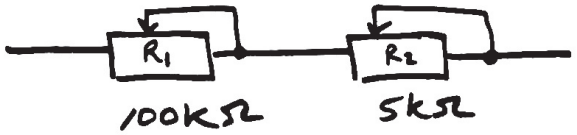
Problem 1

(a) 

$R_\alpha = R_1 + R_2$

⇒ for 1 turn of each potentiometer

$R_1 = R_1 + 100k\Omega$

$R_2 = R_2 + 5k\Omega$

⇒ reference equivalent resistance (no adjustments yet)

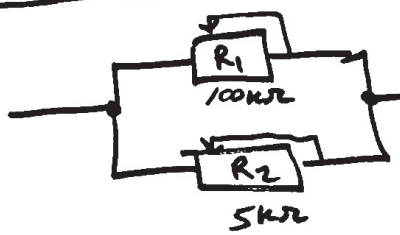
$R_{\alpha_1} = R_1 + R_2 = 105k\Omega$

⇒ adjust each pot. and observe effect on overall resistance

$$100\%\left(\frac{(R_\alpha)_1 - R_\alpha}{R_\alpha}\right) = \left(\frac{(R_1+100+R_2)-(R_1+R_2)}{R_1+R_2}\right)100 = \left(\frac{100}{105}\right)100\% = 95\%$$

$$100\%\left(\frac{(R_\alpha)_2 - R_\alpha}{R_\alpha}\right) = \left(\frac{(R_1+R_2+5)-(R_1+R_2)}{R_1+R_2}\right)100 = \frac{5}{105}\cdot 100\% = 4.76\%$$

∴ R_1 is course adjust (100kΩ)
R_2 is fine adjust (5kΩ)

(b) 

$$R_\beta = \frac{R_1 R_2}{R_1+R_2} = 4.762$$

$$(R_\beta)_1 = \frac{(100+R_1)R_2}{R_1+100+R_2} = 4.87k\Omega$$

$$(R_\beta)_2 = \frac{R_1(R_2+5)}{R_1+R_2+5} = 9.091k\Omega$$

$$\left(\frac{(R_\beta)_1 - R_\beta}{R_\beta}\right)100\% = \left(\frac{4.87-4.76}{4.76}\right)100 = 2.31\%$$

$$\left(\frac{(R_\beta)_2 - R_\beta}{R_\beta}\right)100\% = \left(\frac{9.091-4.76}{4.76}\right)100 = 90.99\%$$

∴ R_1 is fine adjust (100kΩ)
R_2 is course adjust (5kΩ)

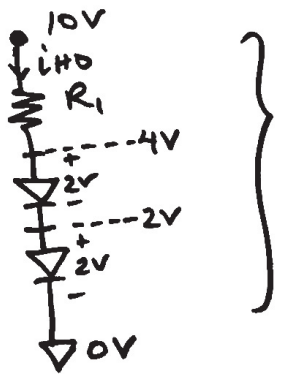
Problem 2

each LED, $V_D = 2V$

$i_{FD} = 10mA$

$i_{HD} = 5mA$

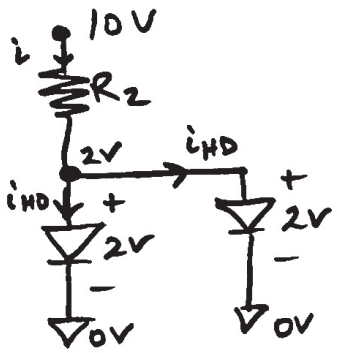
(a)



$$\frac{10V-4V}{R_1} = i_{HD} = \frac{6V}{R_1} = 5mA$$

$$R_1 = \frac{6V}{5\times10^{-3}A} = 1200\,\Omega$$

(b)



$$\frac{10-2}{R_2} = i = 2\cdot i_{HD} = 10mA$$

$$R_2 = \left(\frac{8V}{10\times10^{-3}}\right) = 800\,\Omega$$

Problem # 3 (10 points)

Mark each of the following statements as True or False.
Correct answers receive 2 point and **incorrect answers receive −2 point.**

(a) MQTT is the acronym for _____.

M_essage_____ Q_ueuing_____ T_elemetry_____ T_ransport_____

"query" is incorrect but accepted due to conflicting answers online

(b) The ESP32 is 5V compatible.

The ESP32 can only supply and be measure 3.3V. The fact that the USB connection supplies 5V does not mean that the device is compatible with other 5V devices.

Circle one: True **False**

(c) The solar panel issue in lab is a 10 Watt device.

The solar panel is a 2.5 Watt device. This is on the packaging and the product description as well as can be calculated by its maximum voltage and current ratings: Volts = 5V, I = 500mA

Circle one: True **False**

(d) Op-amps need an external power supply. (This is a freebie)

An op amp can have a gain greater than 1 and thus output a higher voltage (and power) than the input signal. This would break the law of conservation of energy if the op-amp was not using an external power supply to supply its output.

Circle one: **True** False

(e) What is this ?

