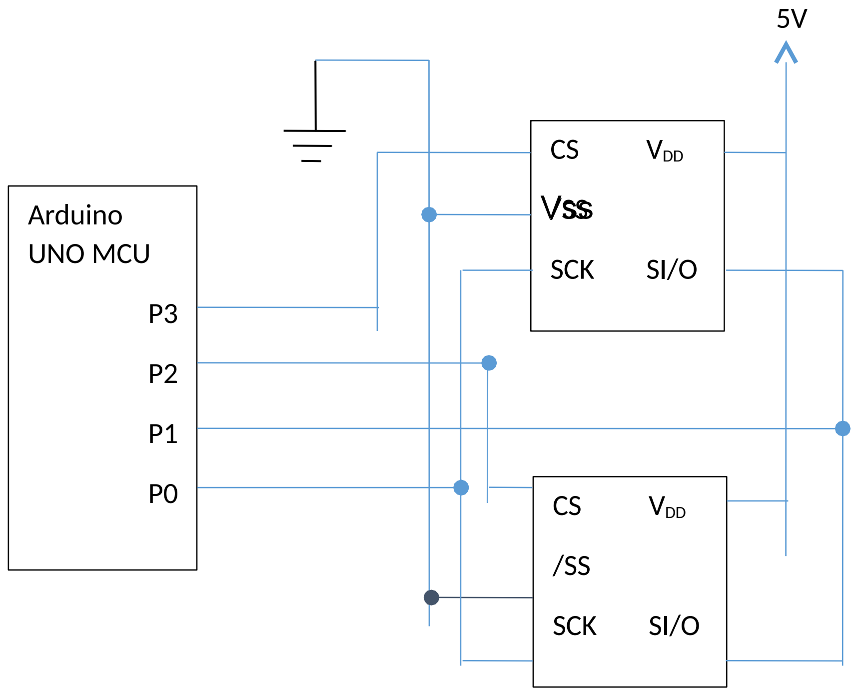
AY15/16

Q4.

a)



a. (10 marks)

b) No.

a. (1 marks)

c) 0.0625 degree per bit

a. (2 marks)

d) 2 bytes

(2 marks)

e) 30 deg/0.0625 = 480 bits = 0 0001 1110 0000

a. (4 marks)

f) Continuous Conversion mode is appropriate as there is no power consumption limitation when the car's engine is on.

