COMMONWEALTH OF AUSTRALIA

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CHARLES DARWIN UNIVERSITY

Family Name	
Given Names	
Student Number	
Teaching Period	Semester 1, 2016

FINAL EXAMINATION	**DURATION**
ENG221 – Analogue Electronics	Reading Time: **10** minutes Writing Time: **180** minutes

INSTRUCTIONS TO CANDIDATES

1. The examination has **5** questions.
2. The exam has 65 marks. Note that questions **ARE NOT** of equal value

   Question 1: 8 marks

   Question 2: 12 marks

   Question 3: 15 marks

   Question 4: 12 marks

   Question 5: 18 marks
3. Read ALL questions carefully

EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a CLOSED BOOK examination

Any non-programmable calculator is permitted

No handwritten notes are permitted

No dictionaries are permitted

ADDITIONAL AUTHORISED MATERIALS	**EXAMINATION MATERIALS TO BE SUPPLIED**
No additional printed material is permitted	1 x 20 Page Book, Formula Sheet/s

THIS EXAMINATION PAPER AND SUPPLIED MATERIALS ARE NOT PERMITTED TO BE REMOVED FROM ANY EXAMINATION VENUE IN ANY CIRCUMSTANCE. THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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Question 1 (8 marks)

For the circuit shown in Figure 1, MOSFET has the following specifications:

V_t=2 V, K'_n (W/L)= 0.5 mA/V^2.

a) Determine the value of current source (I) for drain voltage of 10 V. (2 marks)

b) Based on the result obtained in part (a), what is the source voltage? (3 marks)

c) Based on the result obtained in part (a), what is the voltage gain of the amplifier? (3 marks)

Ignore the body effect.

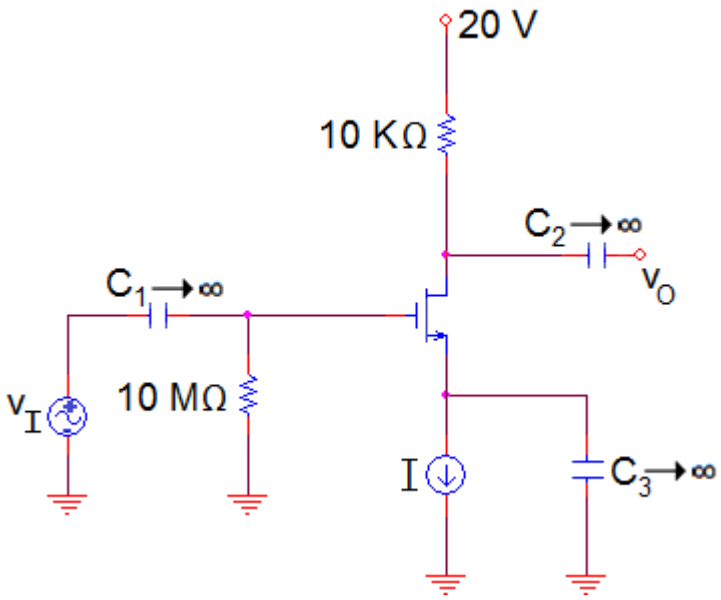

Figure 1.

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Question 2 (12 marks)

The current source (I) of the circuit shown in Figure 2 is 5 mA.

a) Determine the output resistance of the amplifier (R_o). (4 marks)

b) Determine the value of R_L , which reduces the small-signal gain to one-half of the open-circuit value. (8 marks)

Transistor's parameters are:

V_t=-2 V, $k'_p(W/L)$=5 mA/V^2, λ=0.02.

