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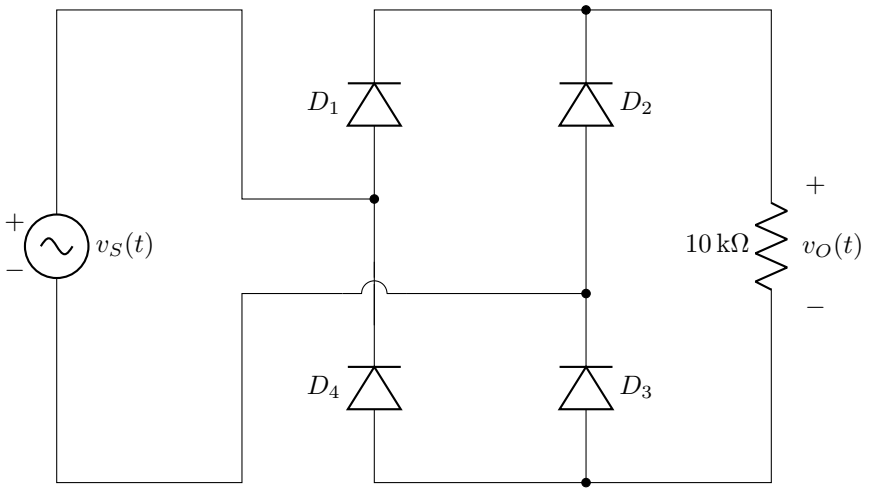
Brac University
Semester: Summer 2025
Course Code: CSE251
Electronics Devices and Circuits

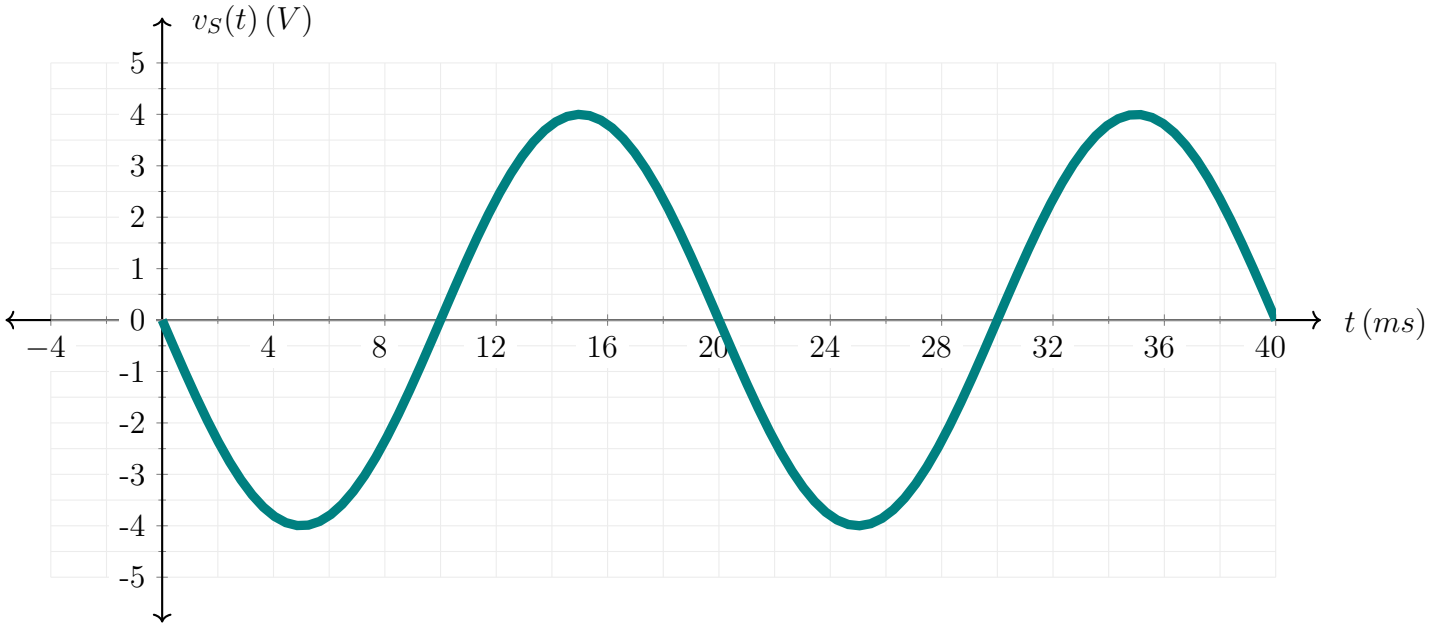
Assessment: *Final Exam*
Duration: 1 hour 30 minutes
Date: September 16, 2025
Full Marks: 60