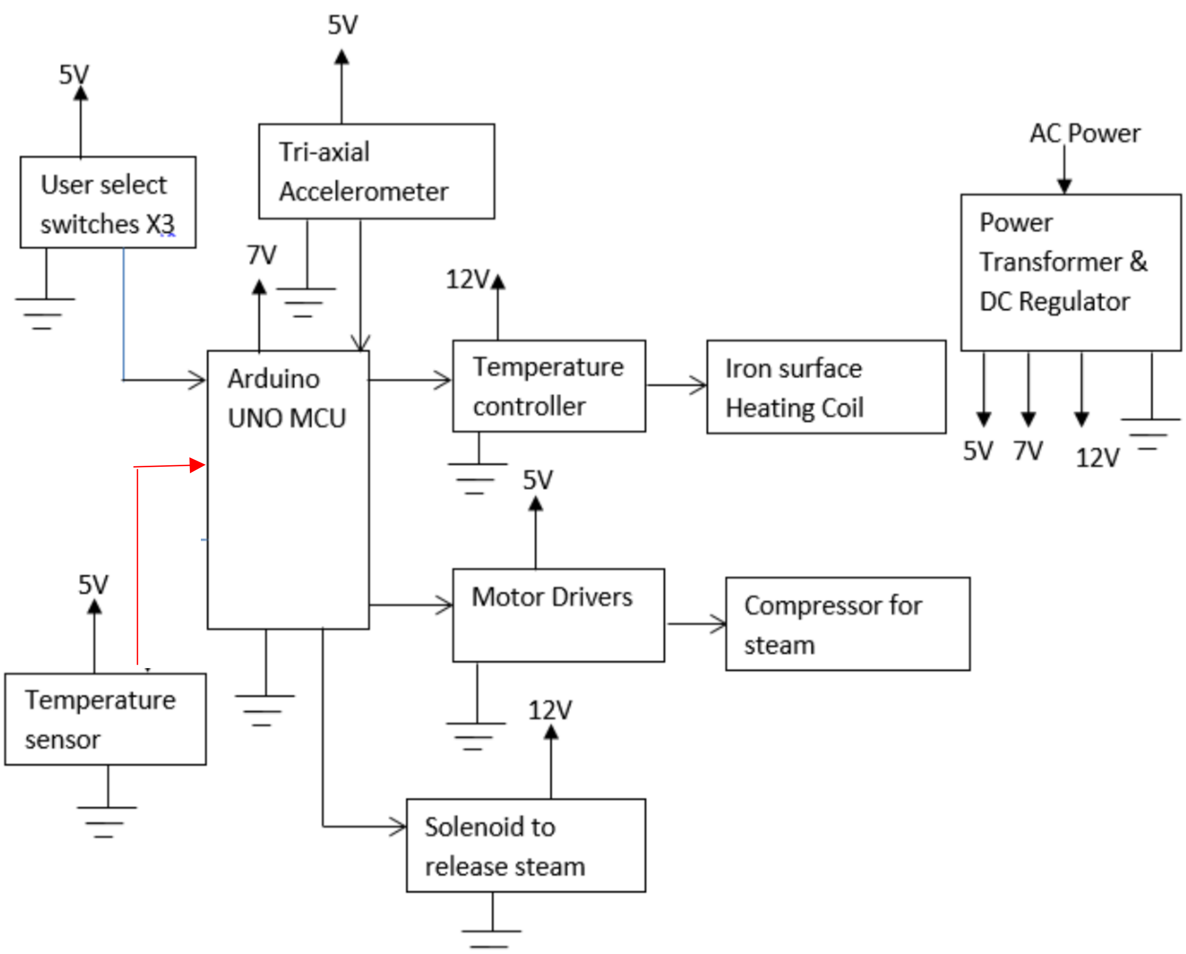
a. (3 marks)

g) 0000

(3 marks)

AY17/18

Q2)



Q3)

a) Vertical axis rotation = -0.45 rad/s = -25.78 deg/s → use 4xOUTX
Horizontal axis rotation = 1.0 rad/s = 57.30 deg/s → use OUTZ
4xOUTX = 1.23V + So*(-25.78) = 1.23 - 0.0333*25.78 = 0.372V
OUTZ = 1.23V + SoA*(57.30) = 1.23 + 0.0083*57.3 = 1.706V
Digitized OUTZ = 1.706/3.0*(2^{10}-1) ≈ 582 = 246 (Hex)
Digitized 4xOUTX = 0.372/3.0*(2^{10}-1) ≈ 127 = 7F (Hex)

(8 marks)

