UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2005

TITLE OF PAPER	:	ELECTRONICS (PAPER 1)
COURSE NUMBER	:	P310 (i)
TIME ALLOWED	:	THREE HOURS
INSTRUCTIONS	:	ANSWER ANY FOUR OUT OF FIVE QUESTIONS
		EACH QUESTION CARRIES 25 MARKS
		MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS 6 PAGES, INCLUDING THIS PAGE.

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QUESTION 1

(a) An RLC bandpass filter is to be designed using a 10 mH inductor whose resistance is 75 Ω. The centre frequency of the filter is to be 25 kHz.

(i) What value of capacitance should be used? (4 marks)

(ii) If the bandwidth of the filter is to be made less than 2500 Hz, what is the quality factor? (3 marks)

(b) For the high-pass filter shown in Fig. 1.1:

(i) Find the cut-off frequency in hertz. (3 marks)

(ii) Find the magnitude of v_{out} when v_{in} has a frequency of 15 kHz and of 100 kHz.

(5 marks)

(iii) Find the phase angle between v_{out} and v_{in}, when v_{in} has a frequency of 20 kHz and that of 80 kHz.

(5 marks)

(c) An RC low-pass filter is to be designed to create a 60° phase lag in a 2.5 kHz signal. If the filter capacitance is 0.2 μF, what value of resistance should be used? (5 marks)

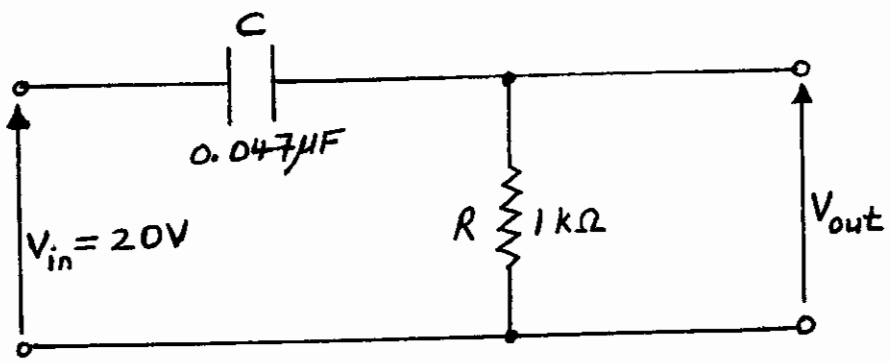

Fig. 1.1

QUESTION 2

(a) The drain current in a junction field effect transistor (JFET) amplifier varies by ± 1 mA when a signal voltage with a peak-to-peak value of 2 V is applied at the input of the amplifier.

Calculate the transconductance, g_m of the transistor. (3 marks)

(b) The I-V characteristics of a **p-channel** JFET may be plotted when the following equipment/components are available for current and voltage measurements: d.c. power supplies, potentiometers, a d.c. ammeter and a d.c. voltmeter.

(i) Draw and label the diagram of a circuit you would use to measure the values of current and voltage. (4 marks)

(ii) Sketch typical transfer and drain characteristic curves for this type of JFET. Label them.

(5 marks)

(c) (i) Draw and label a self-biasing common-source amplifier which utilises an n-channel junction field effect transistor. The diagram should include all capacitors and resistors required in the circuit. (3 marks)

(ii) Draw a small signal equivalent circuit and label it. State the significance of each element shown in the equivalent circuit.

(10 marks)

QUESTION 3

(a) With reference to a labelled schematic diagram, discuss the principle of operation of an npn bipolar junction transistor. (9 marks)

(b) The values of the leakage current I_{CEO} in a bipolar junction transistor at various junction temperatures are listed below:

Junction temperature (°C)	20	30	40	50	60
Leakage current, I_{CEO} (μA)	60	120	240	480	960

This transistor has $h_{FE} = 100$. It is used as an amplifier in common-emitter connection with dc bias current of 30 μA.

