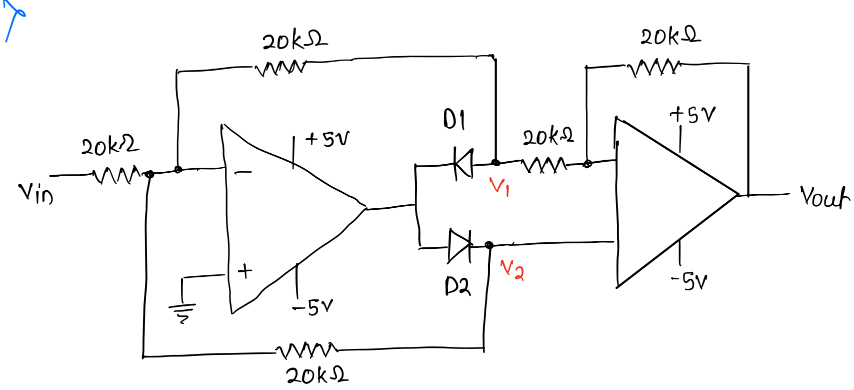
Q1)



When $V_{in} \geq 0$

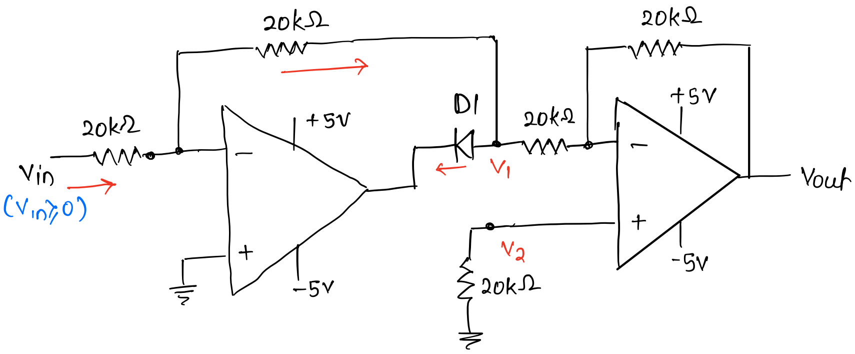


Figure with current path — <1 mark>

(Drawing of o/p opamp is optional)

D1 ON & D2 OFF

$V_1 = -V_{IN}$ — <1 mark>

$V_2 = 0$ — <1 mark>

When $V_{in} < 0$

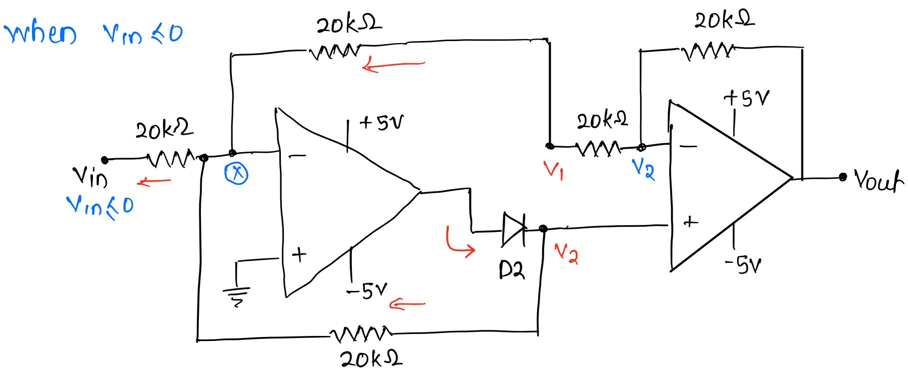


Figure with current path — <1 mark>

(Drawing of o/p opamp is optional)

