جامعة بيرزيت

BIRZEIT UNIVERSITY

ENEE 233
Circuit Analysis II

Exam BOOKLET

دفتر امتحان

Student: ..... :الطالب

Number: Midterm Exam Solution :الرقم

Division: ..... :الشعبة Course: ..... :المادة

Department: ..... :الدائرة College: ..... :الكلية

Instructor: ..... :المدرس

Date: ..../..../.... :التاريخ

For instructor's Use

لاستعمال المُدَرِّس

السؤال Question	العلامة Grade
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
Total	

Question 1 — 30 marks (30/30)

(a) $T_V(s) = \dfrac{-500(s+100)}{s(s+150)}$, RC & only 1 OPAMP — use 1 μF Cap.

(20/20)

$$T_V(s) = \left(\frac{-500}{s}\right)\left(\frac{s+100}{s+150}\right)$$

1st stage — 2nd stage

1st stage Inv. op amp

$$\text{gain} = \frac{-Z_2(s)}{Z_1(s)} = \frac{-500}{s} = \frac{-500/s}{1}$$

$$Z_2(s) = \frac{-500}{s}\ \Omega \Rightarrow C_2 = \frac{1}{500} = 2\times10^{-3}\ F$$

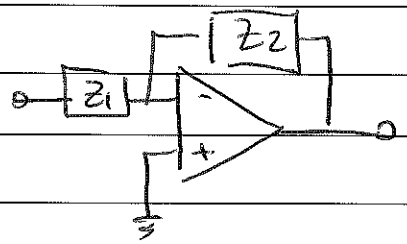
$$Z_1(s) = 1\ \Omega \Rightarrow R_1 = 1\ \Omega$$

(6)

$$K_f = \frac{C_{old}}{C_{new}} = \frac{2\times10^{-3}}{1\times10^{-6}} = \boxed{2000}$$

(2)

$\therefore$ $\boxed{C_1 = 1\,\mu F}$ $\boxed{R_1 = 2k\Omega}$



2nd stage

$$T_{V_2}(s) = \frac{s+100}{s+150} = \frac{1+\frac{100}{s}}{1+\frac{150}{s}} = \frac{Z_2'(s)}{Z_2'(s)+Z_1'(s)}$$

$$Z_2'(s) = 1 + \frac{100}{s}$$

$$Z_1'(s) = 1 + \frac{150}{s} - Z_2'(s) = \frac{50}{s}$$

(6)

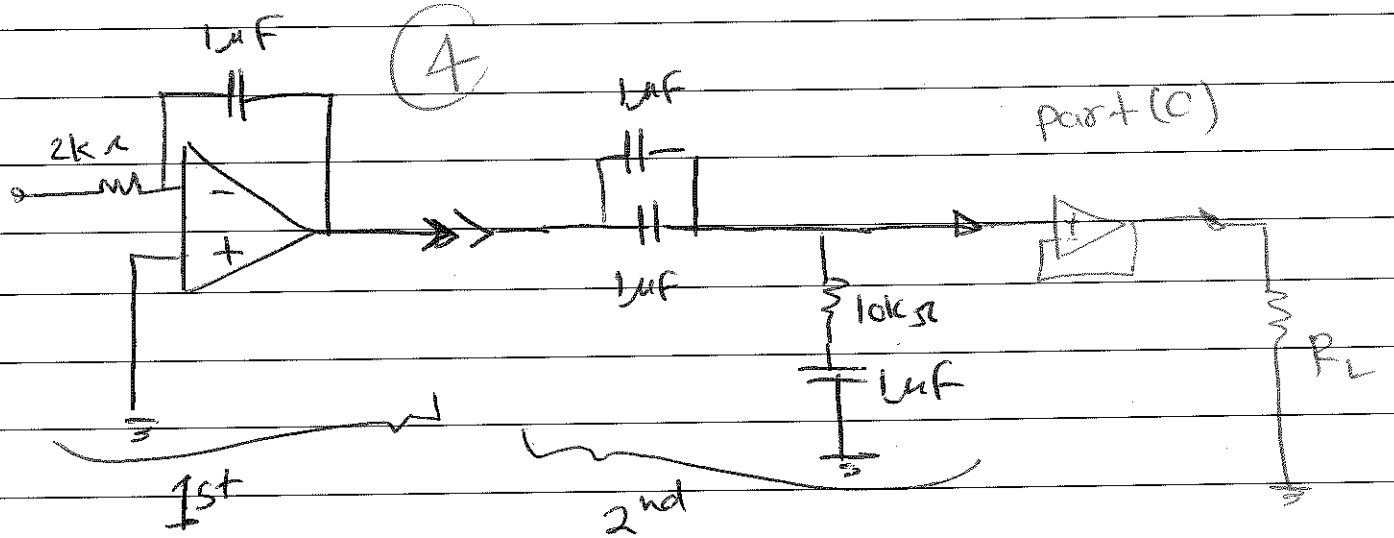
$$C_2' = \frac{1}{100} = 0.01F \quad \& \quad C_1' = \frac{1}{50} = 0.02F$$

