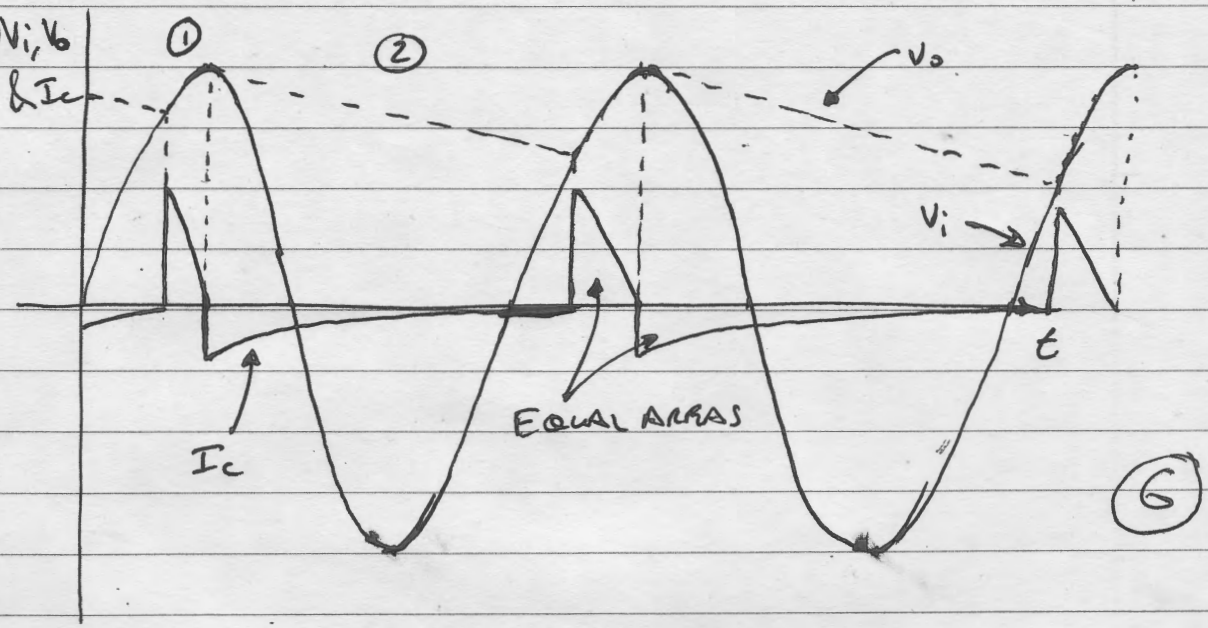
EEE 118 2014 - 2015

1a.i) 

(6)

1- MARK FOR NEARLY RIGHT

2- FOR "PERFECT". PERFECT ONLY IF SHAPE AND TIME ALIGNMENT DEMONSTRATE UNDERSTANDING.

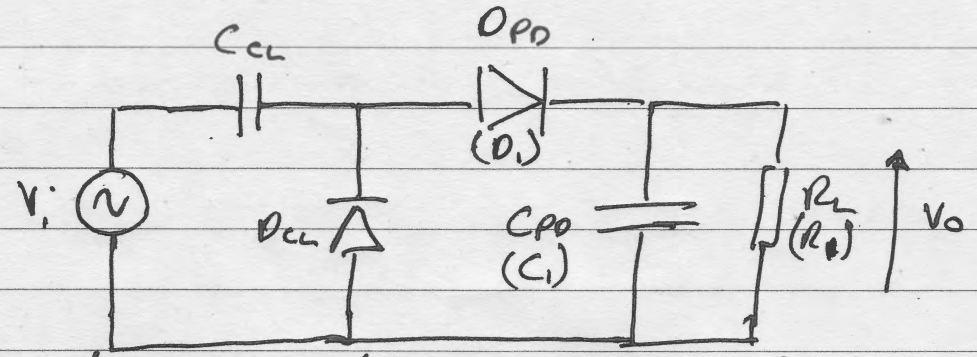
ii) ① - $V_i > V_o$ ∴ DIODE CONDUCTS AND C_1 CHARGES THROUGH DIODE, D_1. CONDUCTION STOPS WHEN V_i STARTS TO FALL AS THE DIODE CURRENT FALLS TO ZERO BECAUSE THE CAPACITOR IS NO LONGER CHARGING FROM THE INPUT SIGNAL. (2)

② - $V_i < V_o$. THE DIODE IS NOW REVERSE BIASED. ONLY A SMALL LEAKAGE CURRENT FLOWS IN D_1. C_1 DISCHARGES THROUGH R_1. PROVIDED C_1 IS CAPABLE OF STORING MUCH MORE CHARGE THAN R_1 WILL CONDUCT OVER THE PERIOD OF THE INPUT WAVE FORM, THE CHANGE IN V_O DUE TO C_1 DISCHARGING CAN BE APPROXIMATED AS LINEAR ALTHOUGH IT IS ACTUALLY EXPONENTIAL.

