University Of Eswatini
Faculty of Science and Engineering
Department of Electrical and Electronic Engineering

Main Examination, December 2018

TITLE of Paper: Analogue Electronics I / Analogue Design I

Course Number: EEE321 / EE321

Time allowed 3 hours

Instructions:

1. **EE321 Students** answer any **Four (4) questions in** Section A
2. **EEE321 students** answer any **Three (3)** questions in **Section A** and **One (1)** question in **Section B.**
3. **Each question carries 25 marks.**
4. **Marks for each question are shown at the right hand margin.**

This paper contains 7 pages including this one.

This paper should not be opened until permission has been granted by the invigilator.

Section A

Question 1

a) State the three modes of operation of an NPN transistor and tabulate the bias conditions of the junctions. [6]

b) For the circuit **Figure 1** below determine the node currents I_C , I_B and I_E and determine the mode of operation of the transistor for $\beta = 100$. [8]

c) Draw the voltage transfer characteristics (VTC) of a MOSFET transistor and explain how the value of v_{GS} in relation to V_t affects the changes in the modes of operation of the transistor. Write the values of V_{DS} and i_D in the saturation region. [5]

d) Describe how to find the current i_D of a MOSFET in terms of the charge Q per unit length and the electron drift velocity. Assume a small v_{DS} is applied to the transistor. [6]

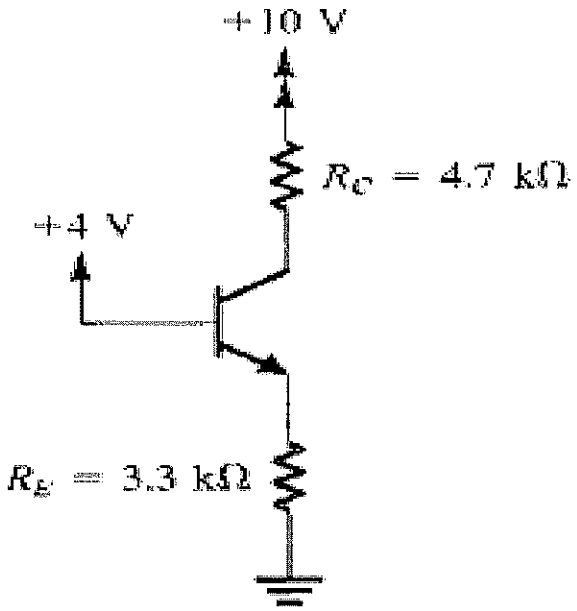

Figure 1

Question 2

a) The circuit **Figure 2(a)** is the Common Gate amplifier

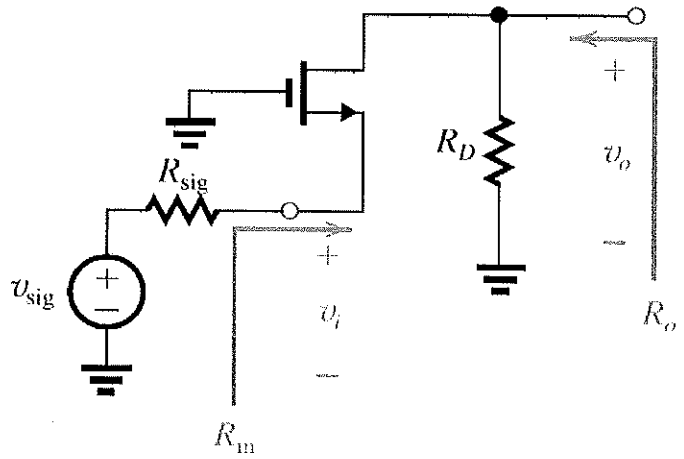

Figure 2 (a)

Find:

i) Input resistance, R_{in}, the output resistance, R_o, and the open circuit gainA_{vo} [6]

ii) $G_V = \frac{v_o}{v_{sig}}$, assuming R_L is connected at the output. [6]

b) Given the circuit shown in **Figure 2(b)** below,

a. Draw the small signal equivalent circuit [3]

b. Find R_{in} [6]

c. Show that it has a gain of unity hence the name "Emitter follower" [4]

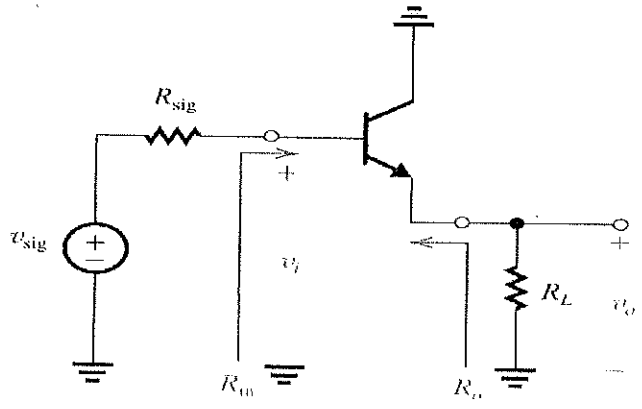

Figure 2 (b)