$$k_f' = \frac{C_{old}}{C_{new}} = \frac{0.01}{1\times10^{-6}} = \boxed{10{,}000}$$

$$\therefore C_2' = 1\,\mu F \quad , \quad R_2' = 10\,k\Omega$$

(2)

$$C_1' = \frac{0.02}{10{,}000} = 2\times10^{-6}\,F$$



(4)

(b) No loading, since Z_{out} of the first stage equals zero.

(5)

(c) if R_L is connected to the output port, then the circuit will involve loading !!

(5)

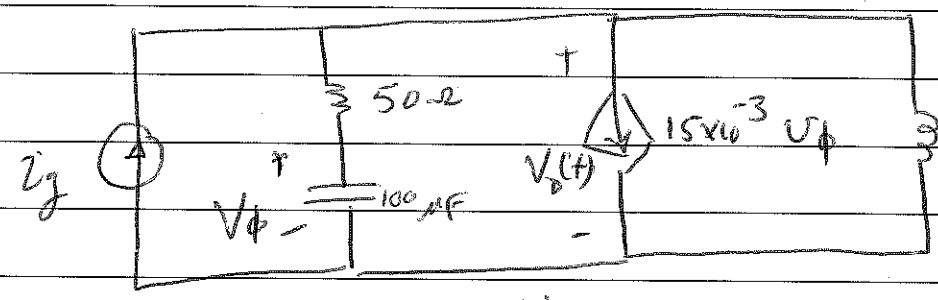
→ to eliminate the loading effect, use voltage follower as shown in the above figure.

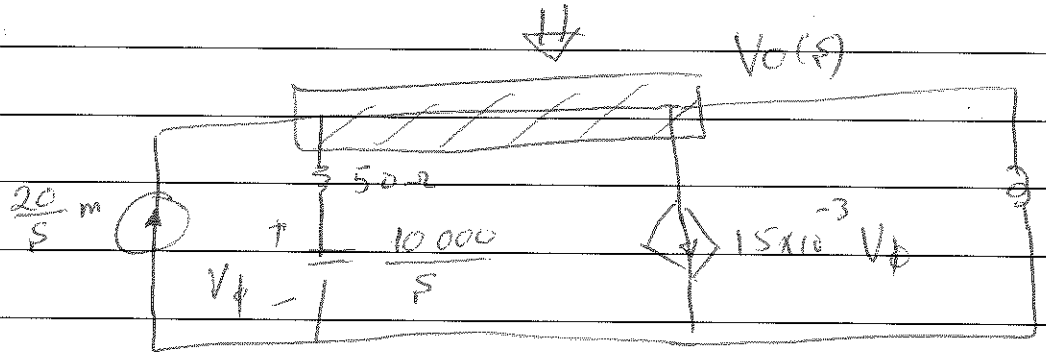
Question 2 | 20 marks

20/20

Find $v_o(t)$ using Nodal Analysis

$i_g(t) = 20u(t)$ mA. No energy stored @ $t=0$





A

A/A

$$\frac{-20\times10^{-3}}{s} + \frac{V_o}{50+\frac{10^4}{s}} + 15\times10^{-3}V_\phi + \frac{V_o}{s} = 0 \quad \text{— (A)}$$

(A)

But $$V_\phi = \frac{\frac{10^4}{s}}{\frac{10^4}{s}+50}\,V_o = \frac{10^4}{10^4+50s}\,V_o = \frac{200}{s+200}\,V_o$$ → sub in (A)

(2)

3/3

$$\therefore \frac{20\times10^{-3}}{s} = \frac{V_o}{50+\frac{10^4}{s}} + \frac{150}{10^4+50s}V_o + \frac{V_o}{s}$$

$$\frac{20\times10^{-3}}{s} = \left(\frac{s+150}{10^4+50s}\right)V_o + \frac{V_o}{s}$$

$$20\times10^{-3} = \left(\frac{s(s+150)}{50s+10^4} + 1\right)V_o$$

$$20\times10^{-3} = \frac{s^2+150s+50s+10^4}{50s+10^4}\,V_o$$

$$\therefore V_o = \frac{20\times10^{-3}(50s+10^4)}{s^2+200s+10^4}$$

$$\boxed{V_o = \frac{s+200}{s^2+200s+10^4}} \quad (2)$$

$$\frac{s+200}{s^2+200s+10^4} = \frac{s+200}{(s+100)(s+100)} = \frac{s+200}{(s+100)^2}$$

