CG1111A:
Engineering Principles & Practice I

Revision Practice Questions for Quiz #2

National University of Singapore

Q1

What is the number of turns in the secondary winding of an ideal transformer, if the currents in the primary and secondary windings are 14 A and 2 A, respectively? The number of turns in the primary winding is 120.

(A) 3360

(B) 840

(C) 18

(D) 2

Ans: B

Q2

A full wave rectifier is connected to a resistive load of 20 Ω with a load voltage of 8 V. If the voltage ripple is 0.4 V peak-to-peak, calculate the value of the filter capacitor connected in parallel to the resistive load. Assume that the AC frequency is 60 Hz, and the diodes are ideal with no voltage drop.

(A) 20000 μF

(B) 10000 μF

(C) 16666.67 μF

(D) 8333.33 μF

Ans: D

Q3

Calculate the secondary voltage (V_S) of a transformer, if the input power at the primary of the transformer is 1200 W at 200 V RMS, and the secondary current is 1.5 A RMS. The number of turns in the primary winding is 50.

(A) 800 V RMS

(B) 50 V RMS

(C) 200 V RMS

(D) 12.5 V RMS

Ans: A

Q4

A full wave rectifier is connected to a resistive load of 40 Ω with a load voltage of 12 V. If the voltage ripple is 0.9 V, calculate the value of the filter capacitor connected in parallel to the resistive load. The AC frequency is 50 Hz. Assume the diodes are ideal with no voltage drop.

(A) 333.33 μF

(B) 666.67 μF

(C) 3333.33 μF

(D) 6666.67 μF

Ans: C

Q5

Calculate the primary voltage (V_P) of a step-up transformer, if the secondary is connected to a load of 1500 W at 600 V RMS and the primary current is 12.5 A RMS. The number of turns in the primary winding is 500.

(A) 30000 V RMS

(B) 3000 V RMS

(C) 1200 V RMS

(D) 120 V RMS

Ans: D

Q6

What is the number of turns in the secondary winding of an ideal transformer, if the currents in the primary and secondary windings are of 4 A and 28 A, respectively. The number of turns in the primary windings is 100.

(A) 700

(B) 15

(C) 4900

(D) 25

Ans: B

Q7

A permanent magnet DC motor is connected to a 12 V DC source. Under NO-LOAD condition, the motor's speed is 1000 RPM. At a load-torque of 1 Nm, the speed drops to 900 RPM. The armature resistance is

(A) 0.138 Ω

(B) 0.115 Ω

(C) 0.014 Ω

(D) 0.012 Ω

Ans: A

Q8

A permanent magnet DC motor is connected to a 24 V DC source. Under NO-LOAD condition, the motor's speed is 2000 RPM. At a load-torque of 1 Nm, the speed drops to 1800 RPM. Suppose we wish to operate the motor at a speed of 1600 RPM for the same load-torque of 1 Nm, using a PWM with an ON voltage of 24 V. The required duty cycle of the PWM is

(A) 0.889

(B) 0.900

(C) 0.800

(D) 0.750

Ans: B

Q9

A permanent magnet DC motor is powered by a 12 V DC supply. Under NO-LOAD condition, the motor's speed is 2500 RPM. If the shaft is clamped mechanically such that it doesn't spin, the current drawn by the motor is 0.5 A. When a particular load is attached to the shaft, its speed drops to 2000 RPM. The current drawn by the motor for this load-torque is

(A) 2.4 A

(B) 0.24 A

(C) 0.4 A

(D) 0.1 A

Ans: D

Q10

. Consider a PWM controlled PMDC motor powered by a 12 V supply. The torque constant of this motor is 30 mNm/A. The motor drives a torque load at the speed of 2000 RPM with 90% duty cycle. If the duty cycle is now reduced to 60%, while the load remains the same, what will be the speed?

(A) 1333 RPM

(B) 472 RPM

(C) 854 RPM

(D) 2292 RPM

Ans: C

Q11

A PMDC motor is powered by a 24 V DC supply. When the motor current is 0.4 A, the motor spins at 3000 RPM. When the motor current is 0.8 A, the motor spins at 1200 RPM. What is the torque constant of the motor?

(A) 30.2 mNm/A

(B) 47.7 mNm/A

(C) 60.4 mNm/A

(D) 23.9 mNm/A

Ans: B

Q12

A PMDC motor is powered by a 24 V DC supply. Its rotor coil's resistance is 2.5 Ω. What is the current drawn by the motor when it is providing maximum mechanical power?