b) Temperature Sensitivity, SoDr = 0.037 %/°C

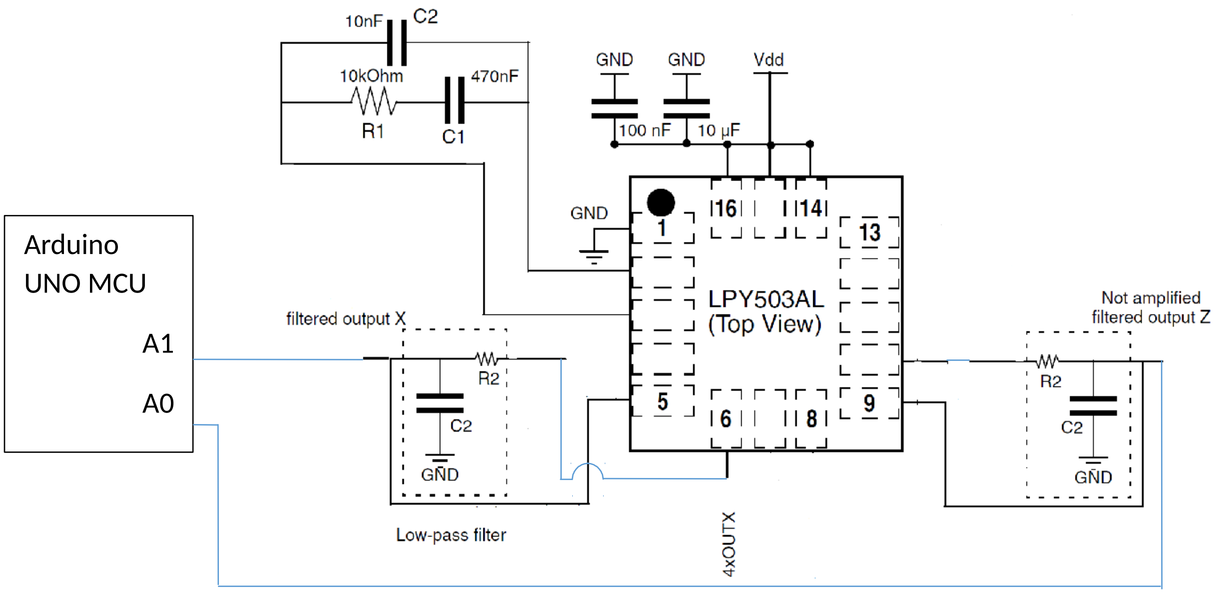
Temp change = 25 – (-25) = 50 °C
Percentage change = 0.037*50 = 1.85%
4xOUTX = 1.23-0.0333*(1-0.0185)*25.78 = 0.387V
OUTZ = 1.23+ 0.0083*57.3*(1-0.0185) = 1.697V
Digitized 4xOUTX = 0.387/3.0*(2^{10}-1) ≈ 132 = 84 (Hex)
Digitized OUTZ = 1.697/3.0*(2^{10}-1) ≈ 579 = 243 (Hex)

(6 marks)

c) No. Because the signal (angular velocity) does not fluctuate much, i.e. signal has no high frequency content.

(2 marks)

d)