- ✓ No washroom breaks. Phones must be turned off. Using/carrying any notes during the exam is not allowed.
- ✓ At the end of the exam, both the **answer script** and the **question paper** must be returned to the invigilator.
- ✓ All **5 questions** are compulsory. Marks allotted for each question are mentioned beside each question.
- ✓ Proper units must be included for all calculated values. Marks will be deducted for missing or incorrect units.
- ✓ Symbols have their usual meanings.

■ Question 1 of 5 *[CO3] [12 marks]*

A rectifier circuit is designed to drive a load of 10 kΩ using four diodes D_1, D_2, D_3, and D_4 with cut-in voltages of 0.5 V, 0.7 V, 0.5 V, and 0.3 V, respectively, as shown below. The circuit rectifies a sinusoidal AC input voltage $v_S(t)$, illustrated in the accompanying plot.





(a) ***[3 marks]*** On the same grid as $v_S(t)$, sketch approximately the waveform of the output voltage $v_O(t)$.

(b) ***[5 marks]*** A capacitor is connected in parallel with the load to filter the rectified voltage. If the output voltage fluctuation is restricted to 10% of its maximum value, determine the required capacitance.

(c) ***[1 mark]*** Determine the average output voltage corresponding to the filtered output in (b).

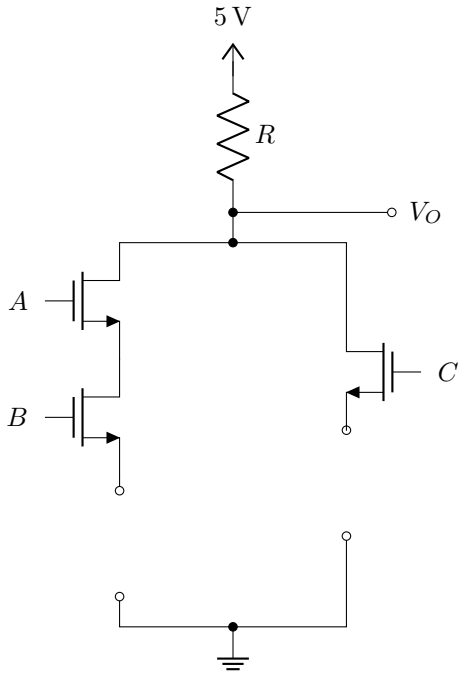
(d) ***[3 marks]*** Draw the voltage transfer characteristic (VTC) graph for the rectifier, that is, the plot of v_O versus v_S.

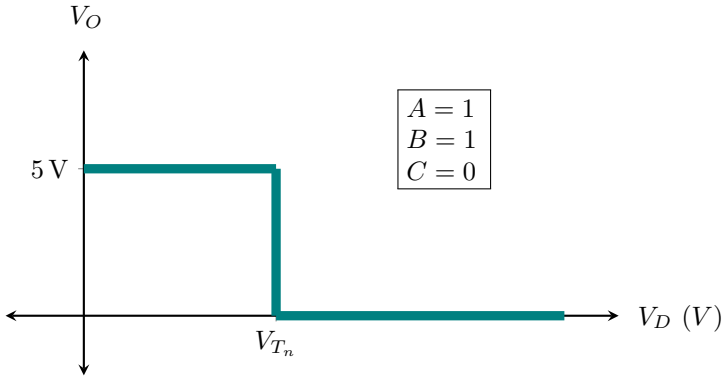
■ Question 2 of 5 *[CO1] [8 marks]*

(a) ***[2 marks]*** In which two operating regions are a MOSFET and a BJT used when functioning as a switch in logic circuits?

