National Exams May 2019

16-Elec-A5, Electronics

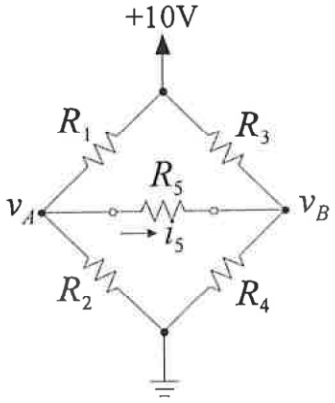
3 hours duration

Notes:

1. If any doubt exists as to the interpretation of any question, the candidate is urged to submit, within their answer, a clear statement of any assumptions made.
2. This is a **CLOSED BOOK EXAM**. One of two calculators is permitted - any Casio or Sharp approved model.
3. Answer all **FIVE** (5) questions.
4. All questions are worth 20 marks each.
5. Please start each question on a new page and clearly identify the question number and part number, e.g. Q4(a).
6. In schematics, ground and chassis may be assumed to be common, unless specifically stated otherwise.
7. Unless otherwise specified, assume that Op-Amps are ideal and that supply voltages are ±15V.
8. If questions require an answer in essay format, clarity and organization of the answer are important. Provide block diagrams and circuit schematics whenever necessary.

QUESTION (1)

In the following circuit, determine the current, i_5 flowing through and the voltage, v_{AB} across resistor R_5. (20 points)

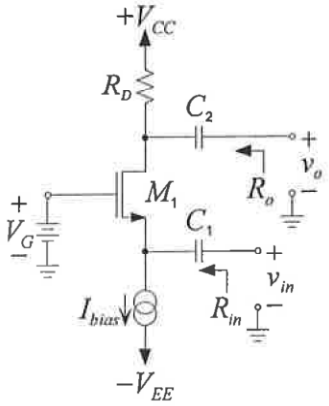


Given:
$R_1 = 1\ \text{k}\Omega$
$R_2 = 1.2\ \text{k}\Omega$
$R_3 = 9.1\ \text{k}\Omega$
$R_4 = 11\ \text{k}\Omega$
$R_5 = 2\ \text{k}\Omega$

QUESTION (2)

For this circuit,

$V_{TH} = 1\ \text{V}$
$K = 2\ \text{mA/V}^2$
$V_{CC} = |V_{EE}| = 10\ \text{V}$
$R_D = 2\ \text{k}\Omega$
$I_{bias} = 2\ \text{mA}$
$\lambda = 0.01\ \text{V}^{-1}$
$V_G = 1\ \text{V}$
$C_1 = C_2 = \infty$



a) Determine the gain v_O/v_i. (10 points)

b) Determine the input and output resistance, R_{in} and R_o. (5 points)

c) What is maximum peak to peak input voltage that can be applied while still keeping M_1 operating in the saturation region? (5 points)

Useful formulae: for n-channel MOSFET

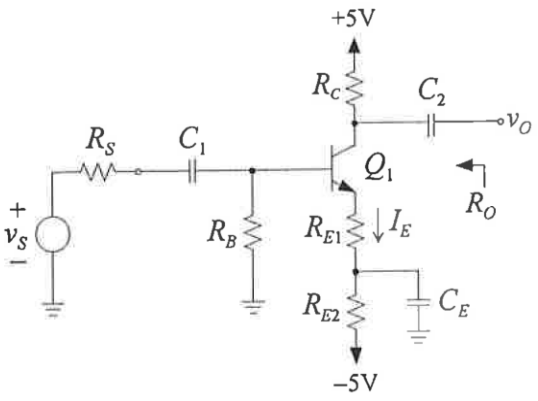
$$i_{DS} = K\left[2(v_{GS} - V_{TH})v_{DS} - v_{DS}^2\right] \quad \text{triode region}$$

$$i_{DS} = K\left(v_{GS} - V_{TH}\right)^2\left(1 + \lambda v_{DS}\right) \quad \text{saturation region}$$

QUESTION (3)

The common emitter amplifier circuit on the right is required to amplify a 12 mVp-p sinusoidal signal from a microphone, v_s to produce an output signal of $v_O = 0.4$Vp-p.

Provide the component values for R_C, R_{E1} and R_{E2} to meet the required specification (20 points)



Given:

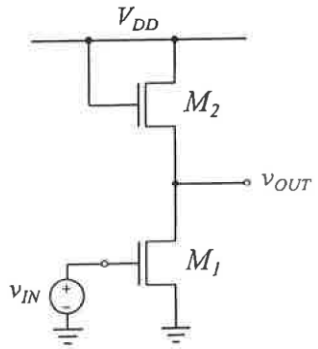
β	= 100
$V_{BE(on)}$	= 0.7V
R_S	= 500 Ω
R_B	= 100 kΩ
I_E	= 0.2mA

QUESTION (4)

The following is a single stage amplifier circuit with an n-channel enhancement load. Assume that both transistors has the same W/L ratio and the threshold voltage $V_{Tn} = 0.2 \times V_{DD}$.

a) Provide an accurate sketch of the transfer function, v_{OUT} versus v_{IN}. (12 points)

b) Provide an expression for the small signal mid-band gain of this amplifier. (8 points)



Useful formulae: for n-channel MOSFET

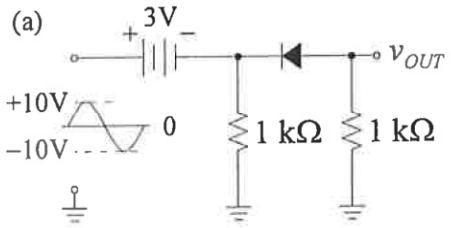
$$i_{DS} = K\left[(v_{GS} - V_{TH})v_{DS} - \frac{1}{2}v_{DS}^2\right]$$ triode region

$$i_{DS} = \frac{1}{2}K(v_{GS} - V_{TH})^2(1 + \lambda v_{DS})$$ saturation region

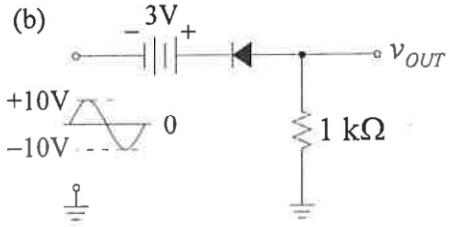
QUESTION (5)

In the following circuits, assume that the diode is ideal and has a forward voltage of 0V. Sketch the output waveform for one complete sine wave input. (20 points)

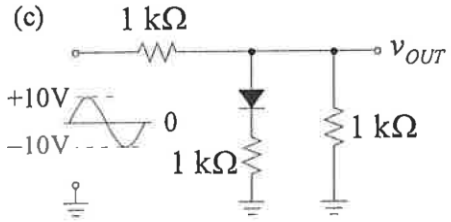
(a)



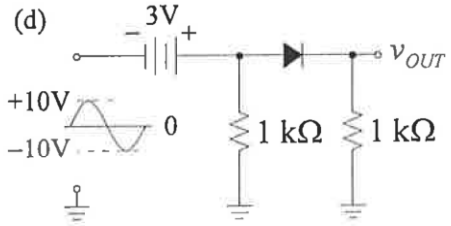
(b)



(c)



(d)



(e)