(A) 4.8 A

(B) 9.6 A

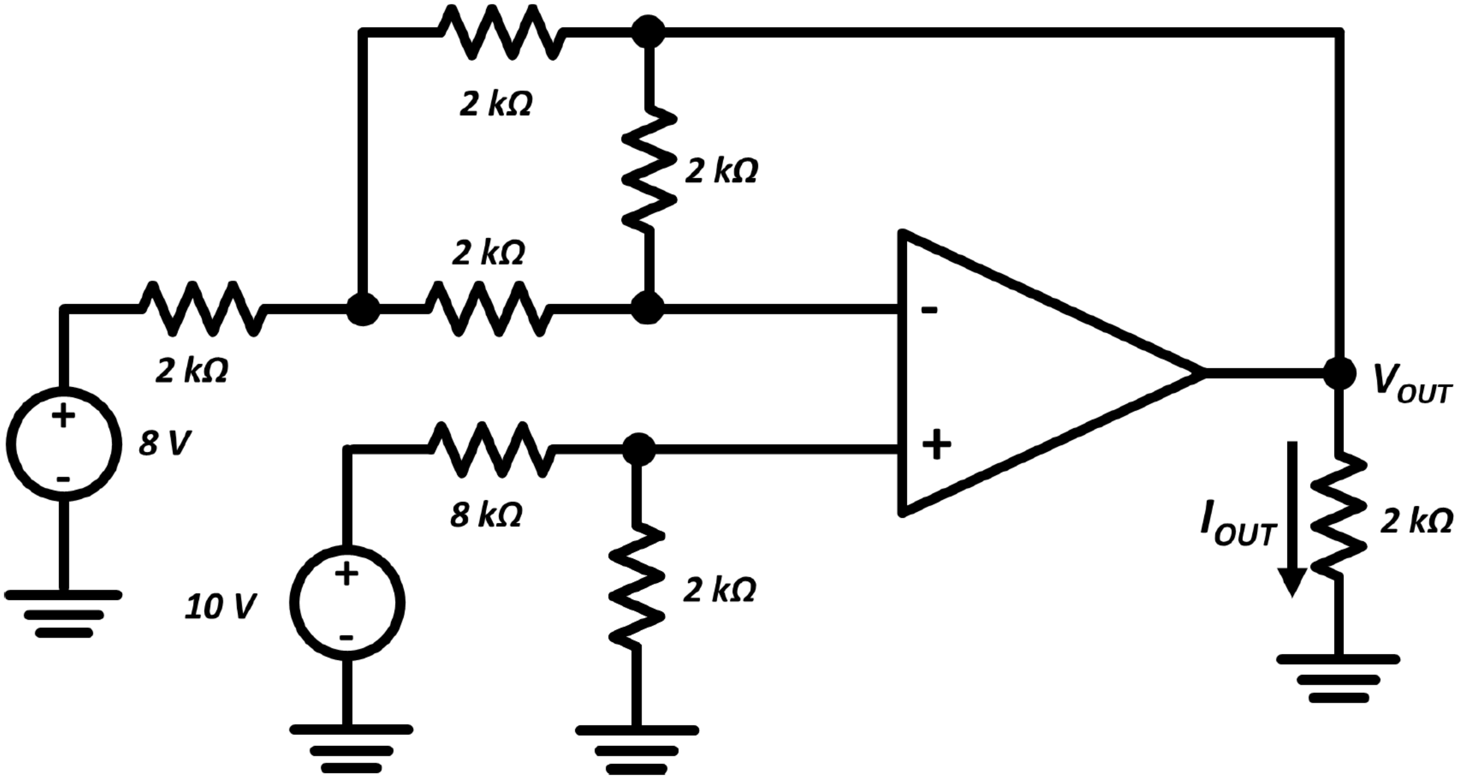
(C) 2.4 A

(D) 1.2 A

Ans: A

Q13

Calculate the value of I_{OUT} in Figure 2. The op-amp is supplied with a dual power supply of ± 5 V.



(A) 0.5 A

(B) 0.5 mA

(C) 2.5 mA

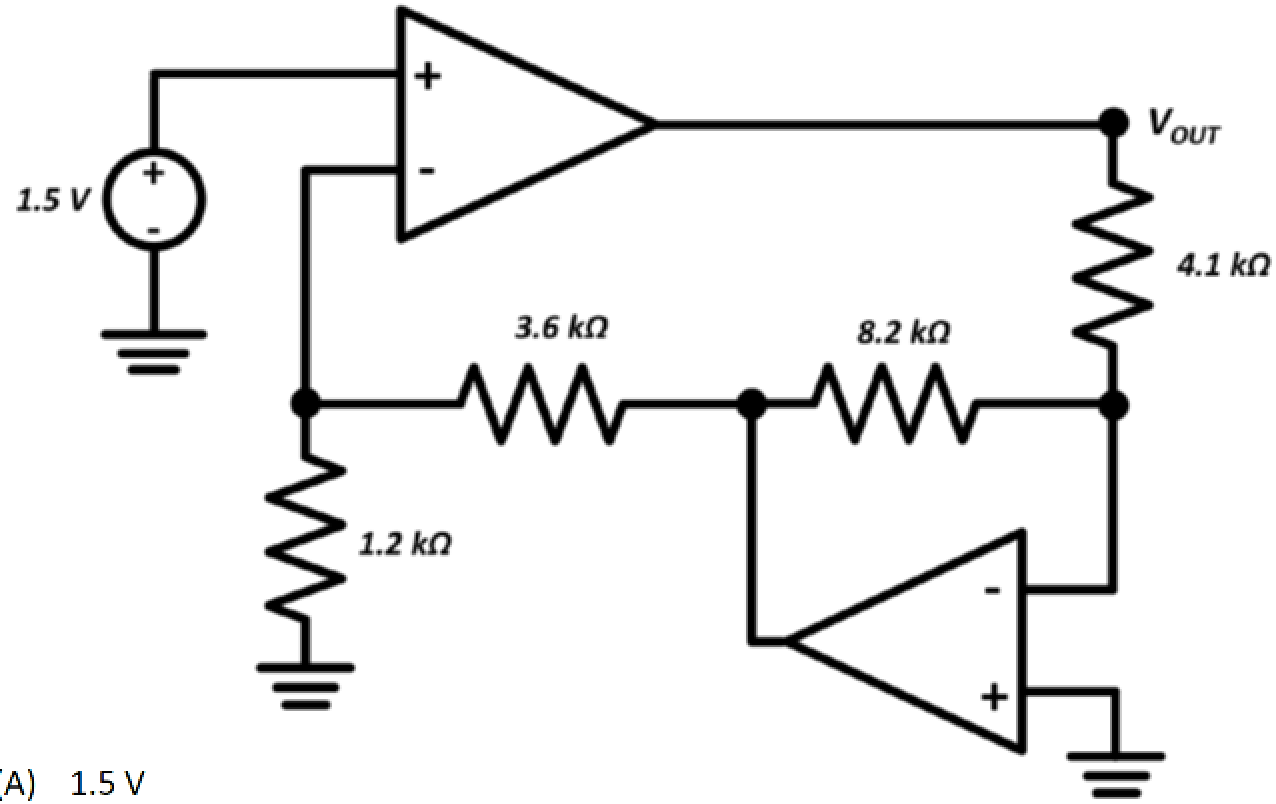
(D) 0.25 mA

Figure 2

Ans: D

Q14

Calculate the value of V_{OUT} in Figure 3. Both the op-amps are supplied with a dual power supply of ± 8 V.



(A) 1.5 V

(B) –1.5 V

(C) –3 V

(D) 3 V

Ans: C

Q15

Calculate the value of V_{OUT} in Figure 4. The op-amp is supplied with a dual power supply of ± 8 V.