(2)

AT LEAST 2 GOOD POINTS FROM THIS OR SIMILAR SENSIBLE COMMENTS.

16 i)



CLAMP PEAK DETECTOR

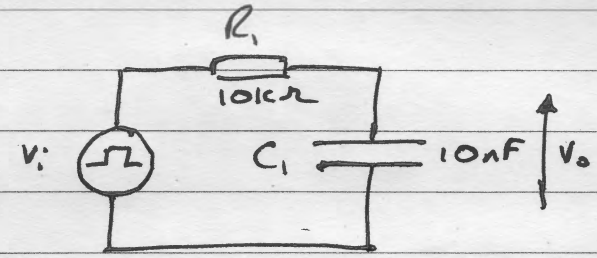
(1) - FOR CAPACITOR IN CORRECT PLACE

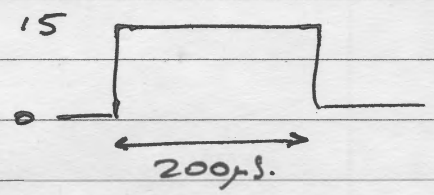
(1) - " DIODE " " "

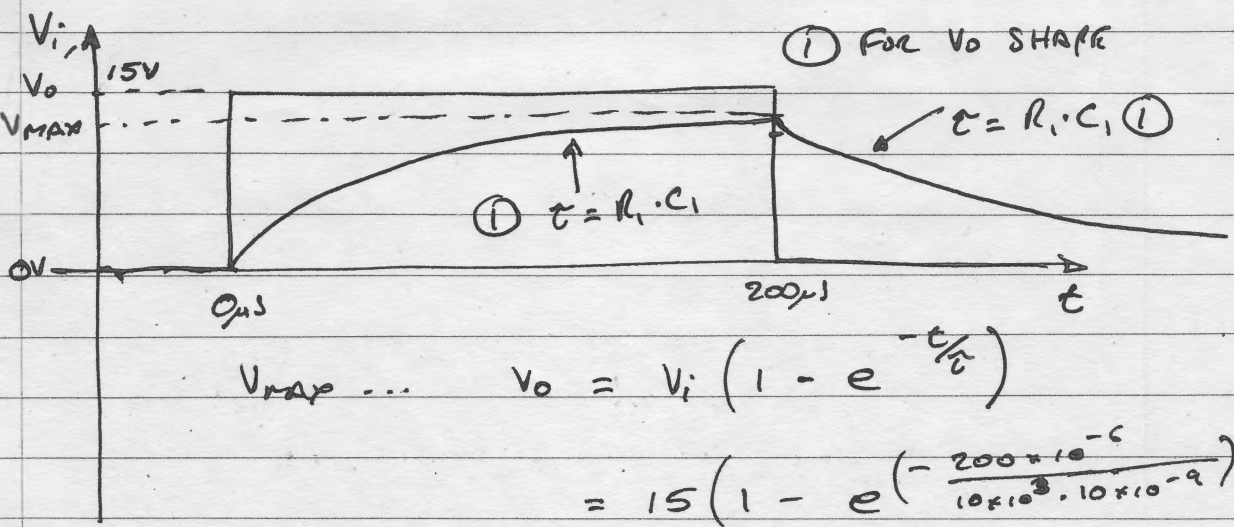
(1) - " PEAK DETECTOR CORRECTLY PLACED.

iii) THE ADDITIONAL CIRCUIT IS A VOLTAGE CLAMP (1)

1c)