Question 3

Consider the Common-Source amplifier circuit, **Figure 3** below.

a) Draw the small signal equivalent circuit. [3]

b) Find

i) The input resistance R_{in} [1]

ii) The voltage gain G_V [4]

iii) The output resistance R_{out} [2]

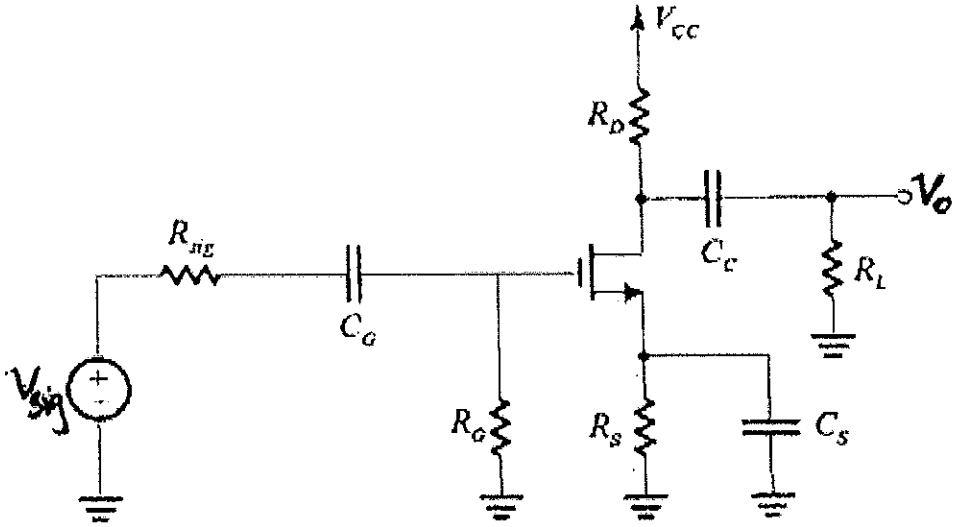

Figure 3

c) For a Common-Emitter amplifier with Emitter resistance, R_e

a. Draw the **circuit diagram** and its **equivalent circuit** after using the *T-model* to replace the transistor. [3]

b. Find the following

i. The input resistance R_{in}, [4]

ii. The output resistance R_{out} and [2]

iii. The overall gain G_v given that a load resistance R_L is connected at the output. [6]

Question 4

a) A BJT operating at $I_C = 2mA$ has $C_\mu = 1pF$ $C_\pi = 10pF$ and $\beta = 150$. Calculate:

i) f_T [4]

ii) f_β [4]

b) For the op-amp inverting integrator circuit,

i) Draw and label the circuit diagram. [3]

ii) Determine the voltage across the capacitor. [4]

iii) Determine output voltage. [2]

c) For a 0.08 μm process technology for which $t_{ox} = 15nm$ and $\mu_n = 550cm^2/V.s$. Given that the transistor is operating in saturation with $I_D = 0.2mA$ with $\frac{W}{L} = 20$, Find

i) C_{ox} [2]

ii) k'_n [2]

iii) V_{ov} [4]

Question 5

Consider the common-emitter amplifier shown in **Figure 5** under the following conditions: $R_{sig} = 5k\Omega$, $R_1 = 33k\Omega$, $R_2 = 22k\Omega$, $R_E = 3.9k\Omega$, $R_C = 4.7k\Omega$, $R_L = 5.6k\Omega$, $V_{CC} = 5V$, $r_0 = 300k\Omega$, $\beta = 120$, dc collector current, $I_C = 0.3mA, V_T = 25mV, C_\mu = 1\,pF$, $f_T = 700MHz$, $r_x = 50\Omega$, Find

a) C_π [5]

b) The mid-band voltage gain A_M [8]

c) The input capacitance C_{in} [4]

d) The effective source resistance R'_{sig} [4]

e) The upper-3dB frequency f_H [4]

