UNIVERSITI KUALA LUMPUR
Malaysian Institute of Marine Engineering Technology

FINAL EXAMINATION
OCTOBER 2025 SEMESTER SESSION

SUBJECT CODE	:	**LEB22003**
SUBJECT TITLE	:	**ANALOGUE ELECTRONICS**
PROGRAMME NAME (FOR MPU: PROGRAMME LEVEL)	:	**BACHELOR OF ELECTRICAL AND ELECTRONICS ENGINEERING TECHNOLOGY (MARINE) WITH HONOURS**
TIME / DURATION	:	**2.00 PM - 5.00 PM (3 HOURS)**
DATE	:	**26 JANUARY 2026**

INSTRUCTIONS TO CANDIDATES

1. Please read **CAREFULLY** the instructions given in the question paper.
2. This question paper has information printed on both sides of the paper.
3. This question paper consists of **TWO (2)** Sections, Section A and Section B.
4. Answer **ALL** questions in Section A. For Section B, answer **THREE (3)** questions.
5. Answer **ALL** questions in the answer booklet provided.
6. Answer **ALL** questions in English language **ONLY**.
7. Formula sheet has been appended for your reference.

THERE ARE 6 PAGES OF QUESTIONS, EXCLUDING THIS PAGE.

SECTION A (Total: 40 marks)

INSTRUCTION: Answer ALL questions.
Please use the answer booklet provided.

Question 1 (CLO 1)

(a) The second major application area of bipolar junction transistor (BJT) is switching application. Explain how a BJT is used as an electronics switch.

(11 marks)

(b) Name the **THREE (3)** regions of a BJT.

(3 marks)

(c) Define DC current gain.

(2 marks)

(d) Describe how dc current gain varies with temperature and collector current.

(4 marks)

Question 2 (CLO 1)

(a) Describe the op-amp operation in common mode.

(6 marks)

(b) Define open-loop voltage gain of an op-amp.

(3 marks)

(c) Describe the input bias current.

(4 marks)

(d) Illustrate the op-amp voltage-follower circuit.

(5 marks)

(e) Name **TWO (2)** sources of dc output error voltages.

(2 marks)

SECTION B (Total: 60 marks)

INSTRUCTION: Answer only THREE (3) questions ONLY.
Please use the answer booklet provided.

Question 3 (CLO 2)

(a) Given that the drain-to ground voltage in Figure 1 is 6 V. Determine the Q-point (I_D, V_{GS}) of the circuit.

(12 marks)

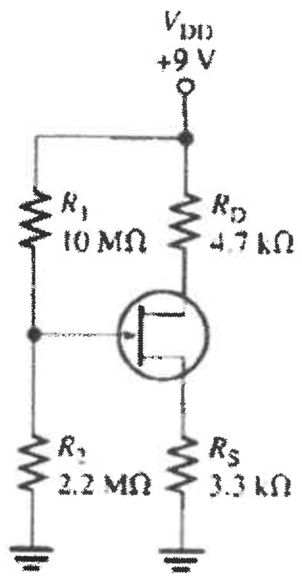

Figure 1

(b) Analyse the circuit shown in Figure 2 and determine gate-to-source voltage, V_{GS}, and drain-to-source voltage, V_{DS}, for the E-MOSFET. Given the data sheet information are: $I_{D(on)} = 3mA@V_{GS} = 4V, V_{GS(th)} = 2V$.

(8 marks)

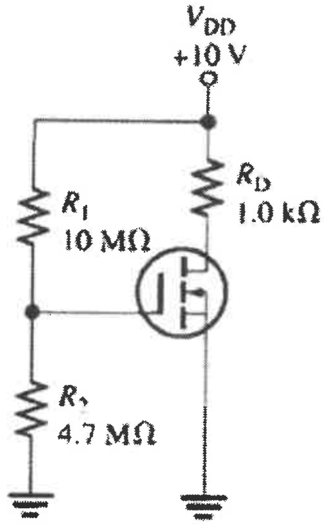

Figure 2

Question 4 (CLO 2)

Figure 3 indicates the common-collector amplifier.

(a) Determine ac emitter resistance, R_e.

(2 marks)

(b) Determine ac input resistance at base, $R_{in(base)}$.

(2 marks)

(c) Determine the total ac input resistance, $R_{in(tot)}$.