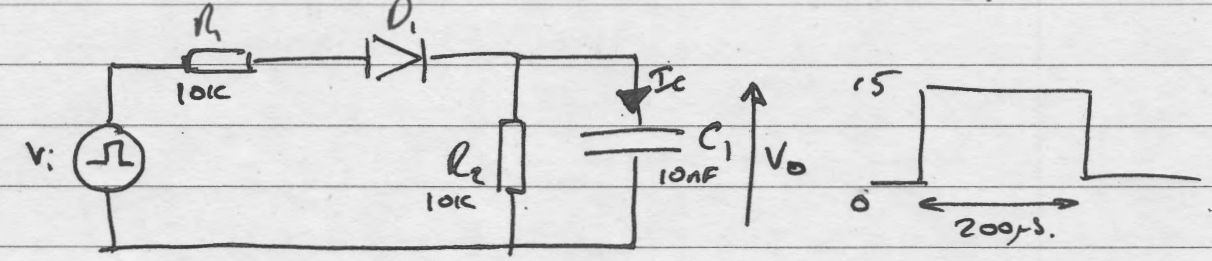
V_{MAX} ... $V_O = V_i\left(1 - e^{-t/\tau}\right)$

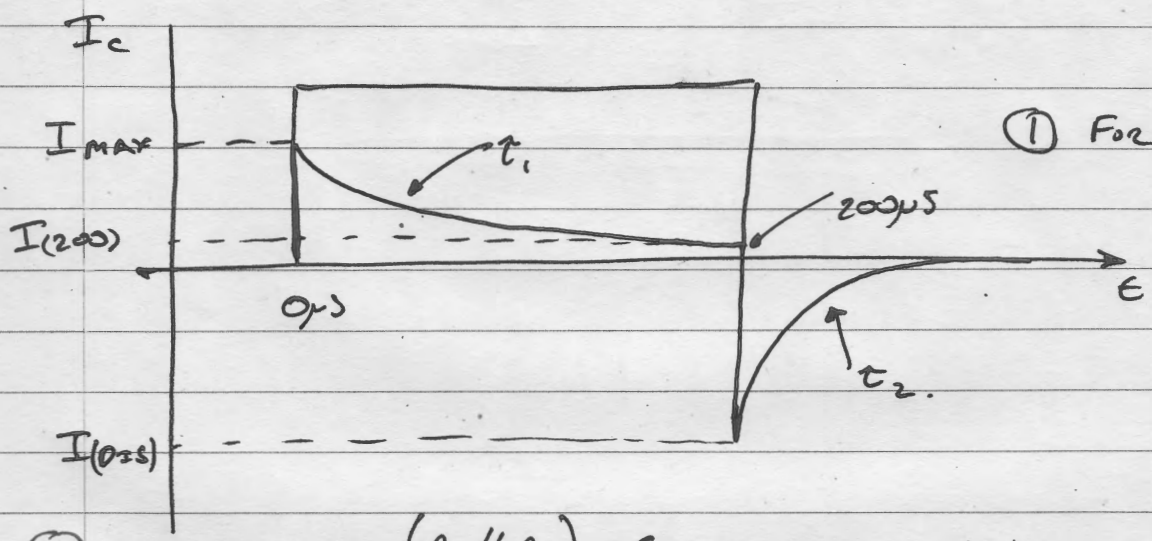
$= 15\left(1 - e^{\left(-\frac{200\times10^{-6}}{10\times10^{3}\cdot 10\times10^{-9}}\right)}\right)$

$= 15\left(1 - 0.13533\right)$

(1) $= \underline{12.9696\ V} \sim \underline{12.97V}$

1d.





(1) FOR Ic SHAPE

(1) $\tau_1 = (R_1 // R_2) \cdot C_1 = \frac{10k \cdot 10k}{10k + 10k} \cdot 10nF = \underline{50\mu s}$

(1) $\tau_2 = R_2 \cdot C_1 = 10k \cdot 10nF = \underline{100\mu s}$

$I_{MAX} = \frac{V_{in}}{R_1} = \frac{15}{10k} = \underline{1.5mA}$ (1)

BECAUSE C_1 LOOKS LIKE A SHORT CIRCUIT WHEN IT IS FULLY DISCHARGED AND BEFORE IT HAS CHARGED APPROX -L7.