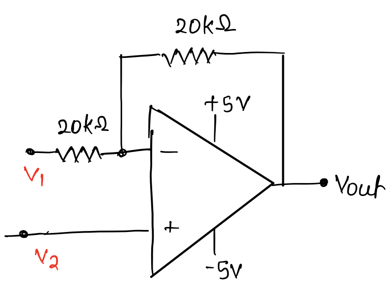
When $V_{in} < 0$ D_1 OFF & D_2 ON

Applying KCL at node ⊗

$$\frac{-V_{in}}{20k} = \frac{V_2}{40k} + \frac{V_2}{20k} \Rightarrow V_2 = -\frac{2}{3} V_{in}$$ — <1 mark>

$$V_1 = \frac{V_2}{2} = -\frac{1}{3} V_{in}$$ — <1 mark>

b) Circuit diagram with V_1 & V_2 as input



$$V_{out} = \left(1 + \frac{20k}{20k}\right) V_2 - V_1 \left(\frac{20k}{20k}\right)$$

$$V_{out} = 2V_2 - V_1$$ — <1 mark>

c) when $V_{in} \geq 0$

$V_1 = -V_{IN}$ & $V_2 = 0$

$\therefore V_{out} = V_{IN}$ —— ~~<1 mark>~~ <0.5 marks>

when $V_{in} < 0$

$V_2 = -\frac{2}{3} V_{in}$ & $V_1 = -\frac{1}{3} V_{in}$

$\therefore V_{out} = 2V_2 - V_1 = 2 \times \left(-\frac{2}{3} V_{in}\right) + \frac{1}{3} V_{in} = -V_{in}$ —— ~~<1 mark>~~ <0.5 marks>

DC Transfer characteristics

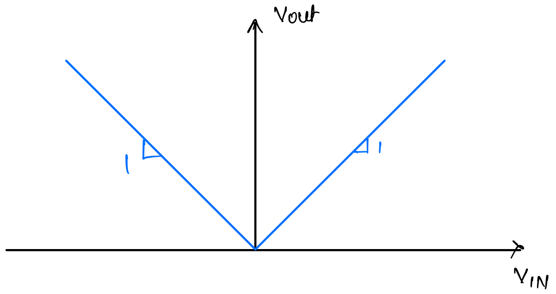
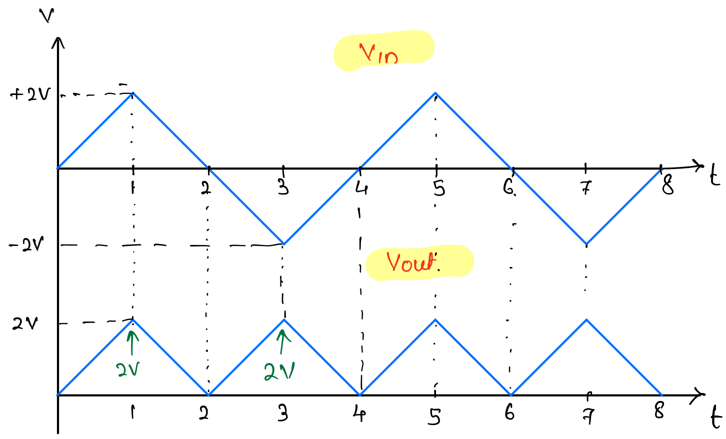


Figure with annotations <1 mark>

d)

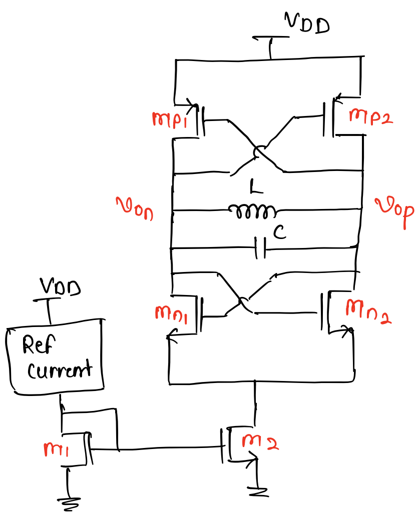


Vout(t)

