# National Exams May 2018

## 16-Elec-A5, Electronics

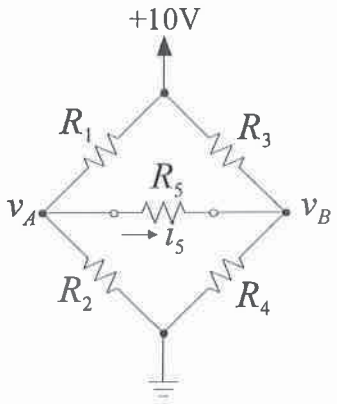
3 hours duration

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.

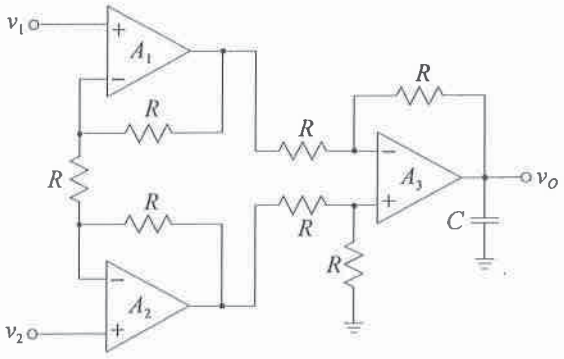
## QUESTION (1)

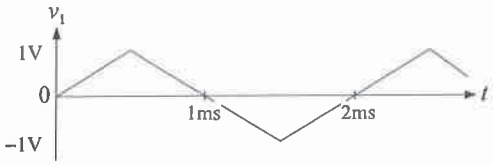
In the following circuit, determine the current, $i_5$ flowing through and the voltage, $v_{AB}$ across resistor $R_5$. (20 points)

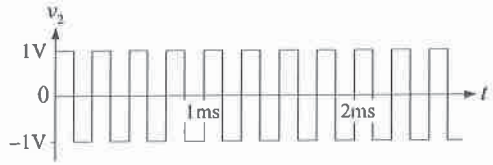



Given:
$R_1 = 1\ k\Omega$
$R_2 = 1.2\ k\Omega$
$R_3 = 9.1\ k\Omega$
$R_4 = 11\ k\Omega$
$R_5 = 2\ k\Omega$

## QUESTION (2)



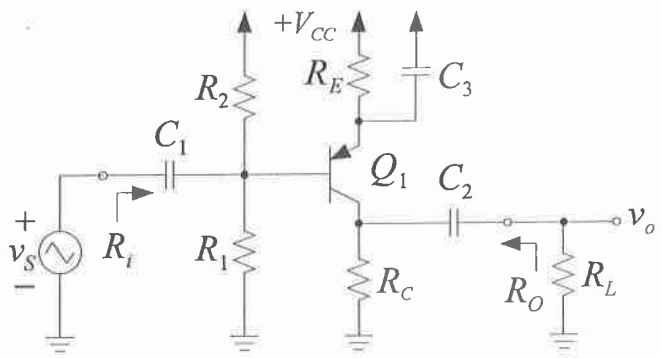




Given that all the op amps are ideal. The power supplies for op amps are ±15V.
Also, $R = 10k\Omega$ and $C = 10\mu F$.

(a) Derive an expression for the output voltage $v_O$ as a function of $v_1$ and $v_2$. (10 points)

(b) Sketch the output waveform accurately in your answer book. (10 points)

## QUESTION (3)




Assume that the BJT has the following characteristics:

$\beta$ = 100
$V_{EB(on)}$ = 0.7V
$V_{EC(sat)}$ = 0.3V
$V_A$ = ∞

Given: $V_{CC}$ = 10V, $R_L$ = 10kΩ, and $R_E$ = 1kΩ,

a) Design this common emitter amplifier circuit to have the following specification:

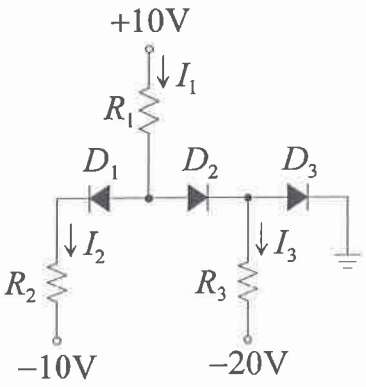
DC bias current, $I_E$ = 2mA,
A mid-band voltage gain $v_{out}/v_S$ = 100 V/V
Provide values for $R_1$, $R_2$, and $R_C$. (15 points)

b) What is the equivalent output resistance, $R_O$? (2 points)

c) What is the maximum undistorted peak to peak output voltage swing at the output? (3 points)

## QUESTION (4)

Solve for the currents $I_1$, $I_2$, and $I_3$ in the following diode circuit. (20 points)




Given:

All diodes are ideal with 0.6V forward drop

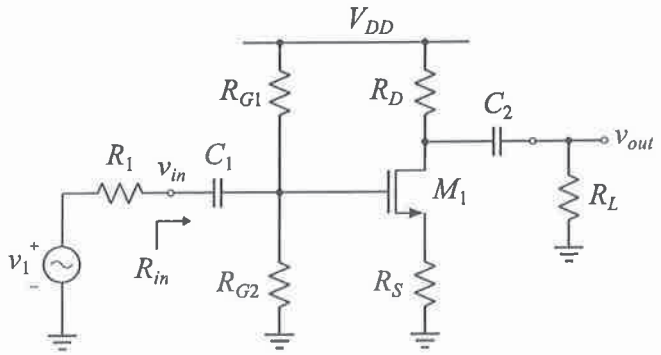
$R_1 = R_2 = R_3$ = 10 kΩ

## QUESTION (5)

The following is a single stage common source amplifier circuit.
Given: $V_{TH} = 1\text{V}$, $K = 4\ \text{mA/V}^2$, and $\lambda = 0$

a) For a supply voltage $V_{DD} = 15$ V, design the bias circuit such that $I_D = 0.5$ mA, $V_S = 3.5$ V, and $V_D = 6$ V. Please specify the values for $R_{G1}$, $R_{G2}$, $R_S$ and $R_D$. (10 points)

b) Assuming that the equivalent input resistance $R_{in}$ = 1.67 MΩ, $R_1$ = 100 kΩ, $R_L$ = 200 kΩ, determine the overall small signal voltage gain $v_1/v_{out}$. (10 points)




Useful formulae: for n-channel MOSFET

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

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