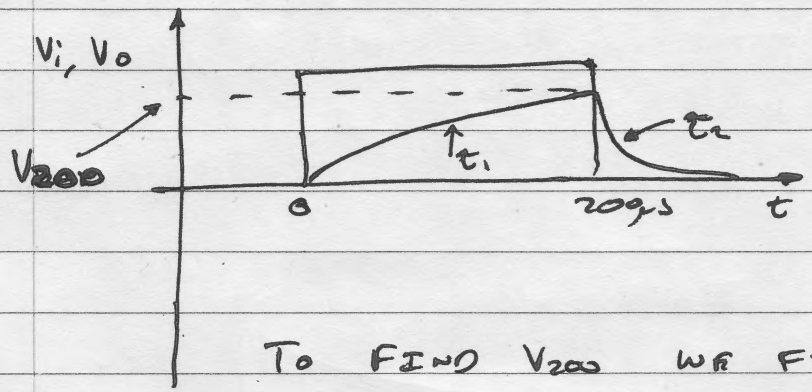
$$I_{(200)} = I_{MAX} \cdot e^{-t/\tau_1}$$

$$= 1.5 \times 10^{-3} \cdot e^{\left(-\left(\frac{200 \times 10^{-6}}{50 \times 10^{-6}}\right)\right)}$$

$$= \underline{27.47\mu A} \quad (1)$$

I_{0ss} ... IS HARDER, WE NEED TO KNOW THE VOLTAGE V_o GOT TO @ 200μS. IT IS NOT THE SAME AS PART C.

1d) CONTINUED...



TO FIND V_{200} WE FIRST NEED V_{MAX}. V_{MAX} IS THE BIGGEST VOLTAGE V_o CAN GET TO IN FIGURE 16. IT IS THE POTENTIAL DIVISION OF V_i BY R_1 & R_2.

(1) $$V_{MAX} = V_i \cdot \frac{R_2}{R_1 + R_2} = 15 \cdot \frac{10}{10+10} = \underline{\underline{7.5V}}$$

$$\therefore V_{200} = V_{MAX} \cdot \left(1 - e^{-t/\tau_1}\right)$$

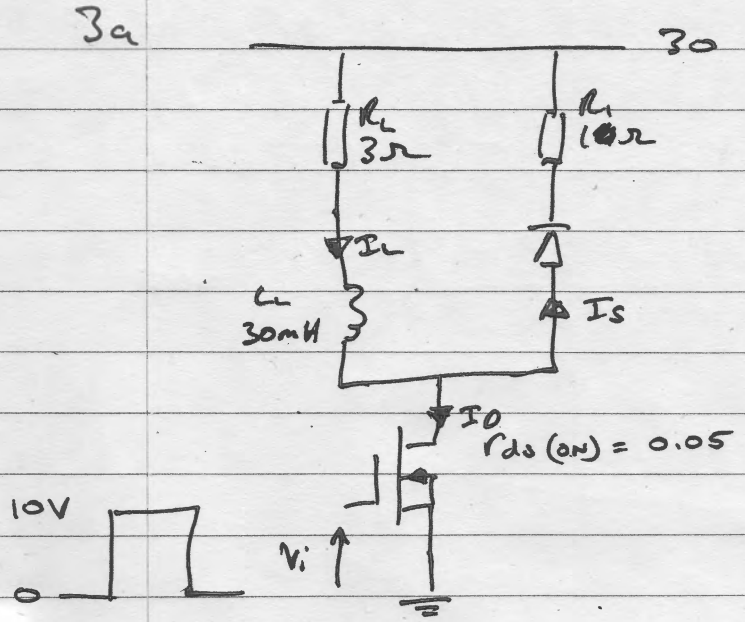
$$= 7.5 \cdot \left(1 - e^{-\left(\frac{200 \times 10^{-6}}{50\mu s}\right)}\right)$$

$$= 7.5 \cdot 0.9817$$

$$= \underline{\underline{7.363V}}$$ ← SO IT NEARLY MAKES IT ALL THE WAY, BUT NOT QUITE.

(1) $$\text{So } I_{(DIS)} = \frac{7.363}{R_2} = \frac{7.363}{10k} = \underline{\underline{736.26\mu A}}$$

3a



i) $I_L = \dfrac{V_S}{R_L + r_{ds(ON)}} = \dfrac{30}{3.05}$

$I_L = \underline{9.8361\ A}$ (1)

ii) $E_{L_L} = \frac{1}{2} L I^2$

$= \frac{1}{2} \cdot 30\times10^{-3} \cdot 9.8361\ A$

$= \underline{147.54\ mJ}$ (1)

iii) $P_{LOAD} = I^2 R_L = 9.8361^2 \cdot 3 = \underline{290.25\ W}$ (1)

iv) $P_{SWITCH} = I^2 r_{ds(ON)} = 9.8361^2 \cdot 0.05 = \underline{4.837\ W}$ (1)

v) DIRECTLY AFTER SWITCH OFF $I_D \rightarrow 0$. AND I_L DOES NOT CHANGE SO $I_S = I_L$.