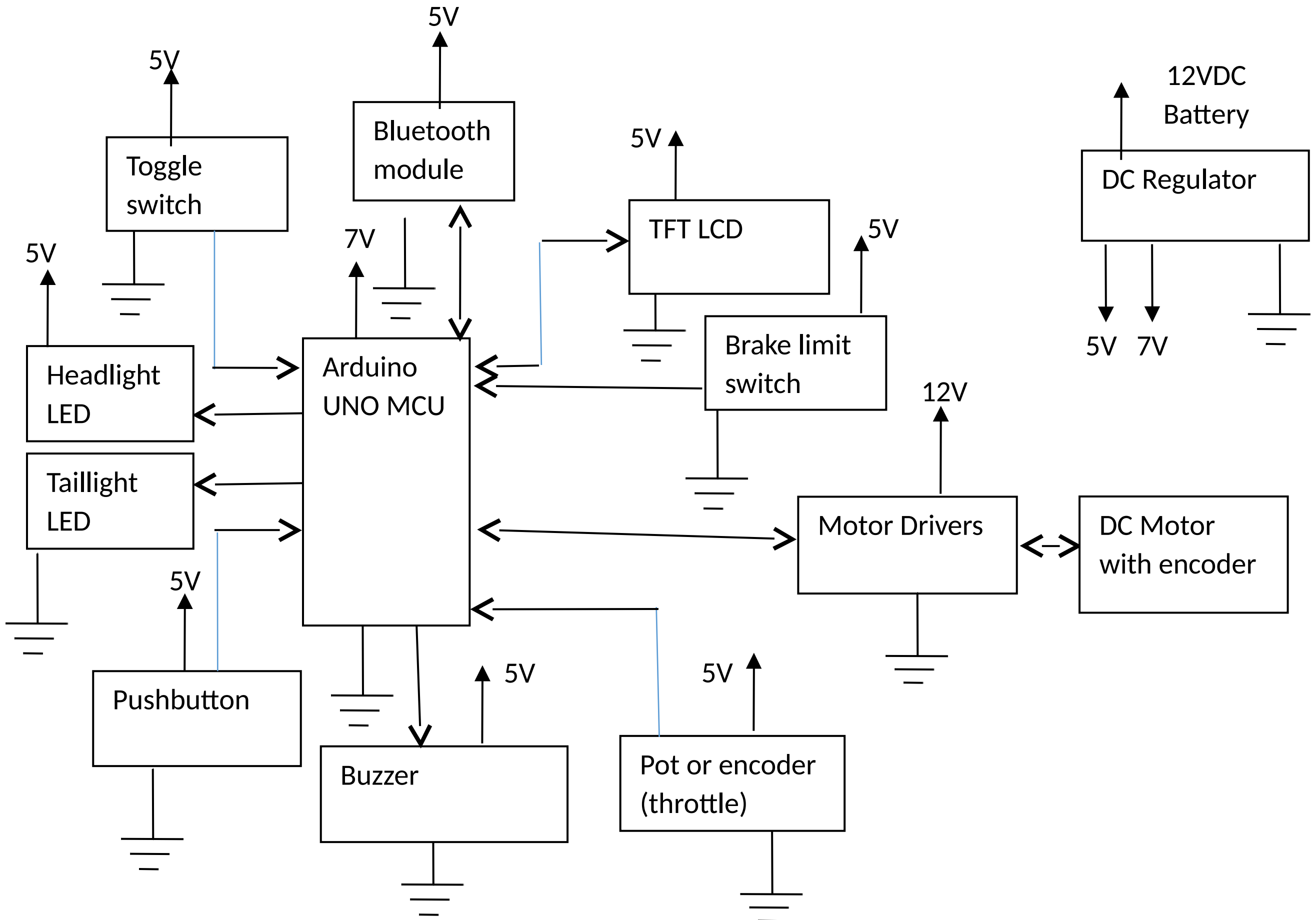


Note: A simple circuit diagram showing the correct pin connections would earn you full marks.

(9 marks)

AY18/19

Q2.



(25 marks)

AY2019/20

Q1.

a) Scale factor = 5.0 / (200 – (-10)) = 23.8 mV/°C

(2 mark)

Increase in Volt per celsius

b)

(i) The voltage output of the sensor, V_T = (100 – (-10)) x 0.0238 = 2.619V.
For $D1$, the ADC has 10-bit resolution, ~~Wrong unless~~ arduino uno has 10 bit input
$D1 = 2.619/5x(2^{10} - 1) = 535.8 \approx 536$ = 0000 0010 0001 1000
For D2, the ADC has 5-bit resolution, Round it to nearest integer
$D2 = 2.619 / 5 \text{ x } (2^5 - 1) = 16.2 \approx 16$ = 0001 0000

You are changing frame of reference

5 bit because limited by the external ADC

(7 marks)

Can calculate by recursive like you multiply by 2 the value, if above 0.5(right side) put 1, otherwise put 0(left side). When overflow -1 then gauge again

(ii) Reduction of 1 degree will reduce the output voltage by 23.8 mV. If you want 16 bit, need do till get 16 numbers
For a 5-bit ADC, the resolution is 5 / 31 = 161.3 mV / unit
There will be no change in $D2$ because the difference in voltage output is lower than the resolution of the ADC.

(4 marks)

c) The digital equivalents of T_T are set at $D1_T = 535$ and $D2_T = 16$.
The analog equivalent of $D1_T$ = (535 / 1023 x 210°C) - 10°C = 99.8°C
Since the thermocouple has a resolution of 1.0 °C, LED2 will be turned on at 100°C.
The analog equivalent of $D2_T$ = (16 / 31 x 210°C) - 10°C = 98.4°C
So LED2 will be turned on first at 99°C in rising temperature.