(4 marks)

(d) Determine the ac internal emitter resistance, r_e'.

(8 marks)

(e) Determine the voltage gain, A_v.

(4 marks)

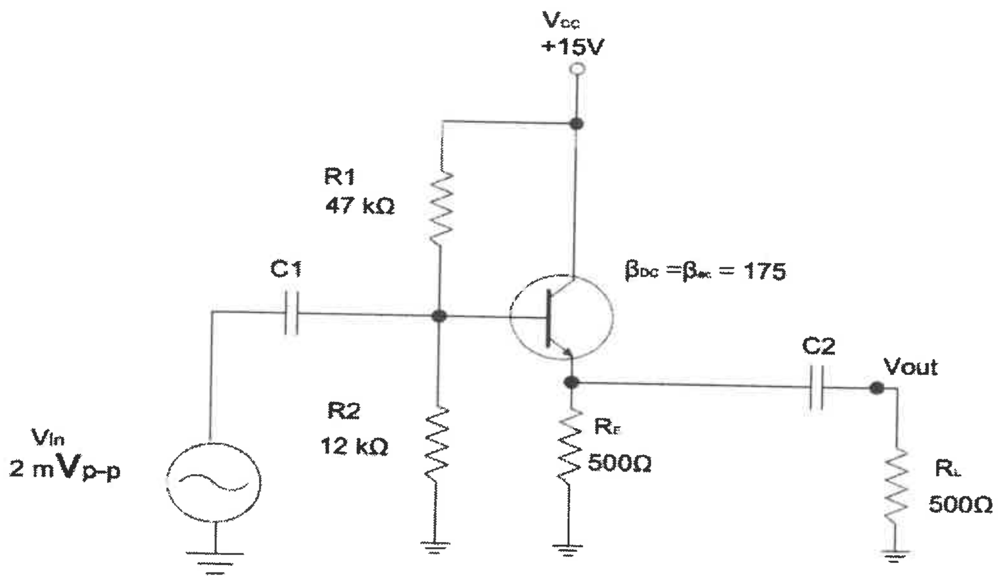

Figure 3

Question 5 (CLO 2)

(a) Analyse the circuit shown in Figure 4. Determine its bandwidth if given the open-loop gain is 100dB and a unity-gain bandwidth (f_T) is 3MHz.

(6 marks)

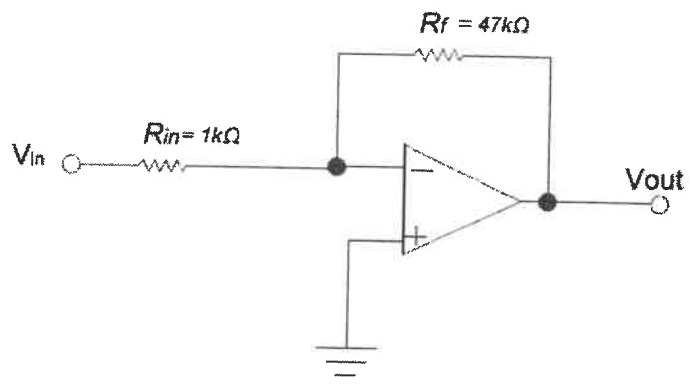

Figure 4

(b) Determine the efficiency of the power amplifier in Figure 5. Given $R_{in(tot)} = 8.4k\Omega$ and the power gain of the amplifier is 817,330.

(14 marks)