(b) ***[2 marks]*** If the gate and source terminals of an n-channel MOSFET are short-circuited, in which mode will the NMOS operate and why?

(c) ***[4 marks]*** In a lab experiment, a logic circuit with four identical NMOS transistors with threshold voltage V_{T_n} is analyzed, each with one of the Boolean inputs A, B, C, and D at their gates. The voltage transfer characteristic (VTC) was measured with respect to the voltage V_D at the input D when $A = 1$, $B = 1$, and $C = 0$ as plotted below. During testing, a jumper wire and the transistor for input D were accidentally removed, resulting in two open junctions as shown in the circuit below. Correct the circuit by reconnecting the transistor and the wire. Also write an expression of the Boolean function.





■ Question 3 of 5 *[CO3] [12 marks]*

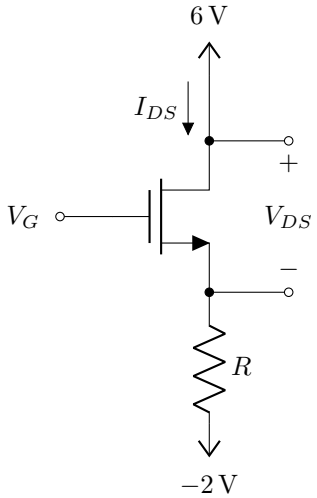
(a) ***[6 marks]*** Implement the following logic function using MOSFETs. Here, A, B, C, and D are Boolean inputs, and f is the Boolean output:

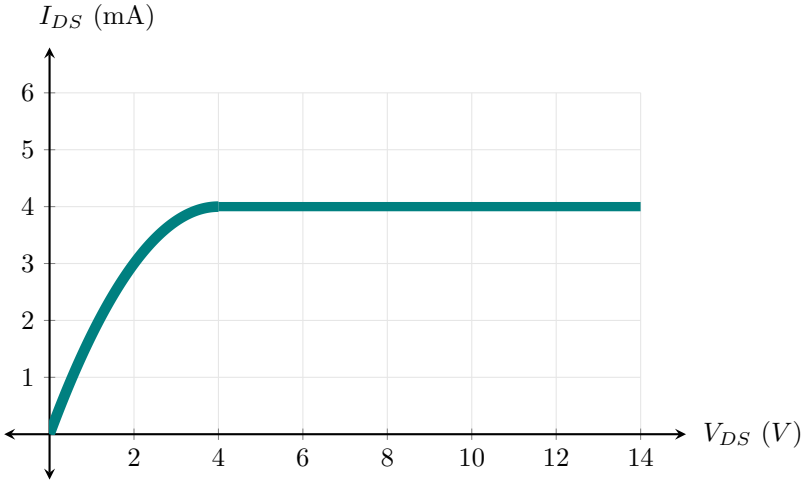
$$f = \overline{(A \cdot B + C) \cdot D + \overline{D}}$$

(b) Consider the transistor in the circuit below, with its I-V characteristics plotted:

(i) ***[4 marks]*** Determine the gate voltage V_G required to operate the transistor at the edge of saturation. The threshold voltage of the transistor is $V_{T_n} = 1\,\text{V}$.

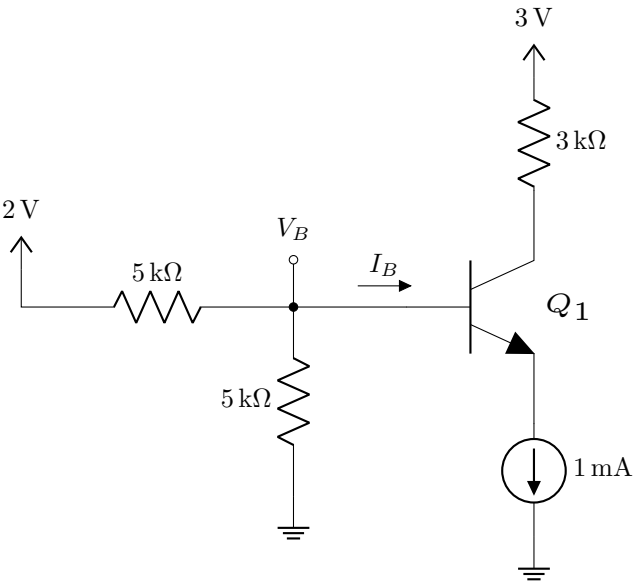
(ii) ***[2 marks]*** Determine the resistance R that satisfies the edge-of-saturation condition found in (i).





