BRAC University
Dept. of Computer Science and Engineering

Assessment: Assignment 1
Due: 12 PM 10 October 2023
Full Marks: **50**

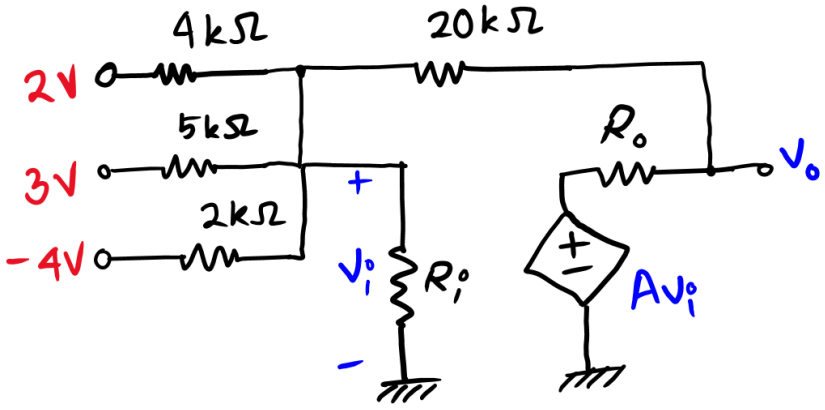
Semester: Fall 2023
Course Code: CSE251
Section: **15**
Course Name: Electronic Devices and Circuits

Name: _____

Student ID: _____

- ✓ Write down your student ID on the **top right corner of each of the pages**.
- ✓ Clearly write the solutions, along with the questions, on white paper with black ink (no need to use color pen, don't use pencils).
- ✓ Use **CamScanner**, or **Adobe Scan**, or **Microsoft Office Lens**, or any other software to scan the pages and make a **single PDF file**.
- ✓ After creating the PDF, make sure that **(a)** there are no pages missing, **(b)** all of the pages are legible, **(c)** your student ID on each page are visible.
- ✓ Please note, **collaboration ≠ copying**. You are allowed to discuss the questions and clear confusion you might have, but you have to write your solutions independently and be able to explain your answers during a random viva.
- ✓ **[Very Important]** Rename the PDF in the following format: **"A1_StudentID_FullNameWithoutSpace.pdf"**. For example, if my student ID is 12345678 and my name is Shadman Shahid, the filename should be **"A1_12345678_ShadmanShahid.pdf"**.
- ✓ **Submission Link:** https://forms.gle/DUiHoK6iKJCWW2QB6

Question 1: 10 Marks



In the above circuit $A = 100$, $R_i = 100\ \text{k}\Omega$ and $R_o = 1\ \text{k}\Omega$. Answer the following questions

a) Write the node equations for the nodes indicated by v_i and v_o. [CO1] 4

b) Solve the node equations to find the values of v_i and v_o. [CO2] 3

c) Can circuit theorems based on linearity principle (such as superposition principle) be applied to the above circuit? Explain in short why or why not. [CO1] 3

Solution:

a) At node v_i:

$$\frac{2-v_i}{4} + \frac{3-v_i}{5} + \frac{-4-v_i}{2} = \frac{v_i - v_o}{20} + \frac{v_i}{100} \quad \ldots\ldots\ldots (i)$$

At node v_o:

$$\frac{v_i - v_o}{20} + \frac{Av_i - v_o}{1} = 0 \quad \text{- - - - - - - - (ii)}$$

b) Simplifying:

(i) becomes:

$$v_i\left(\frac{1}{4}+\frac{1}{5}+\frac{1}{2}+\frac{1}{20}+\frac{1}{100}\right)-v_o\left(\frac{1}{20}\right)=\frac{2}{4}+\frac{3}{5}-\frac{4}{2}$$

$$\therefore\ 1.01v_i-0.05v_o=-0.9 \quad \text{——————(iii)}$$

(ii) becomes:

$$v_i\left(-\frac{1}{20}-\frac{100}{1}\right)+v_o\left(1+\frac{1}{20}\right)=0$$

$$-100.05v_i+1.05v_o=0 \quad \text{——————(iv)}$$

Solving (iii) & (iv) we get:

$$v_i = 0.24\ V$$

$$v_o = 22.842\ V$$

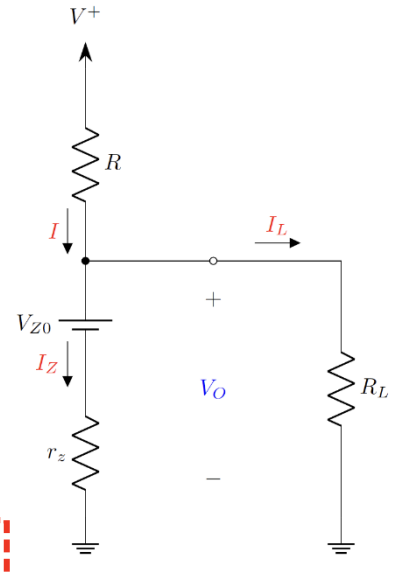
c) Yes! Because all the circuit elements are linear. (Even the voltage dependent voltage source, because the voltage dependence (Av_i) is linear.)