V_{IN} = 1.5 cos(100t) + 2.2 V

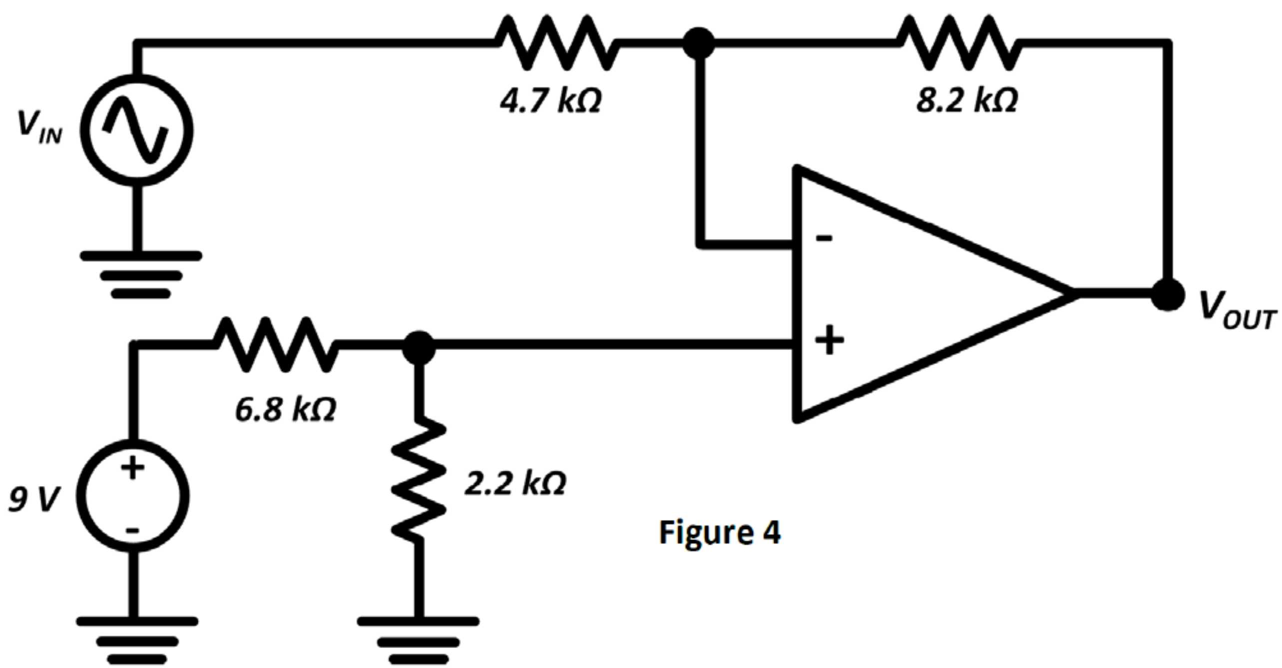


Figure 4

(A) 2.62 cos(100t + 180°) + 2.20 V

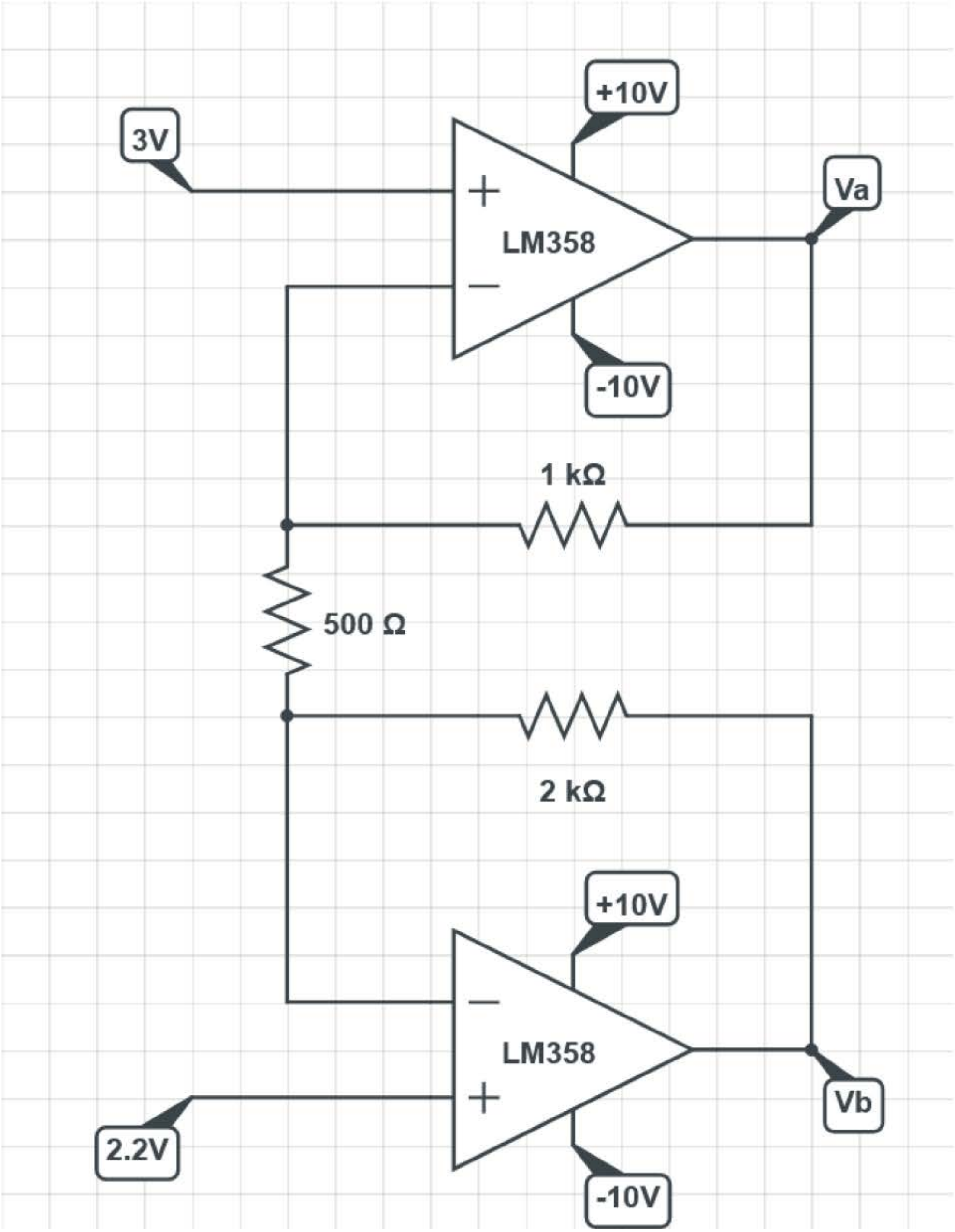
(B) 2.62 cos(100t + 180°) + 3.83 V

(C) 2.62 cos(100t + 0°) V

(D) 2.62 cos(100t + 180°) V

Ans: A

Q16 Calculate the value of $\mathbf{V_b}$ in the following Figure:



(A) 4.6 V

(B) 1 V

(C) -4.6 V

(D) -1 V

Ans: D

Q17

Calculate the value of V_{out} in Figure 2. Both the op-amps are supplied with a dual power supply of $\pm$ 5 V.

