UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2006/2007

TITLE OF PAPER	:	ELECTRONICS II
COURSE NUMBER	:	P312
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) For the network shown in Fig. 1.1, prove that

$$\frac{v_o}{v_i} = \frac{1}{3 + j\left(\omega C_2 R_1 - 1/\omega C_1 R_2\right)}$$

(5 marks)

(b) The network illustrated in Fig. 1.1 is used with an Op-Amp to form an oscillator.

(i) Draw the oscillator circuit. (3 marks)

(ii) Show that the frequency of oscillation is $f_0 = \dfrac{1}{2\pi RC}$ and that the gain must exceed 3. (9 marks)

(c) It is desired that the gain of a feedback amplifier be stable to better than 0.01% for changes in the open-loop gain as high as 10%. If the open-loop gain is -10^5, what is the gain with feedback?

(8 marks)

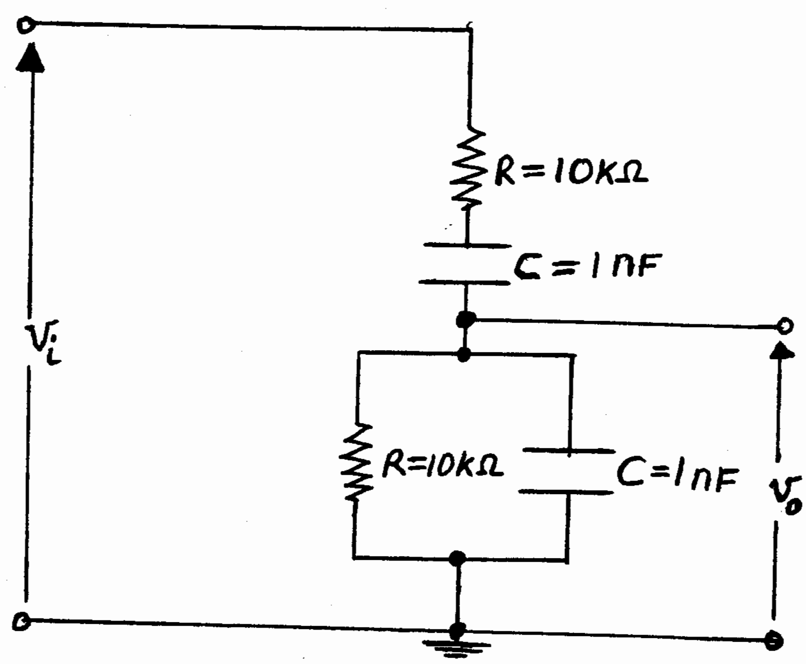

Fig. 1.1

QUESTION 2

(a) The equation below represents the magnitude of the transfer function of the two-port RC network shown in Fig. 2.1. Derive it.

$$|H(s)| = \frac{1}{\sqrt{1+\left(\frac{f}{f_{co}}\right)^2}}.$$ (11 marks)

where $s = j\omega = j2\pi f$

(b) Find L_2 in the high-pass circuit shown in Fig. 2.2, if $|H(s)| = 0.50$ at a frequency of 50 MHz. (8 marks)

(c) The circuit shown in Fig. 2.3 represents a band-stop filter.

(i) Calculate the resonant frequency (2 marks)
(iii) Calculate the Q-factor (2 marks)
(iv) Calculate the lower cut-off frequency (2 marks)

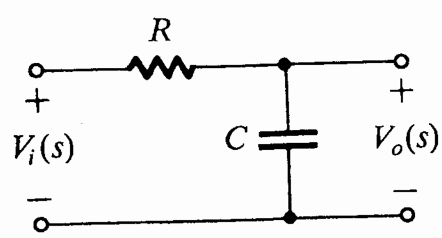

Fig. 2.1

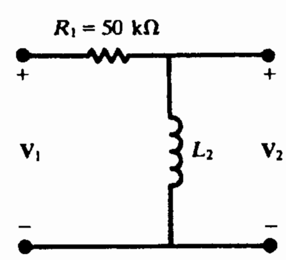

Fig. 2.2

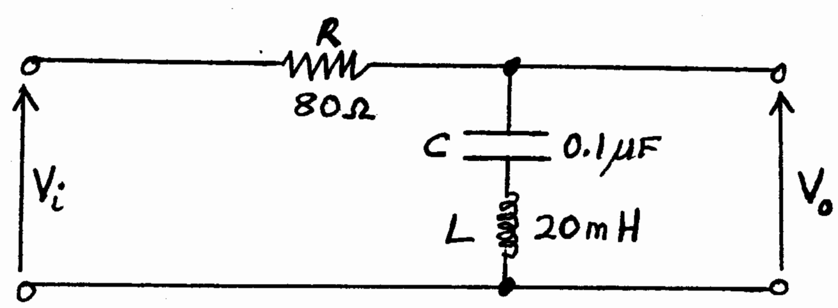

Fig. 2.3

QUESTION 3

(a) What is an operational amplifier and how was the word 'operational' derived? (4 marks)

(b) (i) Draw the circuit diagram for a unity gain voltage follower; (2 marks)
(ii) Derive an expression for the gain of the follower. (4 marks)

(c) Use operational amplifiers to design a circuit which corresponds to the following ideal relationship between the output and the input voltage(s):

$$v_{out} = 5 \times 10^{-6}\frac{d^2 v_{in}}{dt^2} + \int (v_1 + 6v_2)dt$$ (15 marks)

QUESTION 4

(a) What is the function of an antilogarithm amplifier? (2 marks)