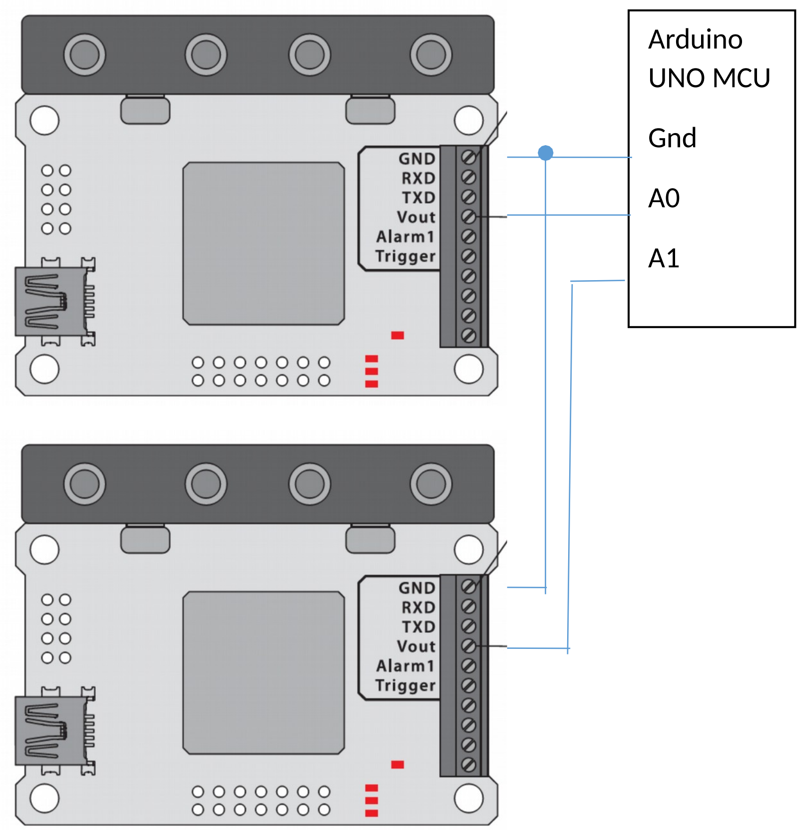
(9 marks)

d) In decreasing temperature, LED1 will be turned off first at 99°C. LED2 will be turned off at 98°C.

(3 marks)

Q4)

a)



(3 marks)

b)

(i) d = v / 3.3 x (DH-DL) + DL

d1 = 2.5 / 3.3 x (20-0)+0 = 15.15m

d2 = 1.6 / 3.3 x 20 = 9.09m

width = d1 + d2 = 24.24m

There is no need to compensate for the distance apart of the 2 sensors because of the datum adjustment of –0.3m.

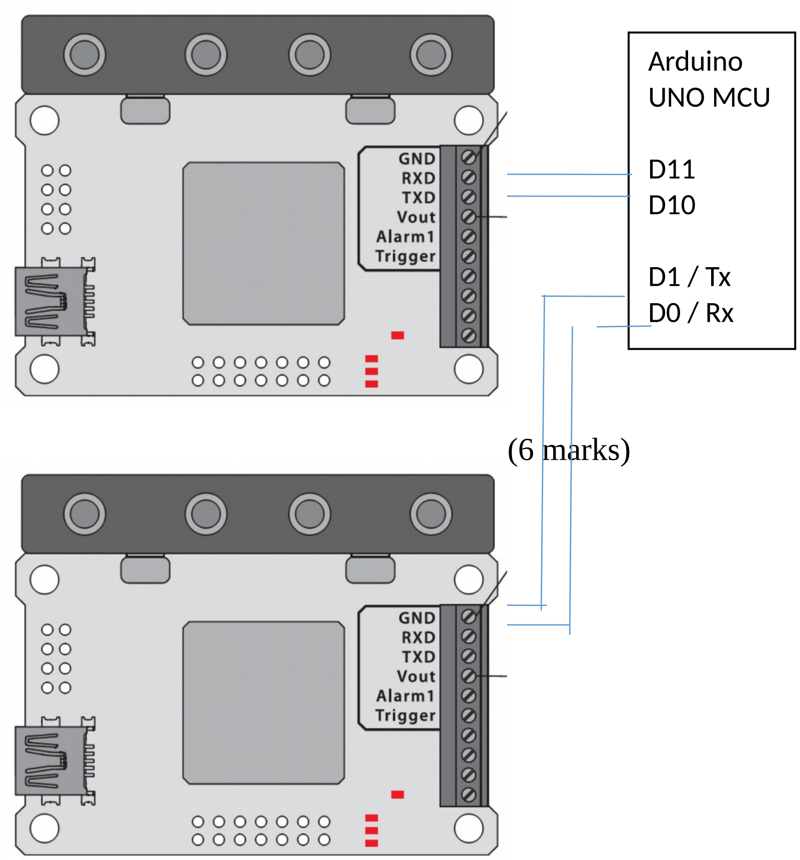
(7 marks)

(ii) Max Error ~ ± 5cm x 2 = ±10cm (is it from alarm hysteresis)

(3 marks)