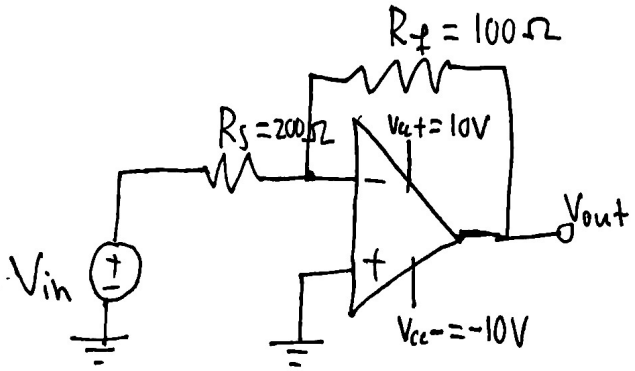
.

Answer:

Python Logo

Problem # 4 (3 + 3 + 4)= 10 points)

(a) Design the **simplest** circuit to satisfy: **Vout = -0.5 Vin** with a valid operation range of +/- 10V at the output. To receive full credit you must label all components with proper units, all power supply (if any), all inputs and outputs are labeled.

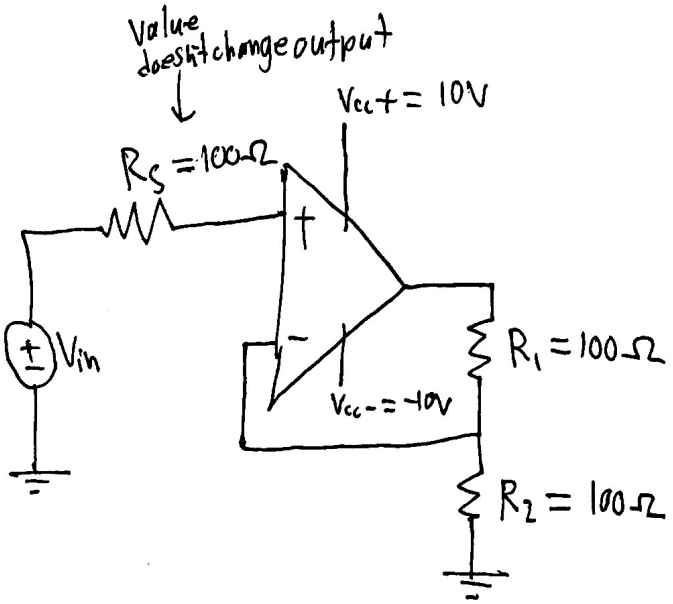


$$G = -\frac{R_f}{R_S} = -\frac{1}{2}$$

$R_f = 100\Omega$ ratio must be 1:2

$R_S = 200\Omega$

(b) Design the **simplest** circuit to satisfy: **Vout = 2.0 Vin** with a valid operation range of +/- 10V at the output. To receive full credit you must label all components with proper units, all power supply (if any), all inputs and outputs are labeled.



$$G = \frac{R_1 + R_2}{R_2} = 2$$

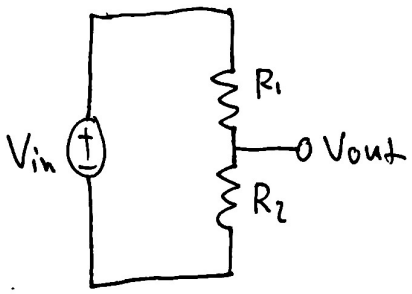
$R_1 = 100\Omega$ ratio must be 1:1

$R_2 = 100\Omega$

Problem # 4 (3 + 3 + 4)= 10 points)

(c) Design the **simplest** circuit to satisfy: **Vout = 0.5 Vin** with a valid operation range of +/- 5V at the output. To receive full credit you must label all components with proper units, all power supply (if any), all inputs and outputs are labeled.

This is the simplest solution.



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

$$G = \frac{R_2}{R_1+R_2} = \frac{1}{2}$$

$R_1 = 100\,\Omega$ ratio must be 1:1

$R_2 = 100\,\Omega$

Problem # 5 (10 points)

What is the terminal output when the following python script is run?

```
1  x = 3
2  y = 5
3  z = 8
4
5  while y>=0:
6      if x >1:
7          y = y-1
8      if z<10:
9          y = y-2
10         x = x+1
11         z = z-1
12     elif z>=10:
13         x = 0
14         y = -1
15
16 print(x,y,z)
17
```

Initially:
x = 3 y = 5 z = 8

The while condition is met and the loop is run the first time. The first if statement is True and runs, thus: x = 3, y = 4, z = 8
The second if statement is True and runs, thus:
x = 4, y = 2, z = 7
Since the second if statement ran the elif statement will not run (and if it did the condition to run will False, anyways)

The loop finishes and returns the beginning of the loop. The while loop condition is still true so the loop runs a second time. The first if statement is true so it runs, thus: x = 4, y = 1, z = 7
The second if statement is True and runs, thus:
x =5, y = -1, z = 6
Again, the elif will not run. The loop finishes and returns the beginning of the loop. The while loop condition is not met and the loop ends.
The print(x,y,z) line runs and the terminal outputs:
5 -1 6

Answer:

5 -1 6