Question 2: 8 Marks

For $R = 100\ \Omega$, $R_L = 10\ \text{k}\Omega$, $r_z = 20\ \Omega$, $V_{ZO} = 3\ \text{V}$, and $I_Z = 1\ \text{mA}$.

a) Find V_O, I_L [CO2] 4

b) Find I, V^+. [CO2] 4



a) $V_o = V_{zo} + I_z r_z = (3 + 0.02)\text{V} = \boxed{3.02\ \text{V}}$

$I_L = \dfrac{V_o}{R_L} = \dfrac{3.02}{10}\ \text{mA} = \boxed{0.302\ \text{mA}}$.

b) $I = I_L + I_z = (0.302 + 1)\ \text{mA} = \boxed{1.302\ \text{mA}}$

$V^+ = V_o + IR = (3.02 + 1.302 \times 0.1)\ \text{V} = \boxed{3.1502\ \text{V}}$

Question 3: 10 Marks

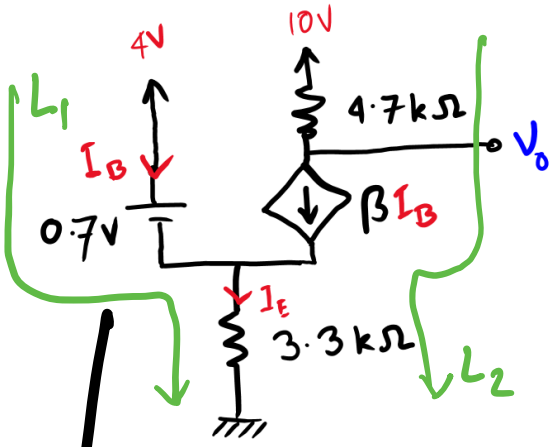
In the adjacent circuit $\beta = 100$.

a) Derive an expression of I_E in terms of I_B and β. [CO1] 2

b) Find the value of the currents I_E., and I_B. [CO2] 3

c) Find the value of the voltage at the output node v_o. [CO2] 2

d) Express v_o in terms of I_B and β. Thereafter, determine how v_o would change for changing the value of β. Show the change in v_o for $\beta = 50$ and $\beta = 20$. [CO2] 3



a) $I_E = I_B + \beta I_B$

b) Taking KVL along L_1: $\boxed{4 - 0.7 - 3.3 I_E = 0}$

$\Rightarrow I_E = \dfrac{3.3}{3.3}\ \text{mA} = 1\ \text{mA}$

$I_B = \dfrac{I_E}{\beta + 1} = \dfrac{1}{101}\ \text{mA}$.

