Simulation
Send To
1 (Arduino Uno R3)
const int analogPin = A0;
const float Vref = 5.0;
void setup() {
Serial.begin(9600);
}
void loop() {
int adcValue = analogRead(analogPin);
float voltage = adcValue * Vref / 1023.0;
Serial.print("ADC = ");
Serial.print(adcValue);
Serial.print(" Voltage = ");
Serial.print(voltage, 3);
Serial.println(" V");
delay(500);
}
Serial Monitor
ADC = 384 Voltage = 1.877 V
ADC = 384 Voltage = 1.877 V
ADC = 384 Voltage = 1.877 V
ADC = 384 Voltage = 1.877 V
ADC = 384 Voltage = 1.877 V
ADC = 384 Voltage = 1.877 V
ADC = 384 Voltage = 1.877 V
Send
Clear
COIN BATTERY
CR 2032
3.0V
ARDUINO
UNO
DIGITAL (PWM~)
POWER
ANALOG IN

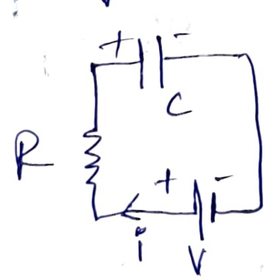
As seen in the measurements, due to the noise, and the unavoidable possibility of an error of $\pm\frac{1}{2}$ LSB, $\left(LSB = \frac{5}{1023}\right)$ measurement <u>donot</u> exactly match theoretical values.

for <u>Vin = 3 V</u>

R_1	R_2	Vin (V)	Theoritical Vout (V)	measured Vout (V)
1	1	3	1.5	1.491
6	3	3	1	0.997
15	25	3	1.875	1.877
27	23	3	1.380	1.378
20	60	3	2.250	2.248

~~Task~~) Code reads the anolog Pin values & converts them to digital code using the conversion formulas. Void setup fonction has serial.begin(9600) which is used to output the values to serial monitor. Serial.print (value) → prints the value in the Serial monitor.

Task B) The simulated RC Circuit is used to measure the capacitance by measuring time constant.



Using the Kirchoff's law at time t,

$$V - iR - \frac{q(t)}{C} = 0$$

where q(t) is the charge in capacitor plate at time t.

as i = current at time 't' $= \frac{dq}{dt}$,

$$V - \frac{q}{C} = R.\frac{dq}{dt} \Rightarrow \frac{dq}{CV-q} = \frac{dt}{RC}$$

integrating both sides, assuming at $t=0, q=0$,

$$\int_0^q \frac{dq}{CV-q} = \int_0^t \frac{dt}{RC} \Rightarrow \ln\left(\frac{CV}{CV-q}\right) = \frac{t}{RC}$$

$$\Rightarrow q = CV\left(1-e^{-t/RC}\right) \Rightarrow \frac{q}{C} = V\left(1-e^{-t/RC}\right)$$