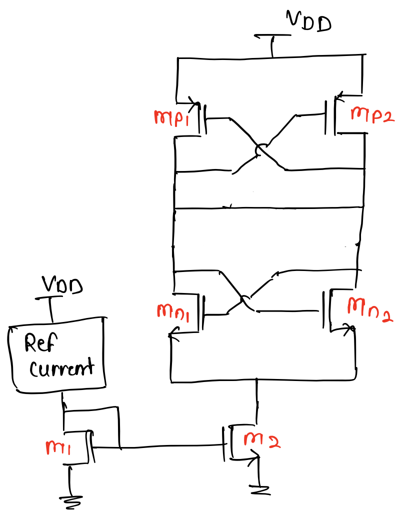
if rectification is shown <1 mark>

if the magnitude is correct <1 mark>

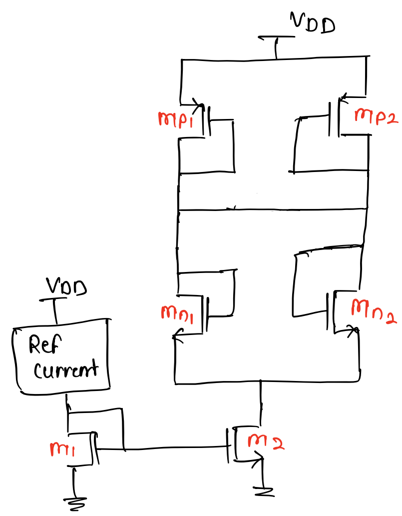
Q2)



a) Schematic at DC operating point



or



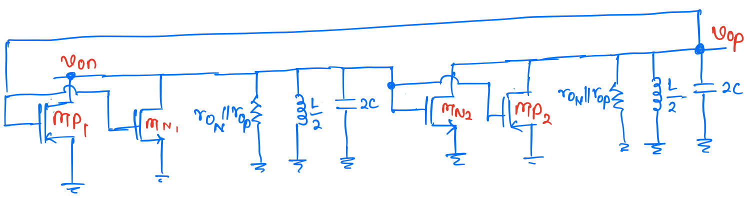
— < 1 mark >

b) At DC operating Point

$I_{Dm_{N_1}} = I_{Dm_{n_2}} = \frac{I_{D_2}}{2}$ — < 1 mark >

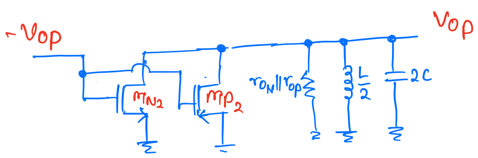
$I_{Dm_{p_1}} = I_{Dm_{p_2}} = \frac{I_{D_2}}{2}$ — < 1 mark >

c) Small signal schematic



— < 2 marks >

Half Circuit



— < 1 mark >

$$Z = \frac{(r_{op} || r_{oN}) \times \frac{L}{2} s}{(r_{op} || r_{oN}) \frac{L}{2} \times 2C \cdot s^2 + \frac{L}{2} s + (r_{op} || r_{oN})}$$

— < 1 mark >

For sustained oscillations

$(g_{m_N} + g_{m_p})^2 \times Z^2 = 1$ — < 0.5 mark >

$$\therefore \quad \frac{-(g_{m_p} + g_{m_N})^2 \times \omega^2 / (2C)^2}{\left(-\omega^2 + \frac{1}{LC} + \frac{j\omega}{(r_{op} || r_{oN})(2C)}\right)^2} = 1$$

— < 0.5 mark >

freq^n of oscillation

$\omega^2 = \frac{1}{LC}$ $\quad \therefore \omega = \frac{1}{\sqrt{LC}}$ — ⟨0.5 mark⟩

for sustained oscillation

$(g_{m_p} + g_{m_N}) \times (r_{op} \parallel r_{on}) > 1$ — ⟨0.5 mark⟩