1 - EACH

vi) $V_{DS} = 30 + I_S R_1 + 0.7$

↑ POWER SUPPLY...

$V_{DS} = 30 + 9.8361 \cdot 10 + 0.7$

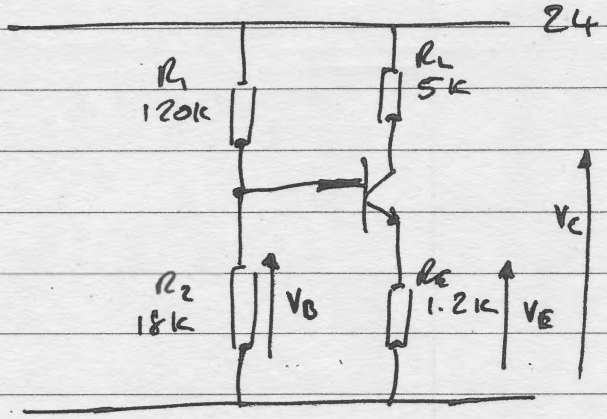
$= \underline{40.5361\ V}$

6i) $V_B = \dfrac{24 \cdot R_2}{R_1 + R_2} = \dfrac{24 \cdot 18k}{120k + 18k}$

(1) $= \underline{3.1304\ V}$

$V_E = V_B - 0.7$

(1) $= \underline{2.43043\ V}$



36i) CONTINUED...

$$I_E = \frac{V_E}{R_E} = \frac{2.43043}{1.2\,k\Omega} = \underline{2.0254\,mA}$$

ASSUMING $I_B = 0$ ($h_{FE} \gg 1$). $I_C = I_E$

SO

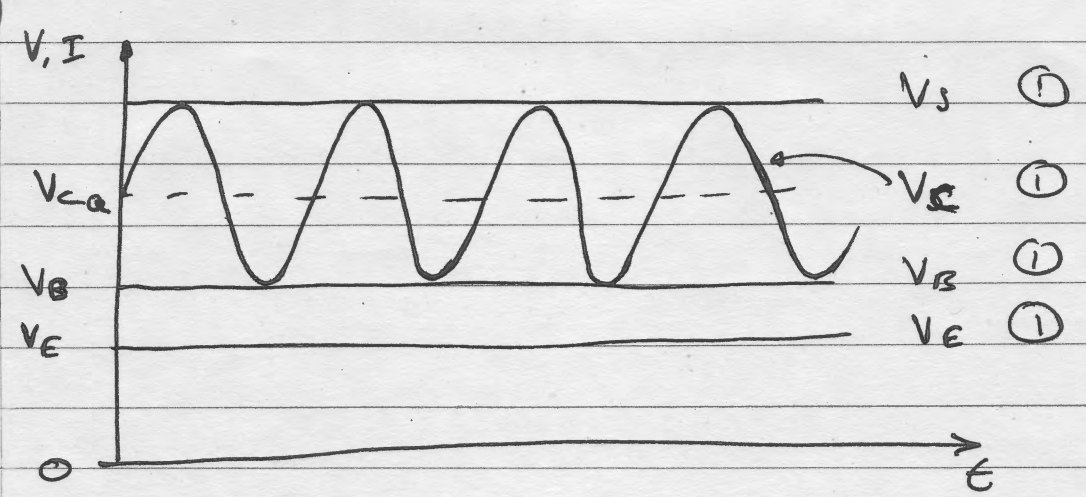
$$V_C = V_S - I_C \cdot R_L$$
$$= 24 - 2.0254 \cdot 5$$
$$= \underline{13.873\,V} \quad (1)$$

$$g_m = \frac{e I_C}{kT} = \frac{1.6\times10^{-19} \cdot 2.0254\times10^{-3}}{1.38\times10^{-23} \cdot 297.15}$$

$$= \underline{79.027\,mS} \quad (1)$$

$$r_{be} = \frac{\beta}{g_m} = \frac{700}{79.027\times10^{-3}} = \underline{8.858\,k\Omega} \quad (1)$$

ii)