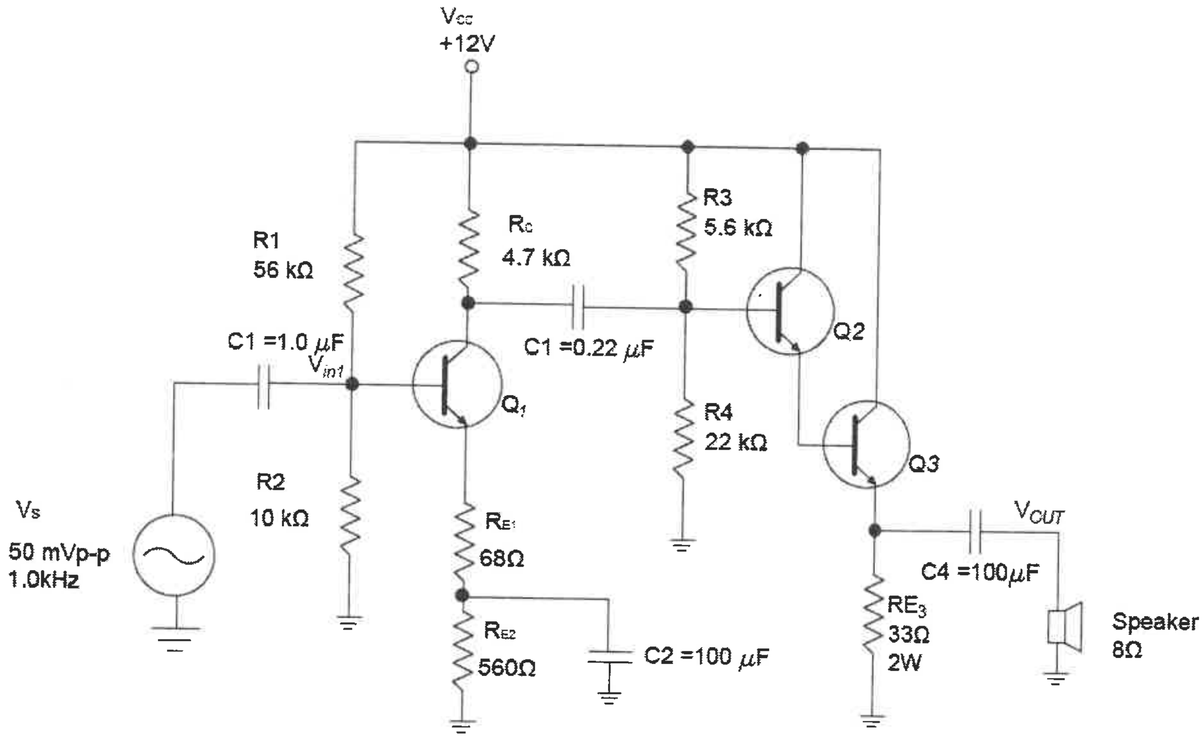

Figure 5

Question 6 (CLO 2)

(a) The following information of operational amplifier are given from a datasheet: $Z_{in} = 2M\Omega$, $Z_{out} = 75\Omega$ and $A_{ol} = 200{,}000$. Determine the following value for circuit in Figure 6:

i. the input impedance

(3 marks)

ii. the output impedance

(3 marks)

iii. the closed-loop gain.

(3 marks)

iv. name the configuration type if attenuation is 1.

(1 mark)

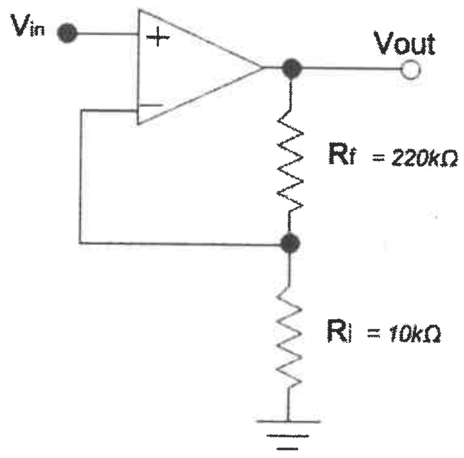

Figure 6

(b) An operational amplifier shown in Figure 7 has the following parameter $A_{ol} = 50{,}000$, $Z_{in} = 4M\Omega$, $Z_{out} = 50\Omega$. Analyse the circuit and answer the following questions:

i. Name the circuit of Figure 7.

(2 marks)

ii. Determine its input impedance.

(2 marks)

iii. Determine its output impedance.

(3 marks)

iv. Determine its closed-loop voltage gain

(3 marks)