i.e., potential difference acceross C is

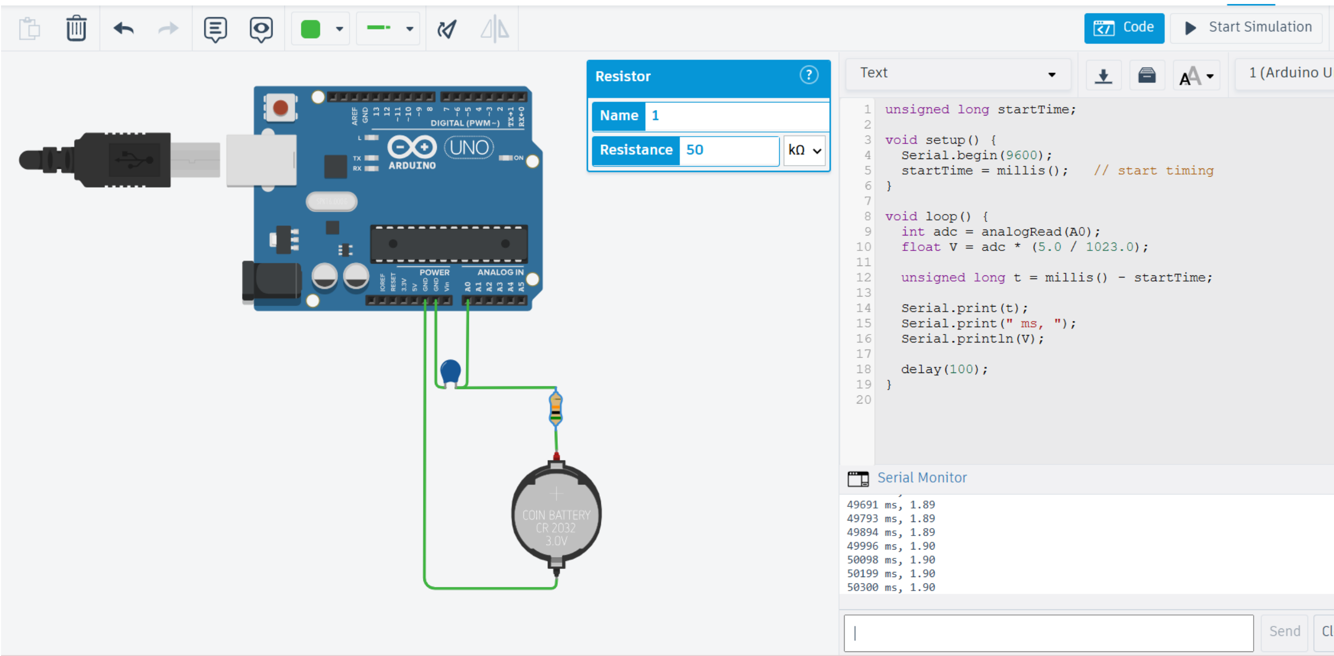
$$V_c(t) = V\left(1-e^{-t/RC}\right)$$

for $t = RC$, $V_c(t) = V(1-e^{-1}) \simeq V(0.63)$

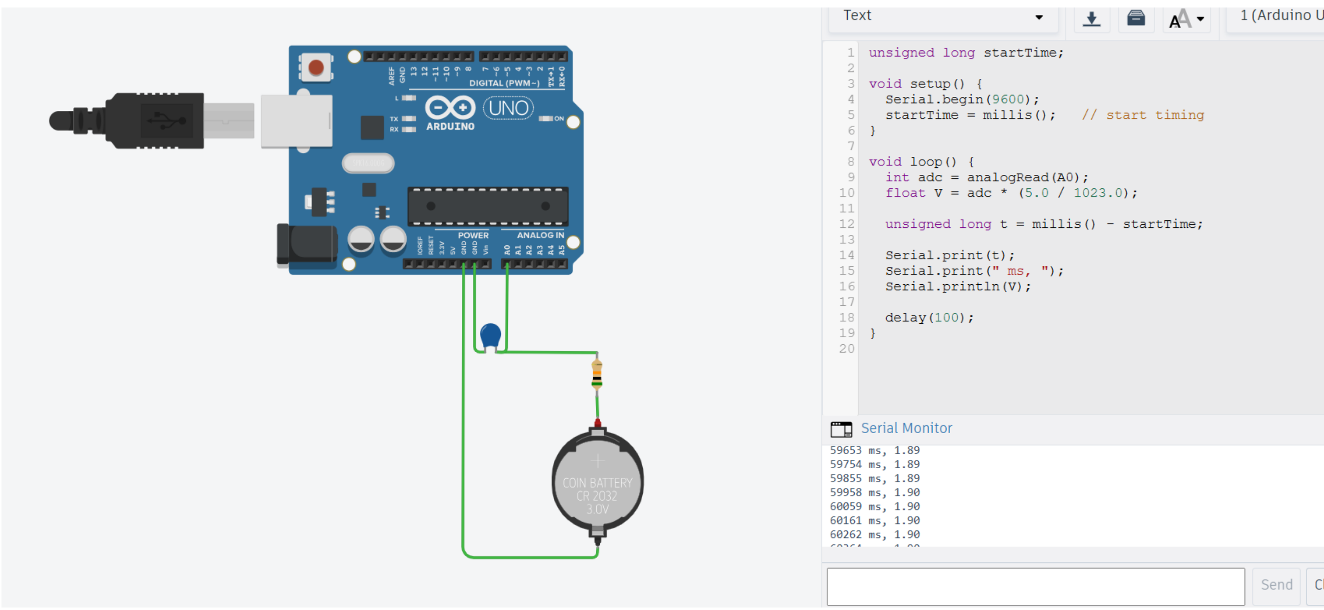
i.e., when the voltage V_c is 63% of battery,

