Solutions to Tutorial Sheet – 3
(Operational Amplifiers)

1. $A_{CL(\min)} = -\frac{(1+0)\ \text{k}\Omega}{1\ \text{k}\Omega} = \mathbf{-1}$ and $A_{CL(\max)} = -\frac{(1+100)\ \text{k}\Omega}{1\ \text{k}\Omega} = \mathbf{-101}$

2. The closed-loop voltage gain of three channels are

$$A_{CL1} = \frac{100\ \text{k}\Omega}{20\ \text{k}\Omega} = 5; \quad A_{CL2} = \frac{100\ \text{k}\Omega}{10\ \text{k}\Omega} = 10; \quad A_{CL1} = \frac{100\ \text{k}\Omega}{50\ \text{k}\Omega} = 2$$

$$\therefore V_o = 5(100\ \text{mV}) + 10(200\ \text{mV}) + 2(300\ \text{mV}) = \mathbf{3.1\ V}$$

3. $V_{out} = -\left(\frac{56}{10} \times 0.4 + \frac{56}{30} \times 0.6 + \frac{56}{18} \times (-0.1)\right) = \mathbf{-3.049\ V}$

4. Due to virtual short between the input terminals of op-amp, the potential at point A is V_i. Hence,

$$V_i = V_o \frac{R}{R+nR} = V_o \frac{1}{n+1} \quad \Rightarrow \quad A_V = \frac{V_o}{V_i} = n+1$$

5. Because of the potential divider, the voltage at the non-inverting terminal is $V_+ = V_2/2$.

$$V_o = -\frac{R_f}{R_1} \times V_1 + \left(1 + \frac{R_f}{R_1}\right) V_+ = -\frac{3R}{R} \times V_1 + \left(1 + \frac{3R}{R}\right)(V_2/2) = 2V_2 - 3V_1$$

6. We have the ideal Op – Amp so that $V_n = V_p = 0$.

In Fig. 6 at V_n node

$$\frac{V_n}{2K\Omega} + \frac{V_n - V_o}{2K\Omega} + 2mA = 0 \quad \Rightarrow \quad \frac{-V_o}{2K\Omega} = -2mA \Rightarrow V_o = 4V$$

In Fig. 7 at V_n

$$\frac{V_n - 2}{R} + \frac{V_n - V}{R} = 0, where R = 2K\Omega \quad \Rightarrow \quad V + 2 = 0 \Rightarrow V = -2V$$

At node with voltage V we have

$$\frac{V - V_n}{R} + \frac{V}{R} + \frac{V - V_o}{R} = 0, where R = 2K\Omega \quad \Rightarrow \quad 3V - V_o = 0 \Rightarrow V_o = 3(-2) = -6V$$