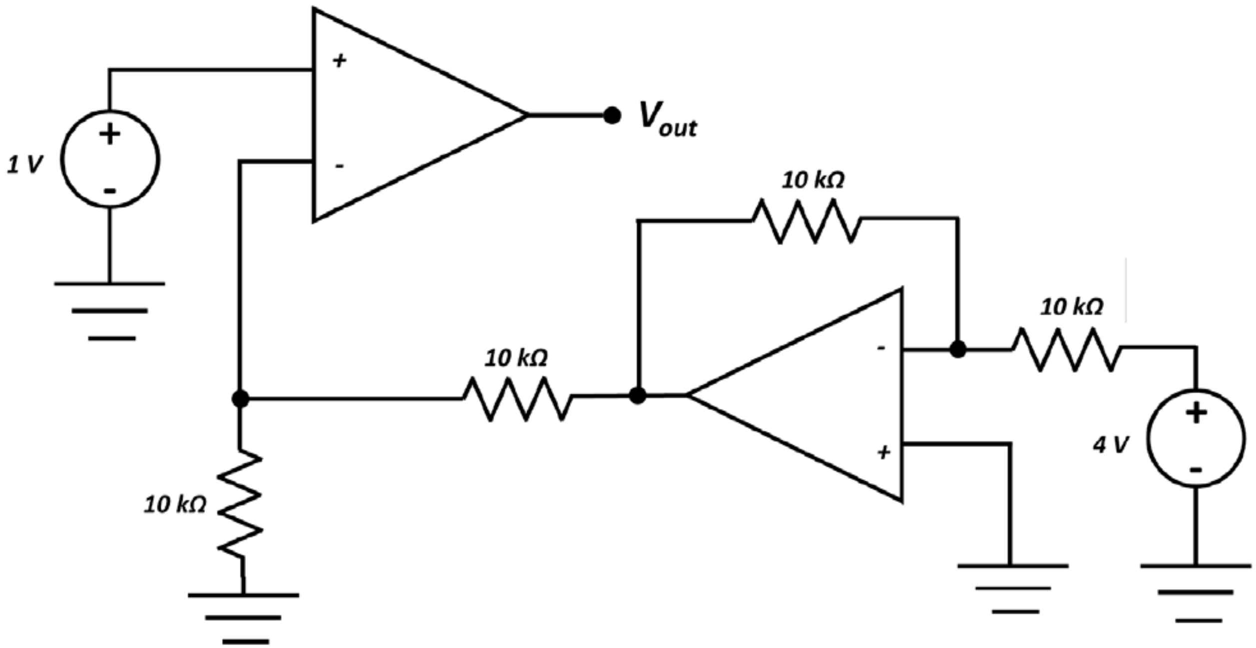


Figure 2

(A) +5 V

(B) –5 V

(C) +3 V

(D) Cannot be determined

Ans: A

Q18

Calculate the value of I_{out} in Figure 3. The op-amp is supplied with a dual power supply of ± 10 V.

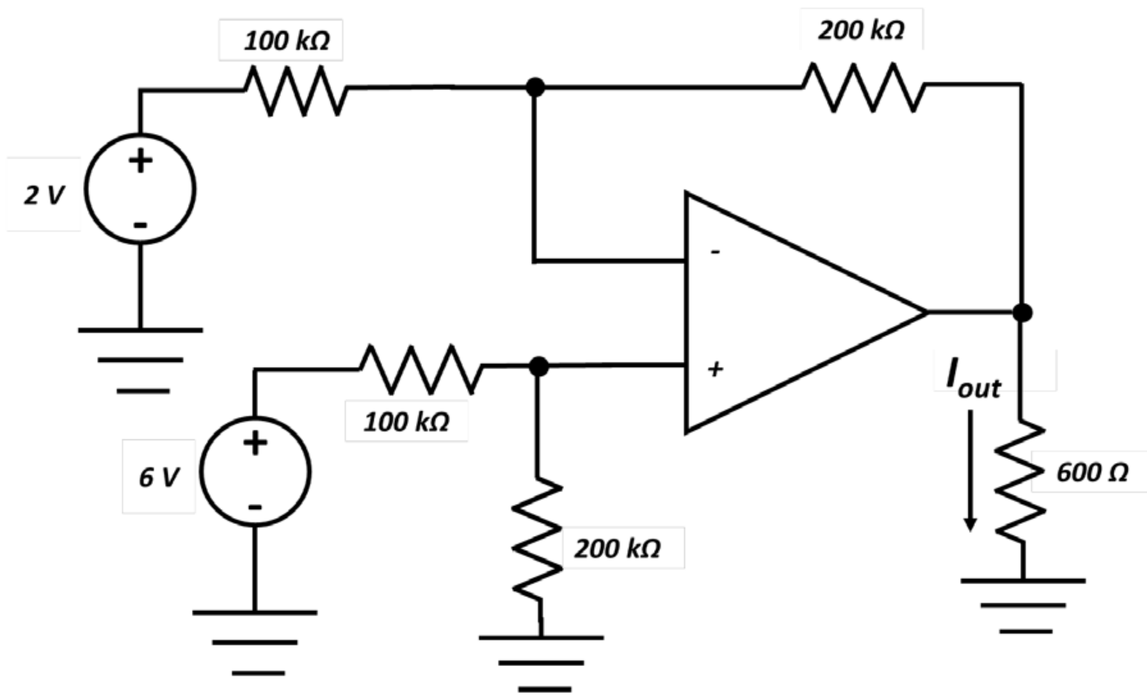


Figure 3

(A) +6.667 mA

(B) −6.667 mA

(C) −13.33 mA

(D) +13.33 mA

Ans: D

Q19

Calculate the value of V_{out} in Figure 4. The op-amp is supplied with a dual power supply of $\pm$ 15 V.