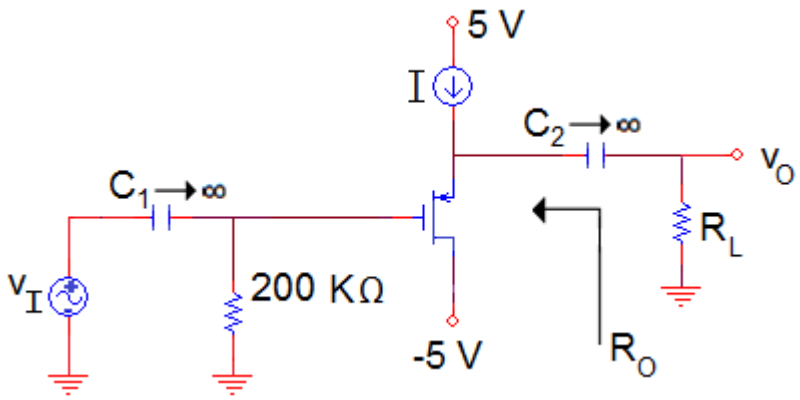

Figure 2.

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Question 3 (15 marks)

This question has two parts, which are independent of each other.

Part 1 (7 marks)

a) Determine the voltage characteristic of the circuit (v_o in terms of v_I) shown in Figure 3.

The transistor has the following specifications:

β=50, V_{BE}(on)=0.7, V_{CE}(in saturation mode)=0.2,

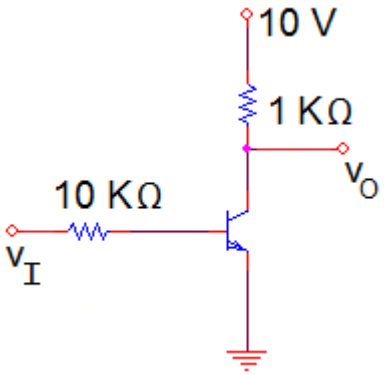

Figure 3.

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Part 2 (8 marks)

It is required to bias the transistor in the circuit of Figure 4 at I_C=1mA. The transistor β is specified to nominally 100, but it can fall in the range of 50 to 150. For V_{CC}=+10 V, R_C=3 kΩ and R_E=1 kΩ.

a) Find the required value of R_B to achieve I_C=1mA for the nominal transistor. (3 marks)

b) Based on the result obtained from part (a), what is the expected range for I_C and V_{CE}? (5 marks)

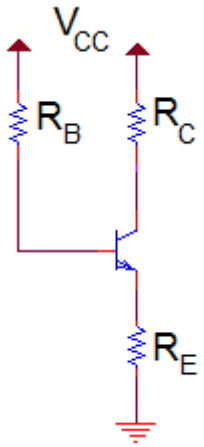

Figure 4.

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Question 4 (12 marks)

For the circuit shown in Figure 5, answer the following questions:

a) Determine the dc collector current and dc voltage at the collector. (4 marks)

b) Replace the transistor by either T or π model, draw the small signal equivalent circuit of the amplifier and determine the voltage gain v_o/v_I. (8 marks)

Assume β=50. Ignore the Early effect.

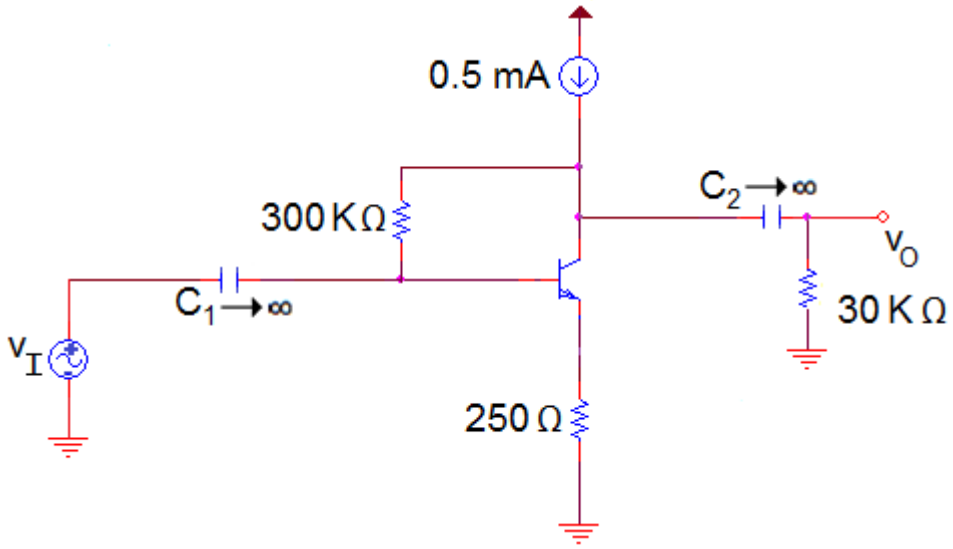

Figure 5.