■ Question 4 of 5 *[CO2] [12 marks]*

The NPN transistor Q_1 in the following circuit has parameters in saturation region given in the box.



NPN BJT Parameters:

For the transistor Q_1:

Current gain: $\beta = 100$

Base-emitter voltage in saturation: $V_{BE(sat)} = 0.8\,\text{V}$

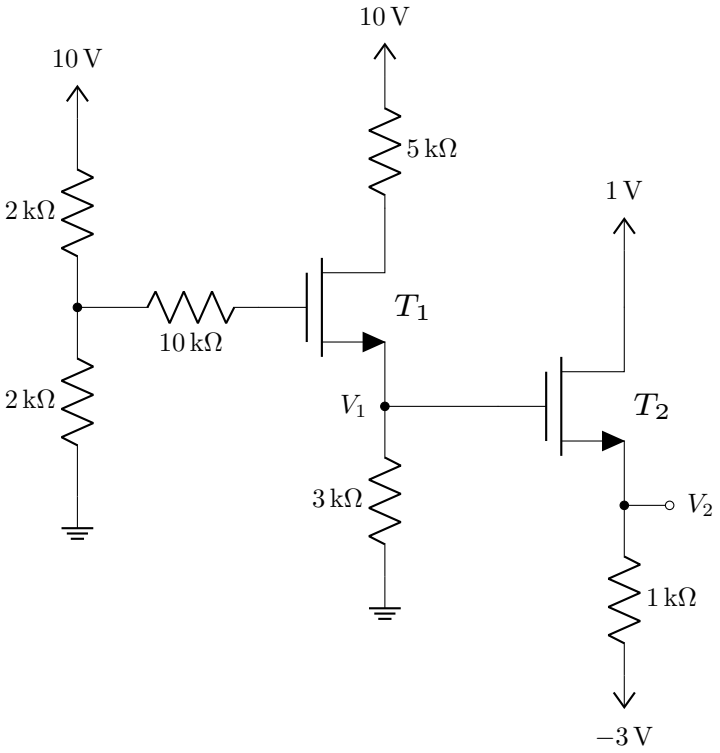
Collector-emitter voltage in saturation: $V_{CE(sat)} = 0.2\,\text{V}$

Verify that Q_1 operates in the saturation region, and determine all terminal currents and voltages of the transistor.

[Hint: the voltages across a BJT are related by $V_{BC} = V_{BE} - V_{CE}$]

■ Question 5 of 5 *[CO2] [16 marks]*

The transistors T_1 and T_2 in the following circuit are identical and have the parameters given in the box.



MOSFET Parameters:

For both T_1 and T_2:

Threshold voltage: $V_{T_n} = 1\,\text{V}$

Transconductance parameter: $k_n = 2\,\text{mA/V}^2$

MOSFET Current Equations:

In Saturation: $I_{DS} = \dfrac{k_n}{2}\,(V_{GS} - V_{T_n})^2$

In Triode: $I_{DS} = k_n\Big[\,(V_{GS} - V_{T_n})\,V_{DS} - \dfrac{1}{2}V_{DS}^2\Big]$

where V_{GS} and V_{DS} are the gate-to-source and drain-to-source voltages, respectively.

If the transistor T_1 operates in the saturation region,

(a) ***[6 marks]*** Determine V_1 and the drain voltage of T_1.

(b) ***[10 marks]*** Using the value of V_1 calculated in (a), determine the voltage V_2 by verifying the operating region of T_2.