36iii)

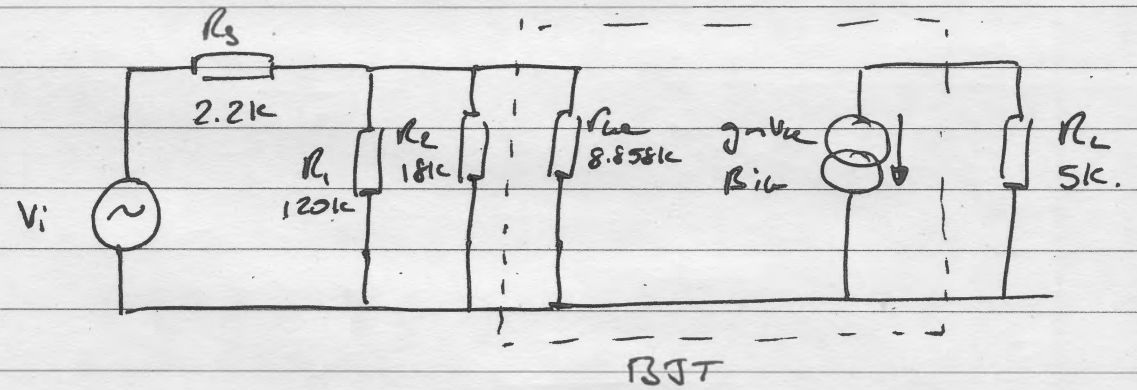
MANY WAYS TO DO THIS...

$$V_{CQ} = \frac{V_B + V_S}{2} = 13.57$$

$$= \frac{3.1304 + 24}{2} = \underline{13.57\ V} \quad (1)$$

DEPENDS ON ASSUMPTIONS TOO. SAY V_C MUST NOT FALL BELOW V_B ... (1)

c i)



(1) – FOR TRANSISTOR PLACEMENT.
(1) – FOR R_1 & R_2 TO GND.
(1) – FOR R_L TO GND
(1) – FOR V_i & R_S PLACEMENT.

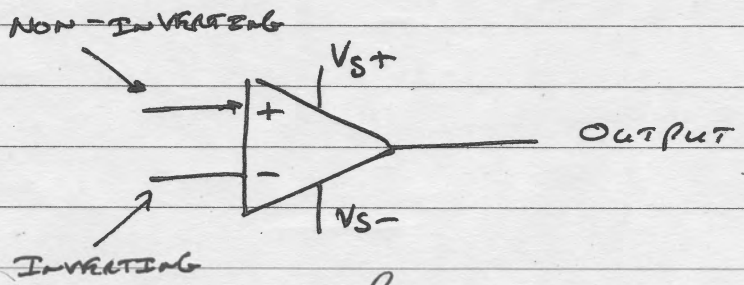
ii) INPUT RESISTANCE BY INSPECTION IS $R_1 // R_2 // r_{be}$

$$\text{So } \frac{1}{r_{in}} = \frac{1}{r_{be}} + \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{r_i} = \frac{1}{8.858} + \frac{1}{120} + \frac{1}{18}$$

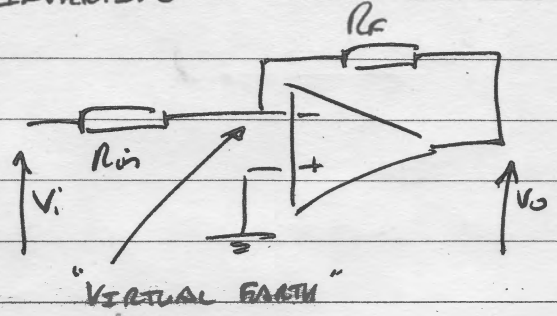
$$r_i = \underline{5.6567\ k\Omega} \quad (1)$$

Gai)



(5)

b)