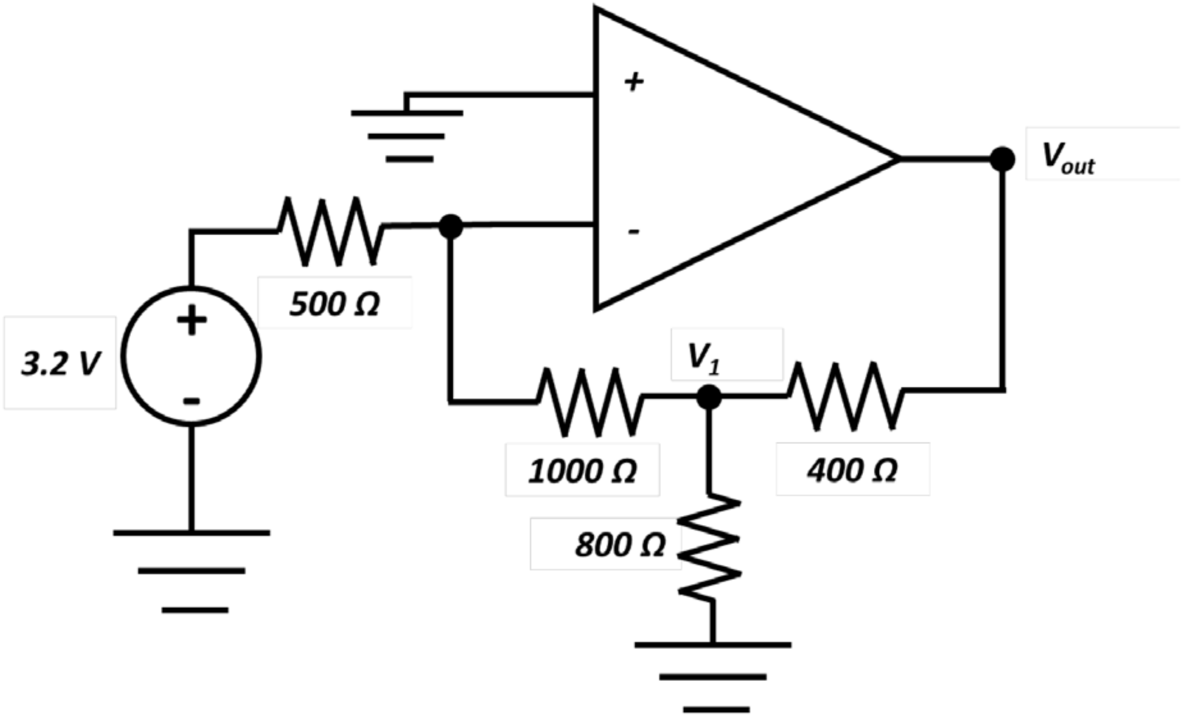


Figure 4

(A) 12.16 V

(B) –12.16 V

(C) –5.76 V

(D) 5.76 V

Ans: B

Q20

Determine the resistor values to design a band pass filter as shown in Figure 1 below, with cut-off frequencies of 1200 Hz and 4500 Hz.

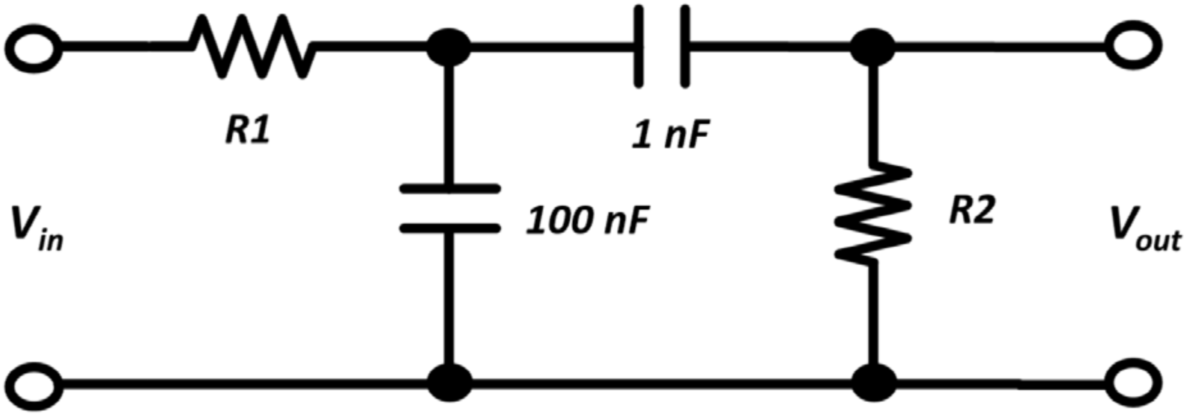


Figure 1

(A) R1= 132629 Ω, R2 = 354 Ω

(B) R1= 354 Ω, R2 = 132629 Ω

(C) R1= 265258 Ω, R2 = 707 Ω

(D) R1= 707 Ω, R2 = 265258 Ω

Ans: B

Q21

Determine the resistor values to design a band pass filter as shown in Figure 1 with cut-off frequencies of 600 Hz and 1600 Hz.

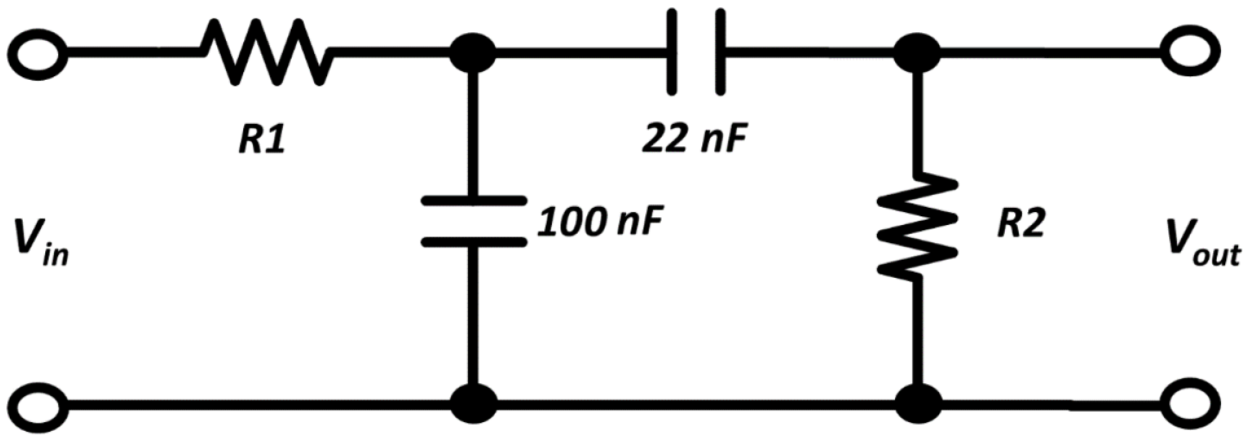


Figure 1

(A) R1= 995 Ω, R2 = 12060 Ω

(B) R1= 12060 Ω, R2 = 995 Ω

(C) R1= 2652 Ω, R2 = 4522 Ω

(D) R1= 4522 Ω, R2 = 2652 Ω

Ans: A

Q22

Toothless is an audio recording artist whose current recording has been corrupted by the noise of the construction work near his recording studio. His recording is in the frequency range of 195 Hz to 395 Hz. He did an analysis of the noise and figured out that the noise is in the frequency range of 4000 Hz to 6000 Hz. Choose the correct combination of the resistor and capacitor values so that Toothless can design a filter that can reduce the construction work noise by at least 18 dB.