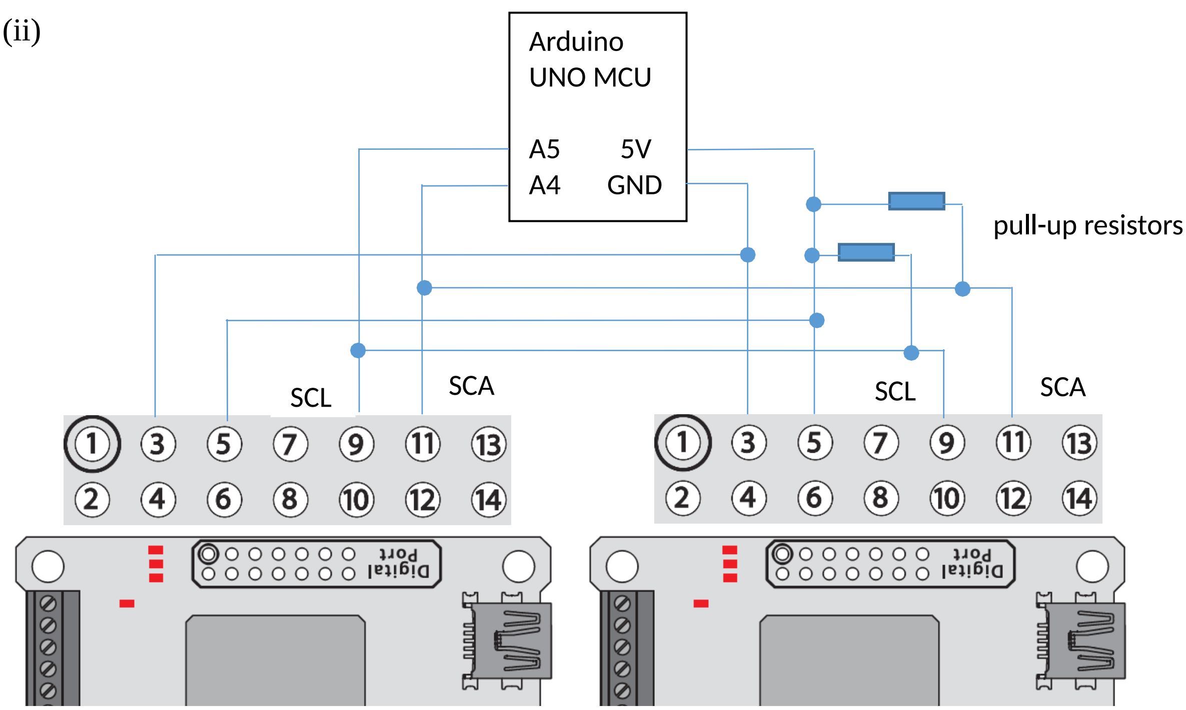
c)(i)

To set up D11 and D10 (or other digital pins) as software virtual Tx and Rx respectively.



(6 marks)

(ii)



(6 marks)

AY21/22

Q4.

(a)-(i) Single-Ended Circuit

- Record the amplifier output at zero flowrate
- Compute the offset voltage, D between the recorded zero flowrate voltage and the reference value as indicated in the relevant flow curves (Fig. 6 or 7).
- Output a small PWM voltage via one of the digital pins to the negative input of the amplifier
- Slowly increment the voltage until D goes to zero.

(5 marks)

(ii) Differential Circuit

- The circuit, by design, will perform a Common Mode Rejection to remove the zero offset voltage.

(3 marks)

(b) Model 1002. Because the maximum flow rate of model 1001 is only 0.5 litre / min and hence not suitable for the application in Q3.

(3 marks)

(c) For model 1002, the output voltage at zero flowrate is around 95 mV. With an amplifier gain of 50x, the voltage into the ADC is 50x0.095 = 4.75V.
Digitized value = 4.75 / 5 * 1023 = 972 = 0x03CC

(6 marks)

(d) No, the saturation Analog input voltage is 5.0v. A gain of 100x would have produced a amplifier output voltage of 9.5V.

(4 marks)

(e) No it wouldn't change, because the amplifier output voltage will still be the same if calibration is properly done, regardless of the signal conditioning circuits.

(3 marks)