op amps 1&2 are non-inverting
& op 3 is not.

(a) V_{o1} & V_{o2} be outputs of 1 & 2.

$$V_{out} = V_o = \frac{R_3}{R_2}(V_{o1} - V_{o2})$$

$V_A = V_B = V_1$ (vir. ground)

$V_C = V_D = V_2$ (vir ground).

$$I = \frac{V_{o1} - V_{o2}}{2R_1 + R_g}$$

zero current in inputs of ① & ②.

$$I = \frac{V_G - V_H}{R_g} = \frac{V_1 - V_2}{R_g}$$

$$\frac{V_{o1} - V_{o2}}{2R_1 + R_g} = \frac{V_1 - V_2}{R_g}$$

$$V_{o1} - V_{o2} = \frac{2(R_1 + R_g)(V_1 - V_2)}{R_g}$$

$$V_{out} = \frac{R_3}{R_2}\left(\frac{2R_1 + R_g}{R_g}\right).(V_1 - V_2)$$

(b) $R_1 = R_2 = R_3 = 10k$, $R_g = 1k$

$V_s = 12V$.

(i) $V_2 = 20mV$, $V_1 = -10mV$.

$V_{o1} = \left(1 + \frac{R_1}{R_g}\right)V_1$, $V_{o2} = \left(1 + \frac{R_1}{R_g}\right)V_2$.

$V_{o1} = \left(1 + \frac{10k}{1k}\right)(-10mV)$

$= -110 \ mV.$

$V_{o2} = \left(1 + \frac{10}{1}\right)(20 mV)$

$= 220 \ mV.$

$V_{out} = \frac{10}{10} \times \left(\frac{10 \times 2 + 1}{1}\right)(-10-20)$

$= -330 \ mV.$

(ii) $V_2 = 2V, \qquad V_1 = -1V.$

$V_{o1} = \left(1 + \frac{10}{1}\right)(-1) = -11 \ V.$

$V_{o2} = \left(1 + \frac{10}{1}\right)(2) = 22 \ mV.$

$V_{out} = \frac{10}{10}(-11 - 22) = -33 \ V.$?

$V_{o2} > 12 \Rightarrow V_{o2} = 12 \Rightarrow V_{o2} = \frac{10}{10}(-11-12) = -23 \ V.$ (not possible)

$\Rightarrow V_{out} = \frac{10}{10}(-11-12)$ which is again bigger than 12.

$\Rightarrow V_{out} = \underline{12 \ V}.$