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Question 5 (18 marks)

For the amplifier shown in Figure 6, answer the following questions by using small-signal model of the transistor (either T or π model).

a) Determine the input resistance of the amplifier (R_{in}) (5 marks)

b) Determine the output resistance of the amplifier (R_{out}) (5 marks)

c) Determine the voltage gain of the amplifier (v_o/v_{sig}) (8 marks)

Assume β=50. Ignore the Early effect.

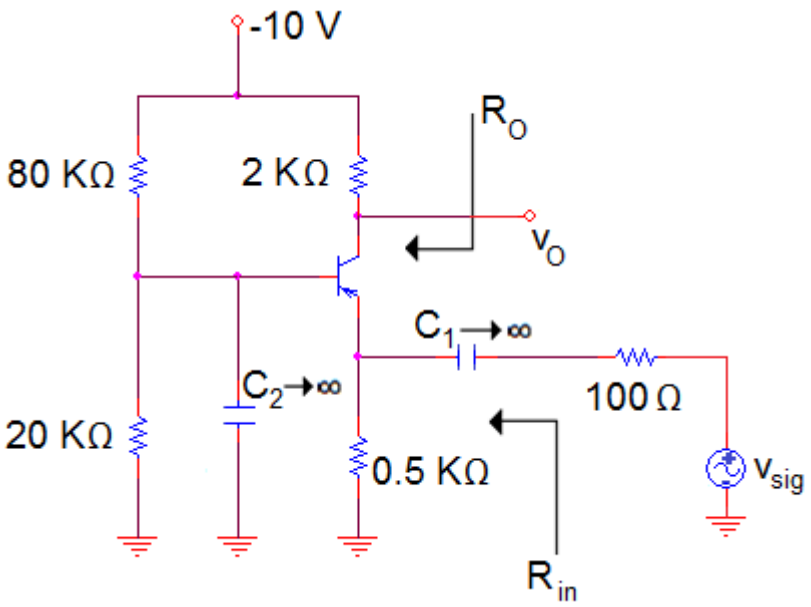

Figure 6.

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Formula sheet

NMOSET

$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(v_{GS}-V_t)^2(1+\frac{v_{DS}}{V_A}) = \frac{1}{2}k'_n\frac{W}{L}(v_{GS}-V_t)^2(1+\frac{v_{DS}}{V_A})$$

$$g_m = (\mu_n C_{ox})\left(\frac{W}{L}\right)V_{OV} = \sqrt{2(\mu_n C_{ox})\left(\frac{W}{L}\right)I_D}$$

$$r_o = \frac{V_A}{I_D}$$

$$V_A = \frac{1}{\lambda} \qquad g_m = \frac{I}{V_{OV}/2}$$

PMOSFET

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(v_{SG}-|V_t|)^2(1+\frac{v_{SD}}{V_A}) = \frac{1}{2}k'_p\frac{W}{L}(v_{SG}-|V_t|)^2(1+\frac{v_{SD}}{V_A})$$

$$g_m = (\mu_p C_{ox})\left(\frac{W}{L}\right)V_{OV} = \sqrt{2(\mu_p C_{ox})\left(\frac{W}{L}\right)I_D}$$

$$r_o = \frac{|V_A|}{I_D}$$

$$V_A = \frac{1}{\lambda}$$

BJT

$$i_C = I_S e^{v_{BE}/V_T}(1+\frac{V_{CE}}{V_A})$$

$$i_B = \frac{i_C}{\beta} \qquad \Delta I_B = \frac{\Delta I_C}{\beta}$$

$$g_m = \frac{I_C}{V_T}$$

$$g_m r_e = \alpha$$

$$\alpha = \frac{\beta}{\beta+1}$$

$$r_\pi = \frac{\beta}{g_m}$$

$$r_o = \frac{V_A}{I_C}$$

V_T=25 m V_{BE}=0.7 V

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