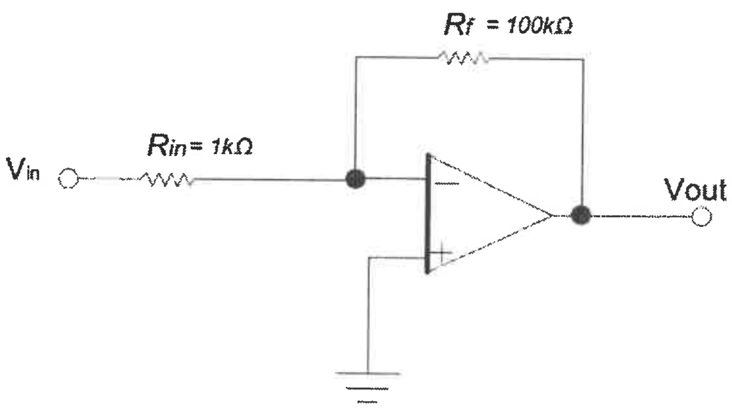

Figure 7

END OF EXAMINATION PAPER

List of Formulae – LEB22003 ANALOGUE ELECTRONICS

NO.	FORMULA
1.	$I_E = I_C + I_B$
2.	$\beta = \frac{I_C}{I_B}$
3.	$V_{CE} = V_{CC} - I_C R_C$
4.	$V_{CB} = V_{CE} - V_{BE}$
	$I_C = \beta_{DC} I_\lambda$
	Voltage-Divider Bias
6.	$V_B = \left(\frac{R_2 \| \| R_{IN(BASE)}}{R_1 + R_2 \| \| R_{IN(BASE)}}\right) V_{CC} \cong \left(\frac{R_2}{R_1 + R_2}\right) V_{CC}$
7.	$V_E = V_B - V_{BE}$
8.	$I_C \cong I_E = \frac{V_E}{R_E}$
9.	$V_C = V_{CC} - I_C R_C$
10.	$R_{IN(BASE)} = \beta_{DC} R_E$
11.	$I_E = \frac{V_{TH} - V_{BE}}{R_E + R_{TH}/\beta_{DC}}$
	Emitter Bias
12.	$I_E = \frac{-V_{EE} - V_{BE}}{R_E + R_B/\beta_{DC}}$
	Base Bias
13.	$V_{CE} = V_{CC} - I_C R_C$
14.	$I_C = \beta_{DC} \left(\frac{V_{CC} - V_{BE}}{R_B}\right)$
	Emitter-Feedback Bias
15.	$I_E = \frac{V_{CC} - V_{BE}}{R_E + R_B/\beta_{DC}}$
	Collector-Feedback Bias
16.	$I_C = \frac{V_{CC} - V_{BE}}{R_C + R_B/\beta_{DC}}$
17.	$V_{CE} = V_{CC} - I_C R_C$
	Field-Effect Transistor (FET)
18.	$I_D \cong I_{DSS}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)^2$
19.	$g_m = g_{m0}\left(1 - \frac{V_{GS}}{V_{GS(off)}}\right)$
20.	$g_{m0} = \frac{2I_{DSS}}{\|V_{GS(off)}\|}$
21.	$I_D = K\left(V_{GS} - V_{GS(th)}\right)^2$
	Common-Emitter
22.	$r'_e \cong \frac{25mV}{I_E}$
23.	$R_{in(base)=\beta_{ac} r'_e}$
24.	$R_{in(tot)} = R_1 \| \| R_2 \| \| R_{in(base)}$
25.	$R_{out} \cong R_c$
26.	$A_v = \frac{R_c}{r'_e}$
27.	$A_i = \frac{I_c}{I_s}$
28.	$A_p = A'_v A_i$
29.	$Attenuation = \frac{V_s}{V_b} = \frac{R_s + R_{in(tot)}}{R_{in(tot)}}$
30.	$A'_v = \left(\frac{1}{Attenuation}\right) A_v$

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Common-Collector	
31.	$A_v = \frac{R_e}{r_e' + R_e} \approx 1$
32.	$R_{in(base)} = \beta_{ac}(r_e' + R_e) \cong \beta_{ac}R_e$
33.	$R_{out} \cong \left(\frac{R_s}{\beta_{ac}}\right) \|\| R_E$
34.	$A_i = \frac{I_e}{I_{in}}$
35.	$A_p = \frac{R_{in(tot)}}{R_L} \cong A_i$
36.	$R_{in(base)} = \beta_{ac1}\beta_{ac2}(r'e + R_e)$
Common-Base	
37.	$A_v \cong \frac{R_c}{r_e'}$
38.	$R_{in(emitter)} \cong r_e'$
39.	$R_{out} \cong R_c$
40.	$A_i \cong 1$
41.	$A_p \cong A_v$
Multistage Amplifier	
42.	$A_v' = A_{v1}A_{v2}A_{v3} \ldots A_{vn}$
43.	$A_{v(dB)} = 20logA_v$
Differential Amplifier	
44.	$CMRR = \frac{A_{v(d)}}{A_{cm}}$
45.	$CMRR = 20log\left(\frac{A_{v(d)}}{A_{cm}}\right)$