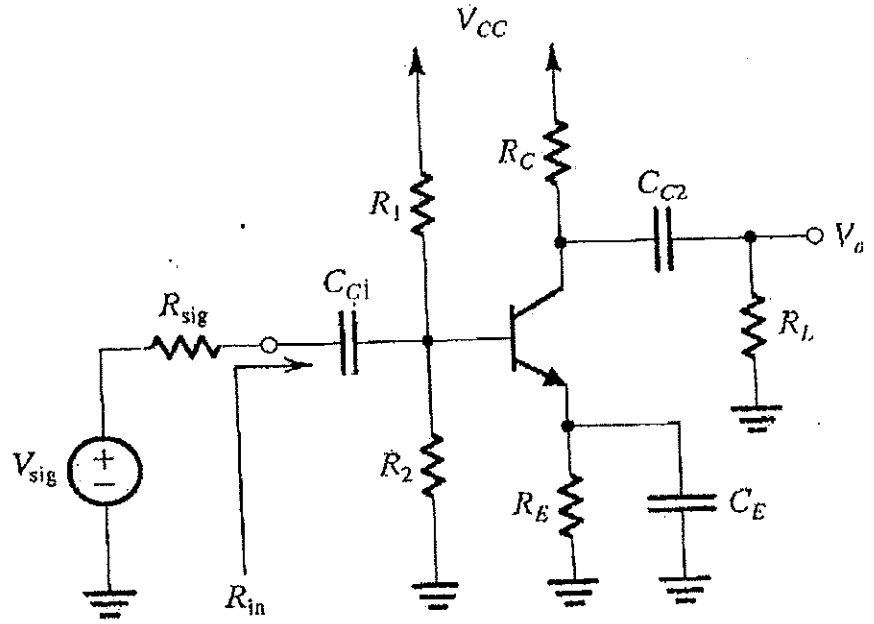

Figure 5

Section B

Question 6

a) Given the half wave rectifier, **Figure 6**, below

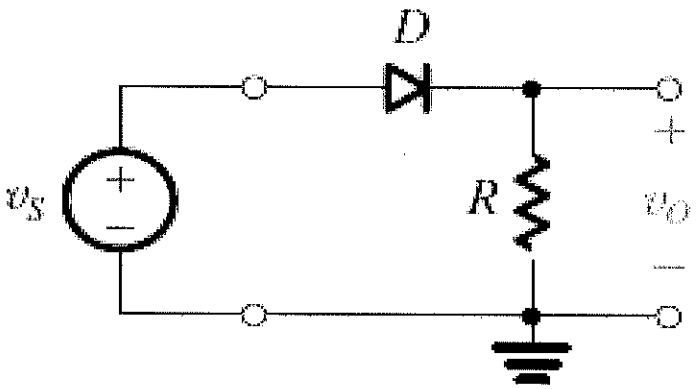

Figure 6

i) Find the RMS value of the load voltage [4]

ii) Find the RMS value of the load current [4]

iii) Given that the current $i(t) = 5\sin(2\pi 100t)$ and the voltage is $v_0 = 10\sin(2\pi 300t)$ find the values of the RMS voltage and RMS current above. [4]

iv) Show that the efficiency of the rectifier above $\eta = 0.405$ [4]

b) State three types of regulators [3]

c) List and describe three elements of a regulator [6]

Question 7

a) In the circuit **Figure 7** below

i) Identify the type of regulator. [2]

ii) Identify the four elements that make up a regulator. [4]

iii) Find the output voltage. [3]

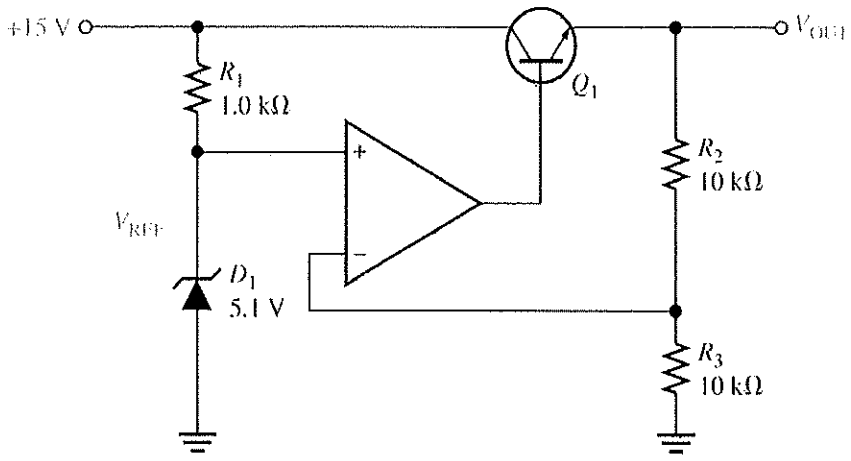

Figure 7

b) For a full wave rectifier

i) Find the mean value of the load current and the load voltage [4]

ii) Show that its efficiency is 0.81 [6]

c) Describe the operation of a shunt regulator [6]