$$= \frac{K_1}{(s+100)^2} + \frac{K_2}{s+100} \quad (2)$$

(1) (1)

$$\boxed{K_1 = 100} \qquad \boxed{K_2 = 1}$$

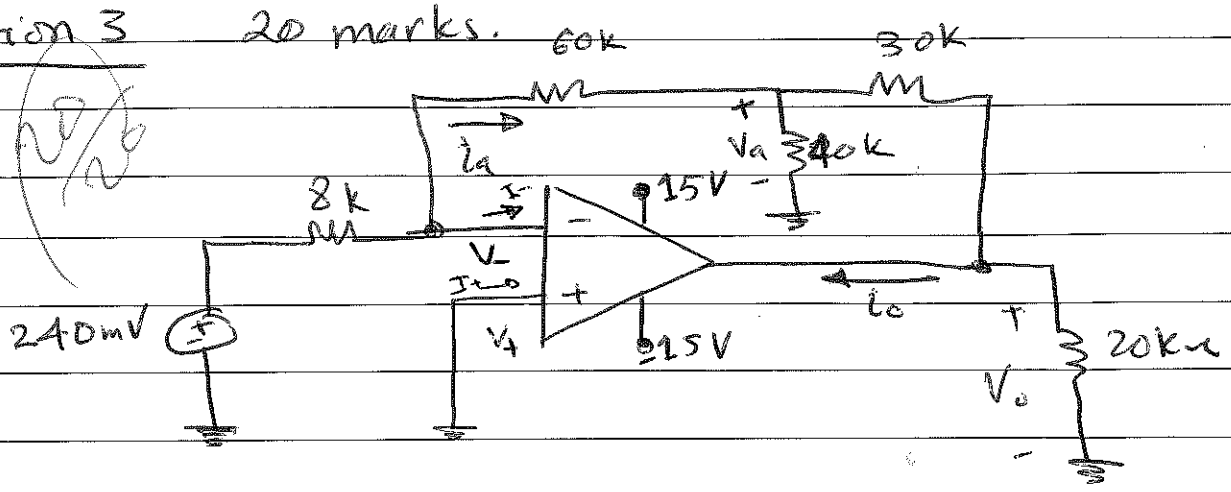
8/8

$$\therefore V_o(s) = \frac{100}{(s+100)^2} + \frac{1}{s+100}$$

(4)

$$\therefore v_o(t) = \left[100t\,e^{-100t} + e^{-100t}\right] u(t) \text{ Volt}$$

Question 3 20 marks.



$V_+ = V_- = 0$

$I_+ = I_- = 0$

[a] $i_a = ??$

$$\frac{0 - 240m}{8k} + I_a = 0$$

$$\therefore I_a = \frac{240m}{8k} = 3 \times 10^{-5} = 30\,\mu A$$

[b] $V_a = ?$

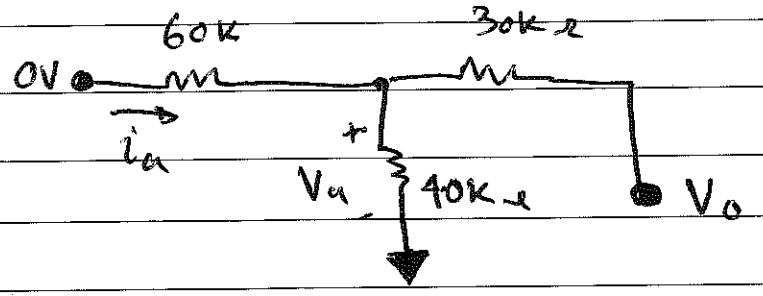
$$i_a = \frac{V_- - V_a}{60k} = \frac{0 - V_a}{60k}$$

$$\therefore V_a = -i_a \times 60k$$

$$= -3 \times 10^{-5} \times 60 \times 10^3$$

$$= -1.8 \text{ Volt}$$

[C] $V_o = ??$



KCL

$$\frac{V_a - 0}{60k} + \frac{V_a}{40k} + \frac{V_a - V_o}{30k} = 0$$

$-i_a$

$\therefore V_a = -1.8$ Volt

$\therefore V_o = 2.25 V_a$

$= -4.05$ Volt.

(d) $i_o' = ?$

for ideal op amp $i_o' = 0$

But

KCL

$$i_o' + \frac{V_o}{20k} + \frac{V_o - V_a}{30k} = 0$$

$$i_o' - \frac{4.05}{20k} + \frac{-4.05 + 1.8}{30k} = 0$$

$$i_o' - 2.775 \times 10^{-4} = 0$$

$$i_o' = 2.775 \times 10^{-4} \text{ A}$$

$$i_o' = 277.5 \mu A$$