the time taken is $\tau = RC$

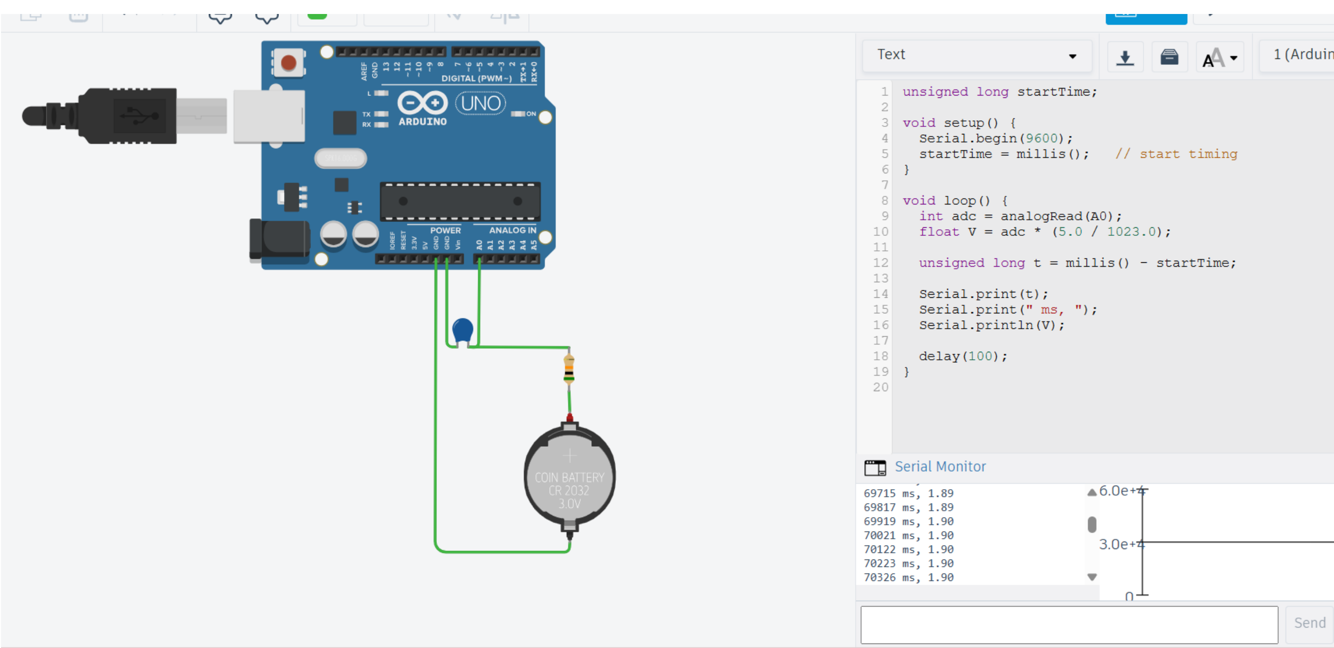
Voltage supply = 3V	63% of V ≈ 1.90V	measured time	expected time
1) $R = 50K\Omega$ $\tau = 50s$	$C = 1000\mu F$ →	49996ms	50000ms
2) $R = 50K\Omega$ $\tau = 60s$	$C = 1200\mu F$ →	59958ms	60000ms
3) $R = 50K\Omega$ $\tau = 70s$	$C = 1400\mu F$ →	69919ms	70000ms.