(b) Draw the circuit diagram of this amplifier and label it. (3 marks)

(c) Derive an expression to show the relationship between the output and input voltages of this amplifier. (5 marks)

(d) Consider the analogue multiplier shown in Fig. 4.1. It utilizes an operational amplifier and consists of two inputs V_1 and V_2. With the aid of a diagram(s), derive an expression to show that the input and output voltages are related as follows:

$$v_{out} = -\frac{V_1 V_2}{I_S R}$$

where I_S refers to the diode reverse saturation current. (15 marks)

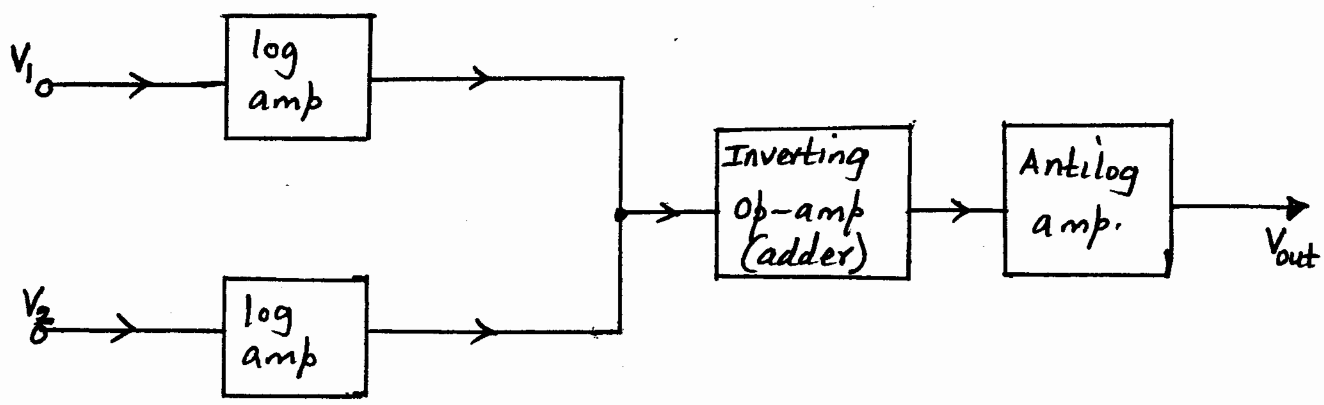

Fig. 4.1

<u>QUESTION 5</u>

(a) With the aid of diagrams, derive an appropriate equation to demonstrate how you would measure the output resistance of a device such as a power supply. (11 marks)

(b) (i) Draw the small signal equivalent circuit of an emitter follower; (3 marks)
(ii) Show that the input resistance of the follower is $R_i = (1 + h_{fe})R_E$. (4 marks)

where R_E represents the resistance of the load. h_{fe} stands for the current gain of the transistor.

(c) Fig. 5.1 illustrates a circuit consisting of an input generator and a voltage amplifier. The same circuit is shown in Fig. 5.2 with an additional unit, the emitter follower, between the generator and the amplifier.

Show, mathematically, that the emitter follower improves the ratio V_{in}/V_s significantly. (7 marks)

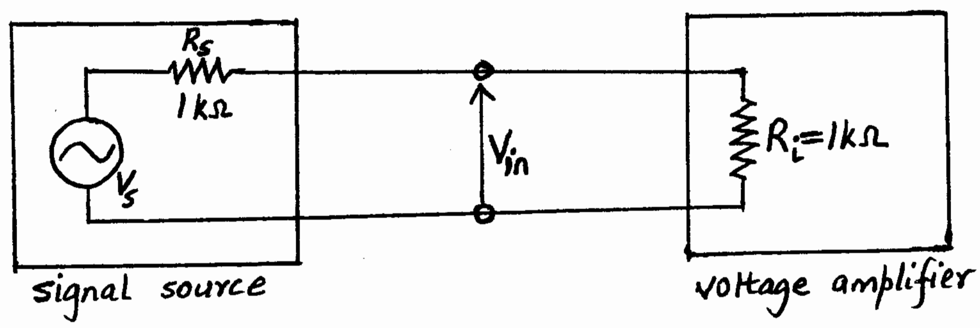

Fig. 5.1

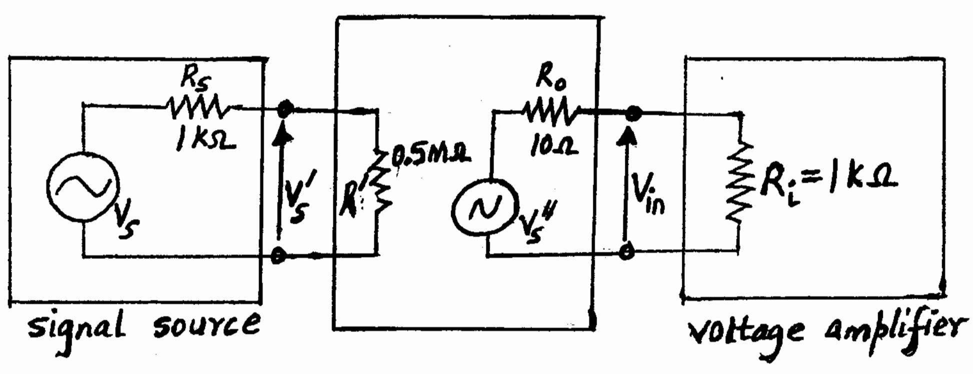

Fig. 5.2