c) $v_o = 10 - 4.7\beta I_B$

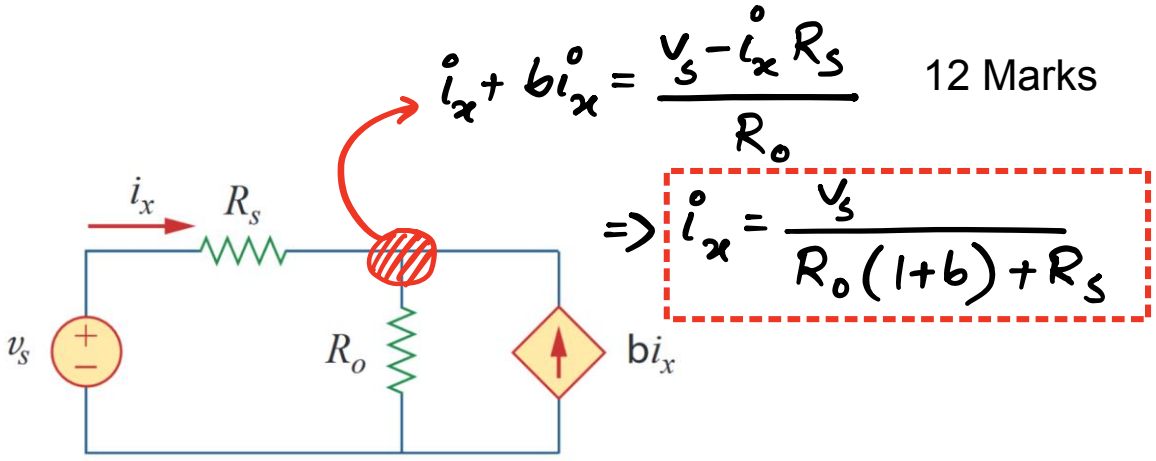
$= 5.346\ \text{V}$

d) $V_o = 10 - 4.7\beta I_B$

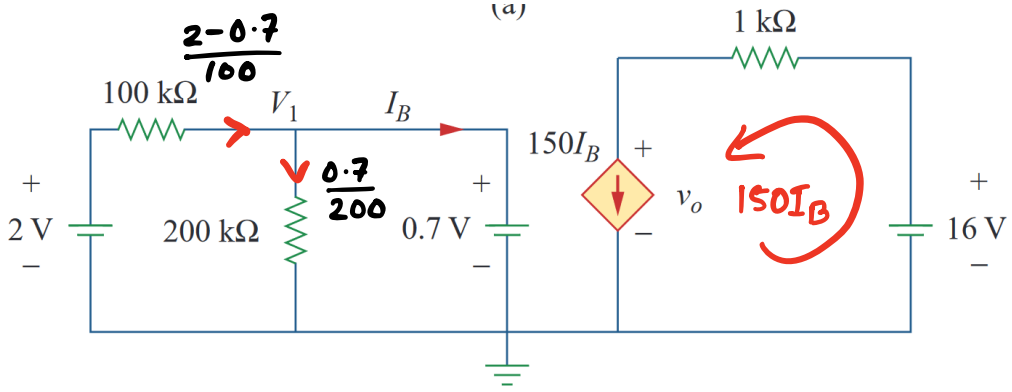
When; $\beta = 50$,	$\beta = 20$
$I_B = \frac{I_E}{\beta+1} = \frac{1}{51}$	$I_B = \frac{I_E}{\beta+1} = \frac{1}{21}$
$\therefore V_o = 10 - 4.7 \times \frac{50}{51}$	$V_o = 10 - 4.7 \times \frac{20}{21}$
$= 5.392\ V$	$= 5.524\ V$

V_o will remain almost constant.

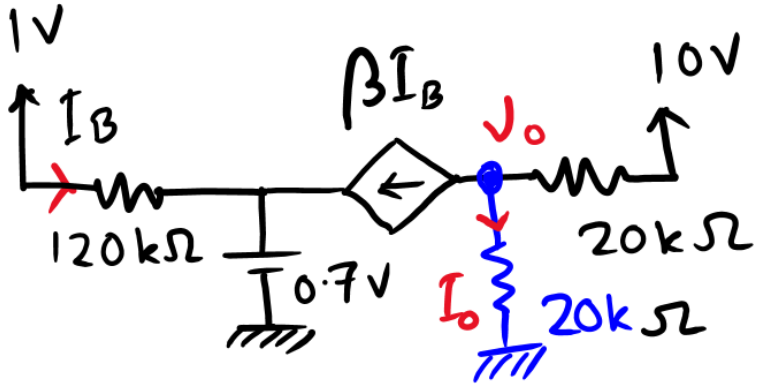
Question 4: 12 Marks



a) Analyze the circuit in the Figure above to find i_x in terms of v_S, R_S, R_O, and b. [CO1] 2



b) For the above circuit, find the value of v_o. [CO2] 4



c) In the above circuit, $\beta = 80$. Find the current I_O and v_o from the given circuit. [CO2] 6

b) $I_B = \frac{2-0.7}{100} - \frac{0.7}{200} = \boxed{9.5\ \mu A}$. [KCL at V_1]

$\therefore v_o = 16 - 1 \times 150 I_B = \boxed{14.575\ V}$. [KVL at right loop]

Solution (c):

$I_B = \frac{1-0.7}{120}\ mA = 2.5\ \mu A$:

$\beta I_B = (80 \times 2.5 \times 10^{-3})\ mA$

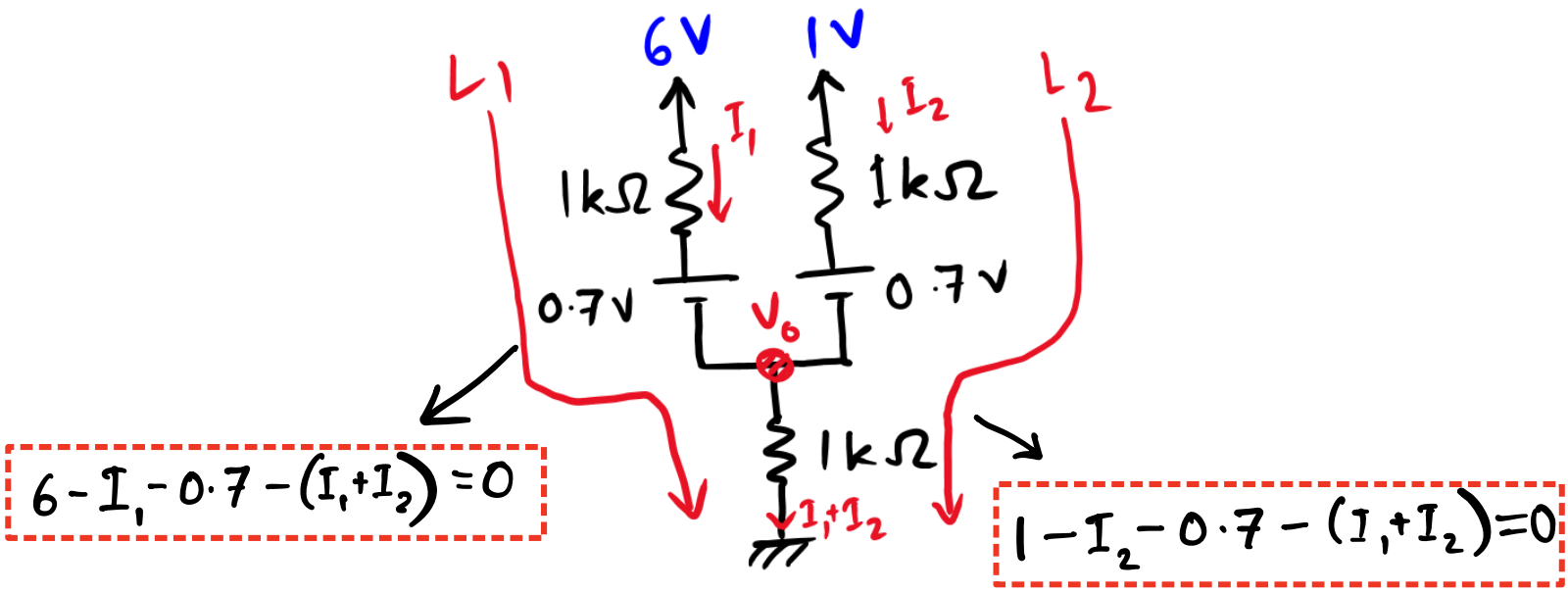
$= 0.2\ mA$

KCL at v_o: $\beta I_B = \frac{10 - v_o}{20} - \frac{v_o}{20}$

$\Rightarrow v_o = \left(\frac{10}{20} - 0.2\right) 10 = \boxed{3\ V}$

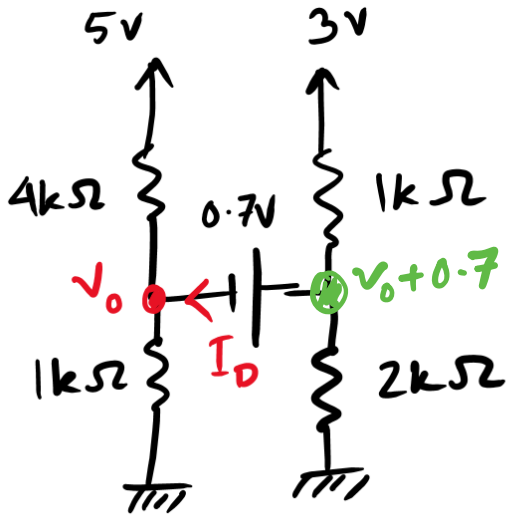
$I_o = \frac{3}{20}\ mA = \boxed{0.15\ mA}$

Question 5: 10 Marks



a) Write down the two KVL equations for the lines (loops) indicated by the red lines L_1 and L_2. [CO1] 3

b) Solve the circuit to find v_0, I_1 and I_2. You may use either mesh analysis or nodal analysis. [CO2] 4



c) Analyze the circuit to find v_0 and I_0. [Use any technique of your choice.] [CO2] 3

b)

$$6 - I_1 - 0.7 - (I_1 + I_2) = 0$$

$$2I_1 + I_2 = 5.3 \quad \text{---------- (i)}$$

$$1 - I_2 - 0.7 - (I_1 + I_2) = 0$$

$$I_1 + 2I_2 = 0.3 \quad \text{---------- (ii)}$$

Solving: $I_1 = 3.433 \text{ mA}$

$I_2 = -1.566 \text{ mA}$

$v_o = (I_1 + I_2) \times 1 = 1.866 \text{ V}$

c) $$\frac{5 - v_o}{4} + \frac{3 - (v_o + 0.7)}{1} = \frac{v_o}{1} + \frac{v_o + 7}{2}$$

Shortcut:

$$v_o\left(\frac{1}{4} + \frac{1}{1}\right) + (v_o + 0.7)\left(\frac{1}{1} + \frac{1}{2}\right) = \frac{5}{4} + \frac{3}{1}$$

$$v_o = \frac{5/4 + 3 - 0.7 \times 1.5}{1/4 + 1 + 1 + 1/2} = \boxed{1.1636 \text{ V}}$$

$$I_o = \frac{v_o - 5}{4} + \frac{v_o}{1} = \boxed{0.2045 \text{ mA}}$$