(A) $R = 314\ k\Omega$, $C = 0.01\ \mu F$

(B) $R = 314\ k\Omega$, $C = 0.001\ \mu F$

(C) $R = 209\ k\Omega$, $C = 0.001\ \mu F$

(D) $R = 209\ k\Omega$, $C = 0.01\ \mu F$

Ans: B

Q23

Momo is a music producer whose recordings are corrupted by the airplanes taking off and landing at the airport near his recording studio. His recordings are in the frequency range of 195 Hz to 540 Hz. He did an analysis of the noise and figured out that the noise is in the frequency range of 8000-13000 Hz. Choose the closest correct combination of resistor and capacitor so that Momo can design a low pass filter that can reduce the airport noise by at least 15 dB.

(A) R = 11 kΩ, C = 0.001 μF

(B) R = 6.78 kΩ, C = 0.01 μF

(C) R = 11 kΩ, C = 0.01 μF

(D) R = 6.78 kΩ, C = 0.001 μF

Ans: C

Q24 Nuby is a music producer whose recordings are corrupted by the sewage drilling work near his recording studio. His recordings are in the frequency range of 600 Hz to 6000 Hz. He did an analysis of the noise and figured out that the noise is in the frequency range of 25-60 Hz. Choose the closest correct combination of resistor and capacitor so that Nuby can design a filter that can reduce the drilling noise by at least 14 dB.

(1 mark)

(A) $R = 130\ k\Omega,\ \ C = 0.01\ \mu F$

(B) $R = 312\ k\Omega,\ \ C = 0.1\ \mu F$

(C) $R = 130\ k\Omega,\ \ C = 0.1\ \mu F$

(D) $R = 540\ k\Omega,\ \ C = 0.001\ \mu F$

Ans: D

Q25

Katy is interested in building a low-cost kettle. She attaches an LM35 temperature sensor at the pitcher spout and intends to cut off the power supply to the heating element in the pitcher when the water boils. However, the output of LM35 only increases by 10 mV per degree Centigrade. She needs the cut-off signal voltage to be around 3.3 V. Help her design a non-inverting amplifier to complete her task. You may assume that the output of LM35 at 0°C is 0 V.

(A) $R_f = 2.7\ k\Omega$, $R_i = 6.2\ k\Omega$

(B) $R_f = 4.3\ k\Omega$, $R_i = 1.3\ k\Omega$

(C) $R_f = 3\ k\Omega$, $R_i = 1.3\ k\Omega$

(D) $R_f = 2\ k\Omega$, $R_i = 1.5\ k\Omega$

Ans: C

Q26 A young engineer tested a new IR sensor for proximity sensing using the indirect incidence setup. He obtained the graph as shown in Figure 5. He built a proximity sensor circuit as shown in Figure 6. By using two op-amp comparators, he wanted his circuit to light up one LED when an opaque object is less than 4 cm from the sensor, and another LED when it is more than 4 cm. Help him complete his circuit design.

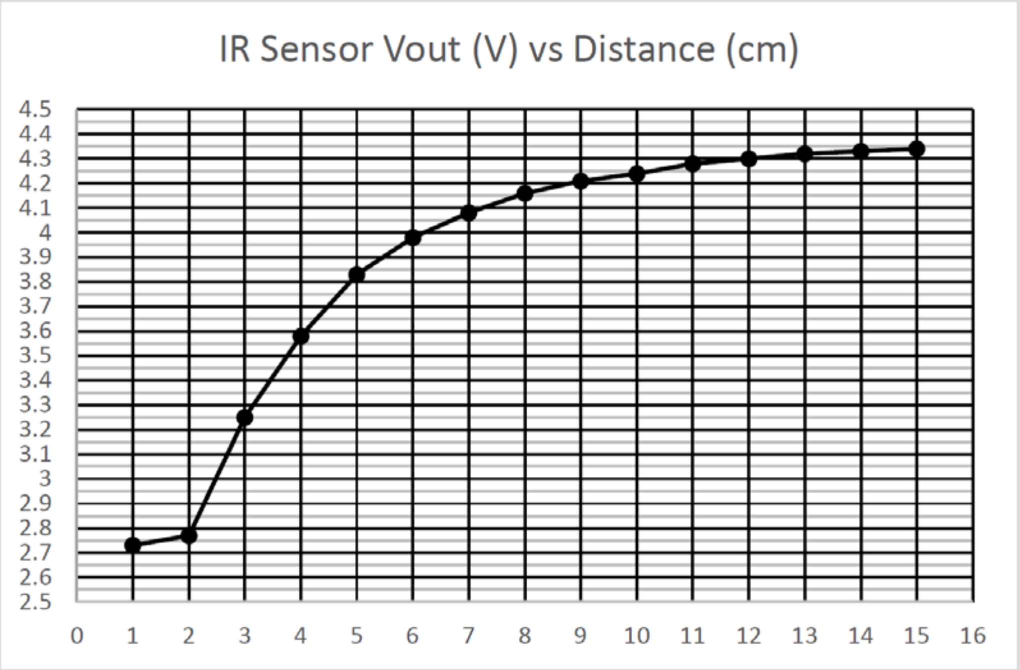


Figure 5: IR Sensor V_{OUT} vs Distance.

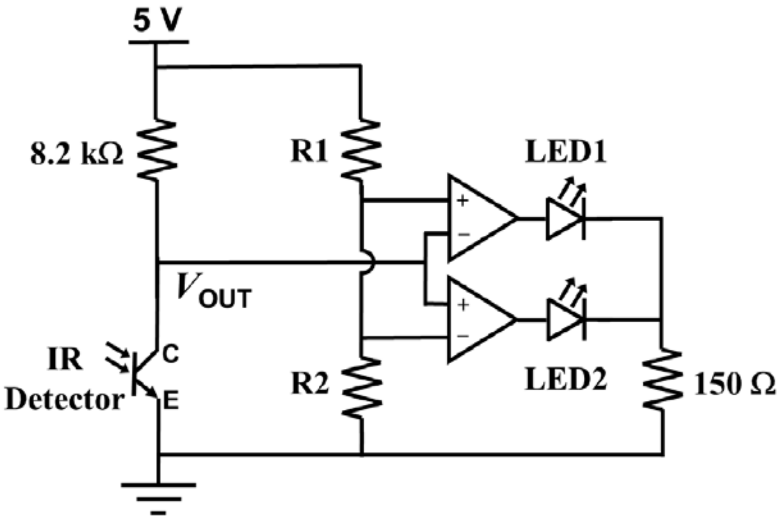


Figure 6: IR Proximity Sensor Circuit.

