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**Brac University****Set: 01**

Semester: Summer 2022

Course No: CSE251

Course Title: Electronic Devices and Circuits

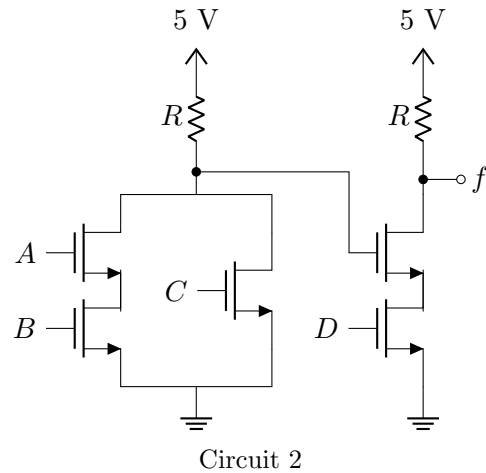
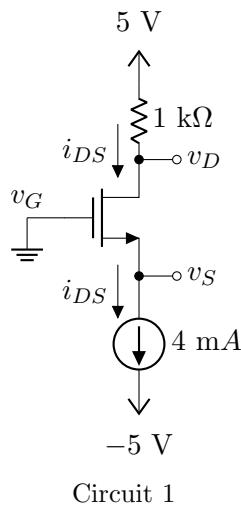
Section: 1 to 13

Final Exam

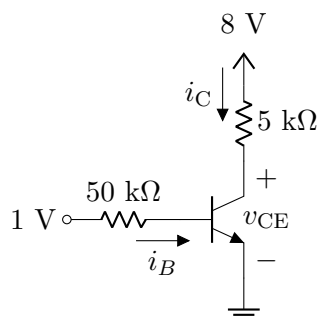
Full Marks: 30

Time: 1 hour 45 minutes

Date: September 9, 2022

Answer **any 3 questions**. All the questions carry equal marks.**Question 1 [CO1, CO2]****10****Part a:** Refer to the **Circuit 1** above. For the MOSFET,  $V_T = 1\text{ V}$  and  $k = k'_n \frac{W}{L} = 4\text{ mA/V}^2$ .

- Identify** the value of the gate voltage  $v_G$  and the drain-source current  $i_{DS}$ . [0.5+0.5]
- Calculate** the value of the drain voltage  $v_D$  using the  $1\text{ k}\Omega$  resistor. [1]
- Analyze** the circuit to find  $v_S$ . Here, **use** the Method of Assumed State. You must **validate** your assumptions. [Hint: assume  $v_S = x$ ] [3+2]

**Part b:** Analyze the **Circuit 2** above to find  $f$  in terms of *boolean* inputs  $A$ ,  $B$ ,  $C$ , and  $D$ . [3]**Question 2 [CO3, CO4]****10****Part a:** Analyze the circuit below to find  $i_C$  and  $v_{CE}$ . Here, **use** the Method of Assumed State. You must **validate** your assumptions. [6]

$$\beta = 100$$

$$\alpha = 0.99$$

$$v_{BE(\text{Active})} = 0.7\text{ V}$$

$$v_{BE(\text{Saturation})} = 0.8\text{ V}$$

$$v_{CE(\text{Saturation})} = 0.2\text{ V}$$

Set: 1

**Part b:** A BJT common emitter amplifier with  $V_S = 20$  V,  $\beta = 120$ ,  $R_L = 3$  k $\Omega$  and  $R_I = 20$  k $\Omega$  has an input signal  $v_{IN} = V_X + v_i(t)$  and an output signal  $v_O = V_Y + kv_i(t)$  where  $v_i(t) = 0.2 \sin(50\pi t)$ .

- (i) **Determine** the operating point  $(V_X, V_Y)$  for maximum input voltage swing. [3]
- (ii) **Calculate** the value of the small signal gain  $k$  for the amplifier. [1]

### Question 3 [CO1, CO4]

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- (a) **Show** the IV characteristics graph of both MOSFET ( $i_D$  vs  $v_{DS}$ ) and BJT ( $i_C$  vs  $v_{CE}$ ). **Identify** the different operating regions in the graphs. [2+2]
- (b) Consider a MOSFET inverter (**SR model**) with the following circuit parameters:  $V_S = 5$  V,  $R_L = 10$  k $\Omega$ . Also, for the MOSFET,  $V_T = 1$  V and  $1/(k'_n V_{ov}) = 5$ . **Determine** a  $W/L$  sizing for the MOSFET so that the inverter gate output of logical 0 is able to switch OFF the MOSFET of another inverter. [4]
- (c) Consider the static discipline  $V_{OL} = 1.5$  V,  $V_{IL} = 3.5$  V,  $V_{IH} = 4.7$  V,  $V_{OH} = 5.5$  V. **Calculate** the noise margins  $NM_0$  and  $NM_1$ . [2]

### Question 4 [CO1, CO4]

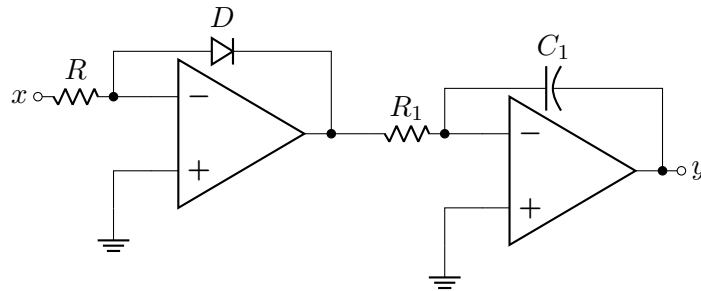
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- (a) **Design** a circuit using **Op-Amp comparator** to automatically turn ON (or OFF) the street lights. For this, you have a lux sensor installed on top of the street lights (facing above) that outputs a voltage proportional to amount of natural light, as listed below:

$v_{\text{night, 0 lux}} = 1$ V	$v_{\text{dusk, 20 lux}} = 2$ V	$v_{\text{dawn, 80 lux}} = 3$ V
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The lights require 20 V and should be ON if the amount of light goes **below** 20 lux (at dusk). [3]

- (b) **Design** a circuit using Op-Amp to implement the expression:  $f = -3\frac{dx}{dt} + 2 \exp y + 4z$  [4]
- (c) **Analyze** the circuit below to find  $y$  as a function of  $x$ . For the diode,  $I_S R = 1$  and  $V_T = 1$ . [3]



Equations for MOSFET

$$I_D = 0, \text{ if } V_{GS} < V_T$$

$$I_D = k \left[ (V_{GS} - V_T) V_{DS} - \frac{1}{2} V_{DS}^2 \right], \text{ if } V_{GS} \geq V_T \text{ and } V_{DS} < (V_{GS} - V_T)$$

$$I_D = \frac{1}{2} k (V_{GS} - V_T)^2, \text{ if } V_{GS} \geq V_T \text{ and } V_{DS} \geq (V_{GS} - V_T)$$