Class A Power Amplifier	
46.	$A_p = \frac{P_L}{P_{in}}$
47.	$A_p = A_v^2\left(\frac{R_{in}}{R_L}\right)$
48.	$P_{DQ} = I_{CQ}V_{CEQ}$
49.	$P_{out)\max)} = 0.5I_{CQ}V_{CEQ}$
Class B/AB Push-Pull Amplifiers	
50.	$I_{c(sat)} = \frac{V_{CC}}{R_L}$
51.	$P_{out} = 0.25I_{c(sat)}V_{CC}$
	Class C Amplifier
52.	$P_{out} = \frac{0.5V_{CC}^2}{R_c}$
53.	$\eta = \frac{P_{out}}{P_{out} + P_{D(avg)}}$
54.	$P_{D(avg)} = \left(\frac{t_{on}}{T}\right)P_{D(on)} = \left(\frac{t_{on}}{T}\right)I_{c(sat)}V_{ce(sat)}$
Comparator	
55.	$V_{UTP} = \frac{R_2}{R_1 + R_2}(+V_{out(max)})$
56.	$V_{LTP} = \frac{R_2}{R_1 + R_2}(-V_{out(max)})$
57.	$V_{HYS} = V_{UTP} - V_{LTP}$
Summing Amplifier	
58.	$V_{OUT} = -(V_{IN1} + V_{IN2} + \cdots + V_{INn})$

List of Formulae – LEB22003 ANALOGUE ELECTRONICS

59.	$V_{OUT} = -\frac{R_f}{R_{IN}}(V_{IN1} + V_{IN2} + \cdots + V_{INn})$
60.	$V_{OUT} = -\left(\frac{R_f}{R_{IN1}}V_{IN1} + \frac{R_f}{R_{IN2}}V_{IN2} + \cdots + \frac{R_f}{R_{INn}}V_{INn}\right)$
Integrator and Differentiator	
61.	$\frac{\Delta V_{out}}{\Delta t} = -\frac{V_{in}}{R_i C}$
62.	$V_{out} = -\left(\frac{V_C}{t}\right)R_f C$
Op-Amp Input Modes and Parameters	
63.	$CMRR = \frac{A_{ol}}{A_{cm}}$
64.	$CMRR = 20log\left(\frac{A_{ol}}{A_{cm}}\right)$
65.	$I_{BIAS} = \frac{I_1 + I_2}{2}$
66.	$I_{OS} = \lvert I_1 - I_2 \rvert$
67.	$V_{OS} = I_{OS}R_{in}$
68.	$V_{OUT(error)} = A_v I_{OS} R_{in}$
69.	$Slew\ rate = \frac{\Delta V_{out}}{\Delta t}$
Op-Amp Configurations	
70.	$A_{cl(NI)} = 1 + \frac{R_f}{R_i}$
71.	$A_{cl(VF)} = 1$
72.	$A_{cl(I)} = -\frac{R_f}{R_i}$

Op-Amp Impedances	
73.	$Z_{in(NI)} = (1 + A_{ol}B)Z_{in}$
74.	$Z_{out(NI)} = \frac{Z_{out}}{1 + A_{ol}B}$
75.	$Z_{in(VF)} = (1 + A_{ol})Z_{in}$
76.	$Z_{out(VF)} = \frac{Z_{out}}{1 + A_{ol}}$
77.	$Z_{in(I)} \cong R_i$
78.	$Z_{out(I)} = \frac{Z_{out}}{1 + A_{ol}B}$
79.	$B = \frac{R_i}{R_i + R_f}$
Op-Amp Frequency Responses	
80.	$BW = f_{cu}$
81.	$\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + f^2/f_c^2}}$
82.	$A_{ol} = \frac{A_{ol(mid)}}{\sqrt{1 + f^2/f_c^2}}$
83.	$\theta = -tan^{-1}\left(\frac{f}{f_c}\right)$
84.	$f_{c(cl)} = f_{c(ol)}(1 + BA_{ol(mid)})$
85.	$BW_{cl} = BW_{ol}(1 + BA_{ol(mid)})$
86.	$f_T = A_{cl} f_{c(cl)}$