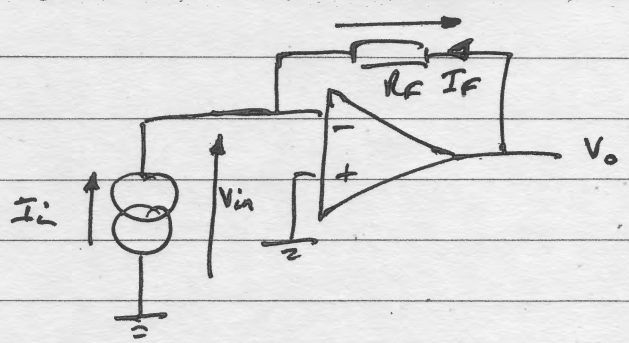
1 - FOR CCT

1 - FOR VE LABEL

THE VIRTUAL EARTH EXISTS DUE TO THE OPAMP OPERATION AND THE USE OF NEGATIVE FEEDBACK. THE OPAMP IS DESCRIBED BY THE EQUATION $V_o = A_v(V^+ - V^-)$. ASSUMING A_v IS LARGE, THE OPAMP WILL, WHEN OPERATED WITH NEGATIVE FEEDBACK, ATTEMPT TO BRING ITS INPUTS TOGETHER BY ADJUSTING ITS OUTPUT VOLTAGE. SINCE THE NON-INVERTING INPUT IS GROUNDED THE OPAMP TRIES TO MAKE THE INVERTING INPUT GROUND TOO. (4)

Ci) IT IS A CURRENT TO VOLTAGE CONVERTER. (1)

ii)



Sum CURRENTS AT V^-

$$I_{in} + I_F = 0$$

$$I_{in} + \frac{V_o - V^-}{R_F} = 0 \quad (1)$$

I_F $A_v \to \infty$ $V^+ = V^- = 0$ ... (1)

6cii) CONTINUED...

$$\therefore \quad I_{in} + \frac{V_o}{R_F} = 0$$

$$\text{SO} \quad \frac{V_o}{I_{in}} = -R_F \qquad (1)$$

iii) FOR R_{IN} AND WITH $A_V \neq \infty$ ...
SUM CURRENTS AT V^-

$$I_{in} + I_F = 0$$

$$I_{in} + \frac{V_o - V^-}{R_F} = 0 \qquad (A)$$

$$V_o = A_V(V^+ - V^-) \qquad (B) \qquad (1)$$

(B) → (A):

$$I_{in} + \frac{A_V(V^+ - V^-)}{R_F} = 0 \qquad (1)$$

$$V^+ = 0$$

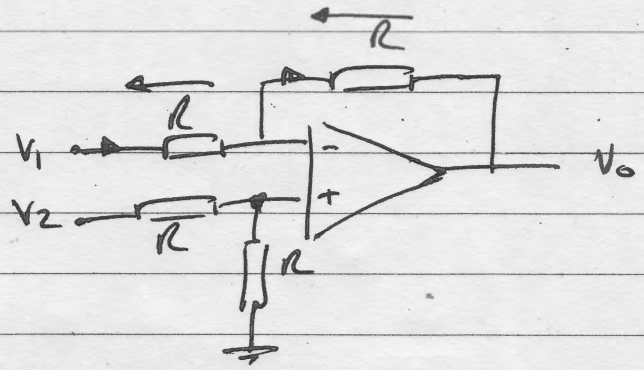
$$\therefore$$

$$I_{in} R_F + A_V V^- = 0 \qquad (V^- = V_{in}) \ldots$$

$$R_{IN} = \frac{V_{in}}{I_{in}} \quad \therefore \quad -A_V V_{in} = -I_{in} R_F$$

$$\text{AND} \quad \frac{V_{in}}{I_{in}} = \frac{R_F}{A_V} \qquad (3)$$

6d i)



Sum I @ V^-:

$$\frac{V_1 - V^-}{R} = \frac{V^- - V_o}{R} \qquad (C) \qquad (1)$$

AND: $V^+ = \frac{V_2 \cdot R}{R+R}$ (D) (1) $A_V \to \infty$ so $V^+ = V^-$

GET (C) IN TERMS OF V^-

$$V^- = \frac{V_1 + V_o}{2} \qquad (E)$$

SUBSTITUTE (D) & (E) INTO $V^+ = V^-$

$$\frac{V_1 + V_o}{2} = \frac{V_2}{2}$$

SIMPLIFY TO:

$$V_o = V_2 - V_1 \qquad (2)$$

ii) THIS IS A SUBTRACTOR CIRCUIT OR A DIFFERENCE AMPLIFIER (1)