(A) R1 = 6.8 kΩ, R2 = 2.7 kΩ, only LED1 lights up when object is < 4 cm, and LED2 otherwise.

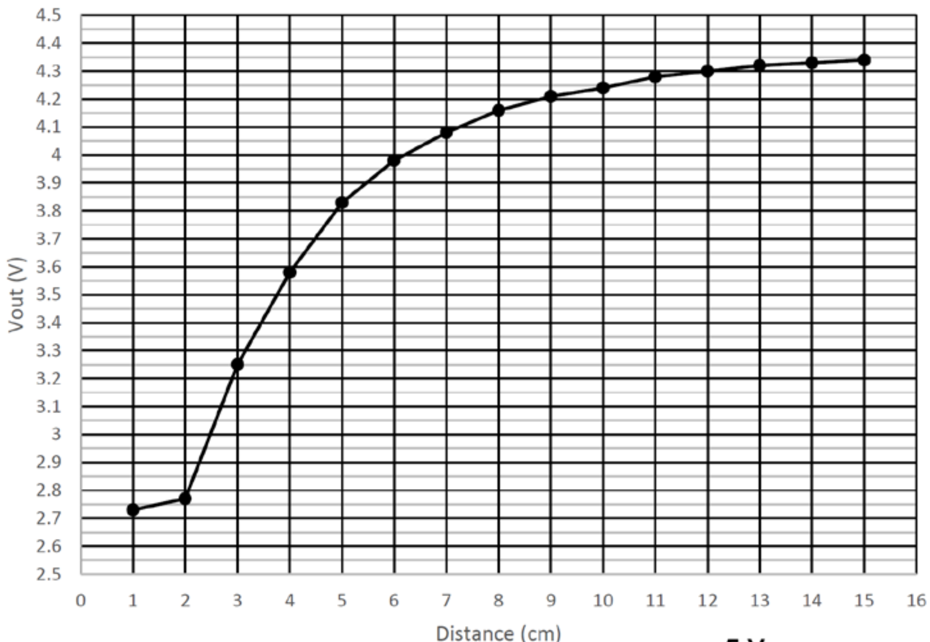
(B) R1 = 2.7 kΩ, R2 = 6.8 kΩ, only LED1 lights up when object is < 4 cm, and LED2 otherwise.

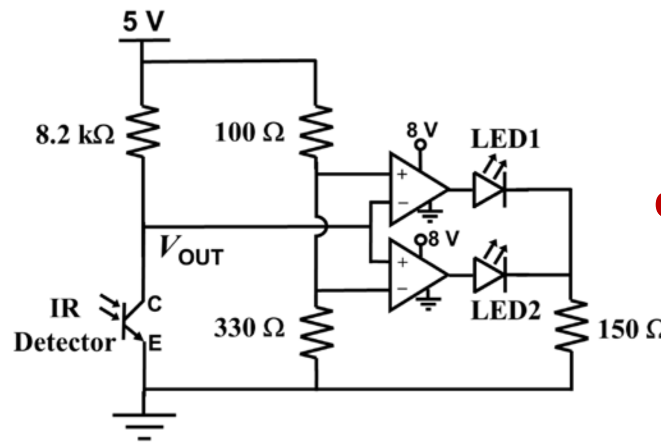
(C) R1 = 6.8 kΩ, R2 = 2.7 kΩ, only LED2 lights up when object is < 4 cm, and LED1 otherwise.

(D) R1 = 2.7 kΩ, R2 = 6.8 kΩ, only LED2 lights up when object is < 4 cm, and LED1 otherwise.

Ans: B

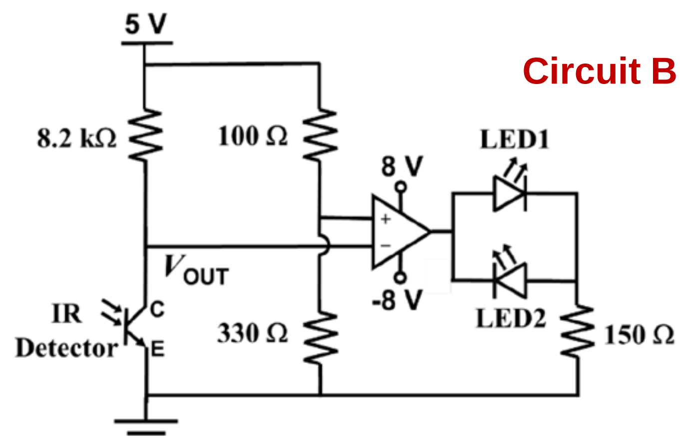
Q27 Figure 5 depicts the characteristic output voltage versus distance of an IR sensor in indirect incidence setup for proximity sensing. A young hobbyist wants to incorporate it into his project – he needs LED2 to be lit when an opaque object is more than 5 cm from the sensor, and LED1 to be lit otherwise. He found three potential circuit diagrams online (namely, Circuit A, Circuit B, and Circuit C, as shown in Figure 6 on next page), but he is uncertain about them meeting his requirement. Help him out by selecting the correct option below.





Circuit A

Circuit B

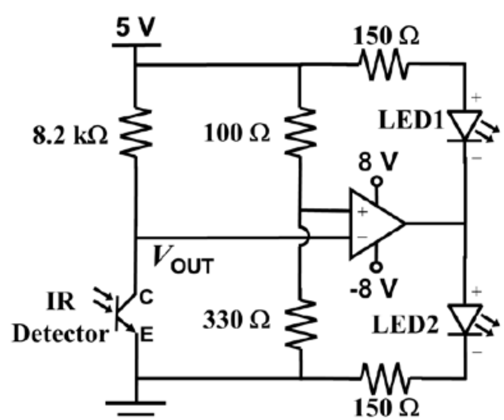


(A) Circuit A only.

(B) Circuits A and B only.

(C) Circuits A and C only.

(D) Circuits B and C only.



Circuit C

Ans: B

Q28

The Humirel HS 1101 is a commonly used 5 V (V_{cc}) humidity sensor that operates according to the following relationship:

$$V_{out} = V_{cc} \times (0.00474 \times \%RH + 0.2354),$$

where $\%RH$ is the relative humidity in percentage (note: $0 \leq \%RH \leq 100$).