Calculate the change in collector current, I_C as the junction temperature rises from 20 °C to 60 °C. (7 marks)

(c) With the aid of a small signal model, derive the expression below which represents the voltage gain of an emitter follower.

$$A_V = \frac{\left(h_{fe} + 1\right)R_L}{r_\pi + \left(h_{fe} + 1\right)R_L}.$$

(9 marks)

QUESTION 4

(a) Suppose that you were required to build the op-amp circuit shown in Fig. 4.1, which gives a voltage gain of 100. What values of R_1 and R_2 would you need for this purpose? (4 marks)

(b) Use operational amplifiers to **design** circuits which correspond to each of the following ideal relationships between the output and the input voltage(s):

(i) $v_0 = -4 \times 10^{-2} \int v_1 dt$ (7 marks)

(ii) $v_0 = -2 \times 10^{-4} \frac{dv_1}{dt}$ (7 marks)

(iii) $v_0 = -(3v_1 + 5v_2 + v_3)$ (7 marks)

where v_1, v_2 and v_3 are input voltage signals.
(Note: determine suitable values of resistors and capacitors)

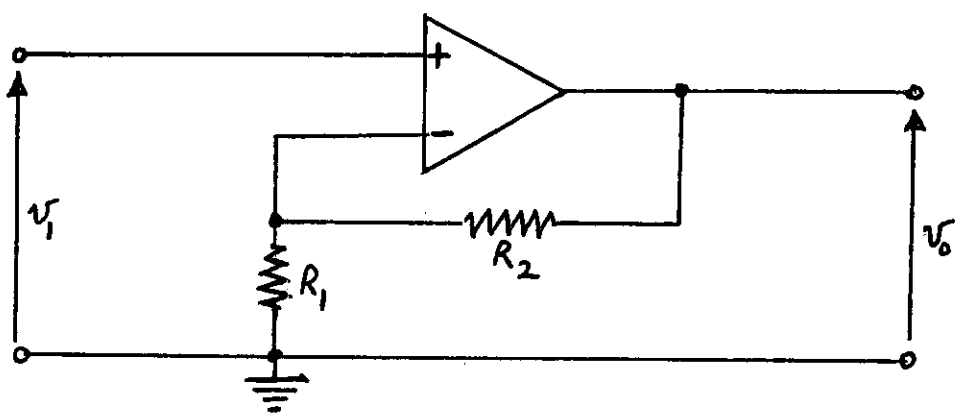

Fig. 4.1

QUESTION 5

(a) Calculate the diode current in the circuit shown in Fig. 5.1, assuming that the turn-on voltage is 0.7 V. (4 marks)

(b) With reference to amplifiers, explain what is meant by degenerative feedback. (3 marks)

(c) Consider an amplifier with an open-loop gain of -700. Negative feedback is applied to the amplifier and the feedback factor is 0.04.

(i) What would be the gain with feedback? (3 marks)

(ii) Calculate the closed-loop gain if the open-loop gain falls by 20%. (5 marks)

(iii) Calculate the percentage change in closed-loop gain from the results obtained in (i) and (ii). (2 marks)

(d) (i) Draw the schematic diagram of a phase-shift oscillator and label it. (3 marks)

(ii) Discuss, briefly, the principle of operation of this oscillator and comment on the attenuation effect of the phase-shift ladder network as well as the Barkhauszen criterion. (5 marks)

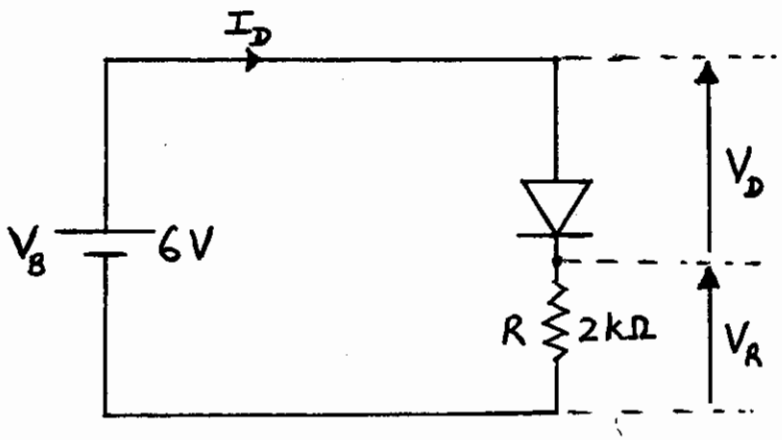

Fig. 5.1