Code
Start Simulation
Resistor
Name 1
Resistance 50 kΩ
Text
1 (Arduino U
unsigned long startTime;
void setup() {
Serial.begin(9600);
startTime = millis(); // start timing
}
void loop() {
int adc = analogRead(A0);
float V = adc * (5.0 / 1023.0);
unsigned long t = millis() - startTime;
Serial.print(t);
Serial.print(" ms, ");
Serial.println(V);
delay(100);
}
Serial Monitor
49691 ms, 1.89
49793 ms, 1.89
49894 ms, 1.89
49996 ms, 1.90
50098 ms, 1.90
50199 ms, 1.90
50300 ms, 1.90
Send
COIN BATTERY
CR 2032
3.0V
UNO
ARDUINO



Text
1 (Arduino U
unsigned long startTime;
void setup() {
Serial.begin(9600);
startTime = millis(); // start timing
}
void loop() {
int adc = analogRead(A0);
float V = adc * (5.0 / 1023.0);
unsigned long t = millis() - startTime;
Serial.print(t);
Serial.print(" ms, ");
Serial.println(V);
delay(100);
}
Serial Monitor
59653 ms, 1.89
59754 ms, 1.89
59855 ms, 1.89
59958 ms, 1.90
60059 ms, 1.90
60161 ms, 1.90
60262 ms, 1.90
Send
COIN BATTERY
CR 2032
3.0V
UNO
ARDUINO



Text
unsigned long startTime;
void setup() {
Serial.begin(9600);
startTime = millis(); // start timing
}
void loop() {
int adc = analogRead(A0);
float V = adc * (5.0 / 1023.0);
unsigned long t = millis() - startTime;
Serial.print(t);
Serial.print(" ms, ");
Serial.println(V);
delay(100);
}
Serial Monitor
69715 ms, 1.89
69817 ms, 1.89
69919 ms, 1.90
70021 ms, 1.90
70122 ms, 1.90
70223 ms, 1.90
70326 ms, 1.90
6.0e+
3.0e+
0
Send
COIN BATTERY
CR 2032
3.0V
UNO
ARDUINO

~~A~~ The measured time doesnot perfectly correspond to theoretical time constant because the voltage gets added with noise and then ADC has limitation in measurement, ~~and~~ so there is a systematic error of $\pm\frac{1}{2}$ LSB $\approx \pm\frac{1}{2}$ (4.88 mV)

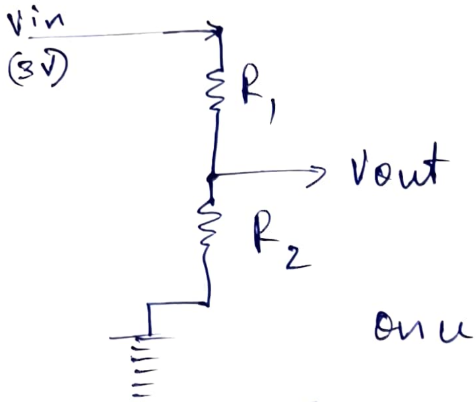
Code:

unsigued long startTime;

void setup() function does the same work with then ~~k~~ using ~~an~~ ~~extra~~ a reference time from which the time measurement starts.

the millis() $\rightarrow$ increments time every one millisecond, and we finally need ~~time - reference (starting time)~~ final incremented time - starting time, which is the duration taken to reach a voltage printed along with it in the serial monitor.

Task c) For a given Resistor $R_1 = 5k\Omega$, $5k\Omega$, we can measures the ~~the~~ Voltage ~~as~~ Vout of the Voltage Divider consisting the unknown Resistance R_2 and $R_1 = 5k\Omega$.



$$V_{out} = V_{in} \frac{R_2}{R_1 + R_2}$$

once we know Vout, using the ADC connected, we can find R_2.

$$(R_1 + R_2) V_{out} = V_{in} R_2$$

$$\boxed{\frac{R_1 V_{out}}{V_{in} - V_{out}} = R_2}$$

Known Resistor $R_1 = 5k\Omega$

R_2 (used) ($k\Omega$)	Vout (measured) (volts)	R_2 (measured) ($k\Omega$) $= \frac{R_1 V_{out}}{V_{in} - V_{out}}$
$5k\Omega$	1.500	$R_2 = \frac{5(1.5)}{3 - 1.5} = 5k\Omega$
$10k\Omega$	1.999	$R_2 = \frac{5(1.999)}{3 - 1.999} \approx 9.985k\Omega$
$7k\Omega$	1.750	$R_2 = \frac{5(1.75)}{(3 - 1.75)} \simeq 7k\Omega$
$11k\Omega$	2.063	$R_2 = \frac{5(2.063)}{3 - 2.063} = 11.008k\Omega$

Due to uncertainity in Vout, there is an Uncertainity in R_2 measured as well.