If its V_{out} is to be amplified by a non-inverting amplifier before being sampled by an Arduino, which one of the following amplifier designs optimizes both the sensor operating range, and the Arduino ADC range of 0 to 5 V?

(A) R_f = 3.1 kΩ, R_i = 2.2 kΩ

(B) R_f = 1.1 kΩ, R_i = 2.7 kΩ

(C) R_f = 8.2 kΩ, R_i = 3.9 kΩ

(D) R_f = 1.8 kΩ, R_i = 2 kΩ

Ans: B

Q29 While on a "Charity: Water" project mission trip to a remote village, an NUS undergraduate volunteer decided to put his CG1111A knowledge to good use and offered to help in ascertaining that the water is within safe pH range (preferably pH 7.4) before commissioning the wells to the villagers. The output voltage of the analog pH sensor he used to evaluate the water pH is in the millivolts range as shown in the attached sensor characteristics table. He figured he has to use an amplifier to boost the sensor output signal before sampling it with an Arduino Uno. Which of the following is the most appropriate amplifier design he should use to correctly identify the water pH?

VOLTAGE (mV)	pH value	VOLTAGE (mV)	pH value
414.12	0.00	-414.12	14.00
354.96	1.00	-354.96	13.00
295.80	2.00	-295.80	12.00
236.64	3.00	-236.64	11.00
177.48	4.00	-177.48	10.00
118.32	5.00	-118.32	9.00
59.16	6.00	-59.16	8.00
0.00	7.00	0.00	7.00

(A) non-inverting amplifier, single 5 V power supply, $R_f = 1.8\ k\Omega$, $R_i = 150\ \Omega$

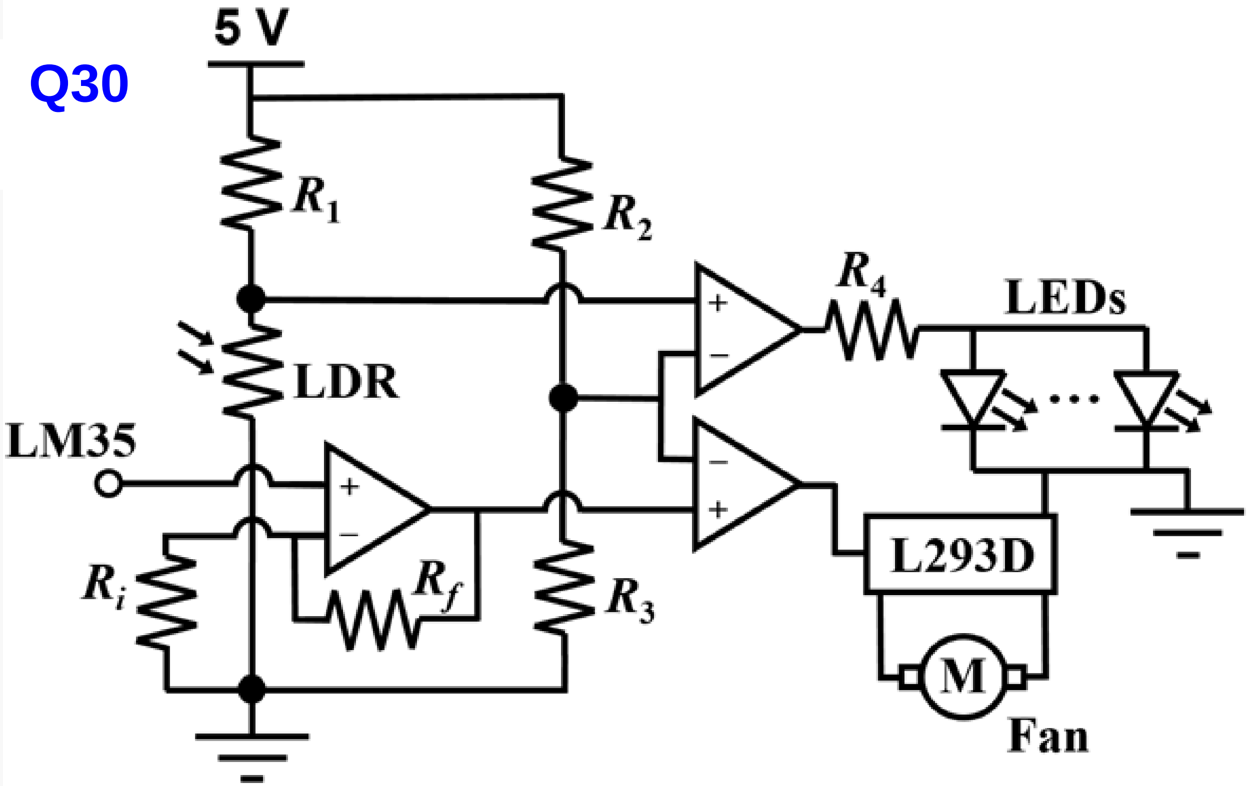
(B) inverting amplifier, dual 5 V power supply, $R_f = 20\ k\Omega$, $R_i = 3.3\ k\Omega$

(C) inverting amplifier, single 5 V power supply, $R_f = 8.2\ k\Omega$, $R_i = 680\ \Omega$

(D) non-inverting amplifier, dual 5 V power supply, $R_f = 9.1\ k\Omega$, $R_i = 1.5\ k\Omega$

Ans: C

Q30



During the COVID-19 circuit breaker, a CG1111 student was unable to get his broken lamp and fan replaced. He decided to use his CG1111 studio components and a temperature sensor (LM35) to build a circuit that turns on LEDs when his room is dim and turns on his self-made fan when the room temperature is above 25 °C. The resistance of the LDR decreases with increasing luminosity (light) received on the component's sensitive surface, while the output voltage of LM35 increases by 10 mV per degree Centigrade (given that the output is 0 V at 0 °C). Which of the following is the most suitable set of resistors that allows him to implement the intended functionalities?

(A) Ri = 470 Ω, Rf = 4.7 kΩ, R1 = 470 kΩ, R2 = 470 Ω, R3 = 470 Ω and R4 = 470 Ω

(B) Ri = 330 Ω, Rf = 3 kΩ, R1 = 3.3 MΩ, R2 = 330 Ω, R3 = 330 Ω and R4 = 330 Ω

(C) Ri = 220 Ω, Rf = 2 kΩ, R1 = 120 kΩ, R2 = 220 Ω, R3 = 220 Ω and R4 = 220 Ω

(D) Ri = 100 Ω, Rf = 9.1 kΩ, R1 = 1 MΩ, R2 = 100 Ω, R3 = 100 Ω and R4 = 1 MΩ

Ans: C