UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2010

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) The feedback factor, β of the RC network illustrated in Fig. 1.1 is

$$\frac{v_1}{v_2} = 3 + j\left(\omega RC - \frac{1}{\omega RC}\right) \text{, when } C_1 = C_2 \text{ and } R_1 = R_2$$

(i) Show that the resonant frequency of the Wien network is $f_0 = \dfrac{1}{2\pi RC}$.
(5 marks)

(ii) Explain why the gain must exceed 3 in order for oscillation to occur.
(4 marks)

(b) An single-stage amplifier has an open-loop gain of magnitude A. A fraction β of its output signal voltage is fed back to the input so as to provide negative feedback.

Derive an expression for the overall voltage gain with feedback. (6 marks)

(c) An amplifier has an open-loop gain of –600. Feedback is applied with a feedback factor of 0.3.

(i) Find the voltage gain with feedback. (3 marks)

(ii) Determine the percentage fall in gain with feedback if the open-loop gain of the amplifier falls by 40 per cent. (7 marks)

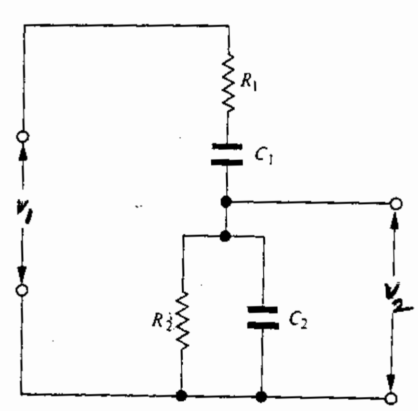

Fig. 1.1

QUESTION 2

Notes

(a) Derive the equation below which represents the magnitude of the transfer function of a low-pass filter which utilises a resistor and a capacitor. (11 marks)

$$|T(s)| = \left[1 + \left(\frac{\omega}{\omega_{co}}\right)^2\right]^{-\frac{1}{2}}$$

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

(b) The circuit shown in Fig. 2.1 represents a band-pass filter.

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

(c) Find the value of R in the high-pass circuit shown in Fig. 2.2, if $|T(s)| = 0.2$ at a frequency of 10 MHz. (8 marks)

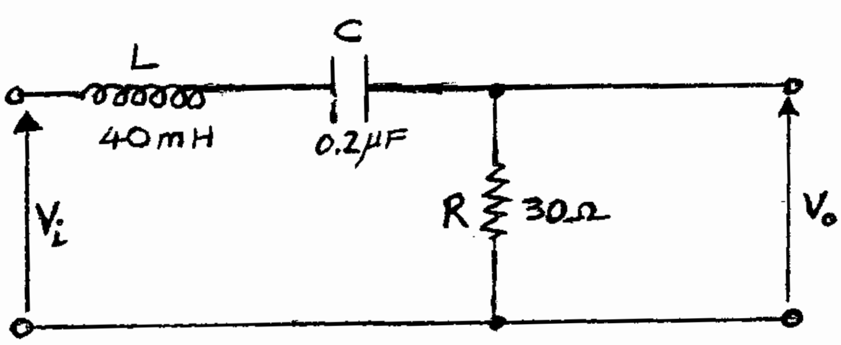

Fig. 2.1

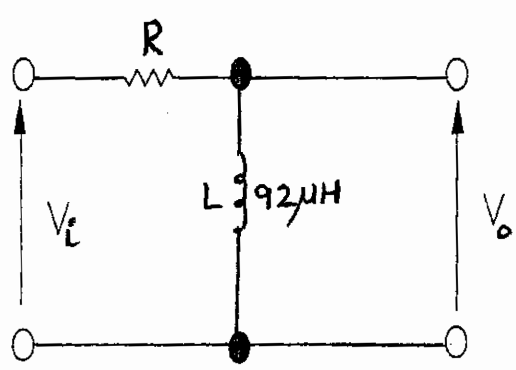

Fig. 2.2

QUESTION 3

(a) (i) Sketch a circuit diagram of an operational integrator. (3 marks)

(ii) Derive the equation below which describes the relationship between the output and input voltages, v_{out} and v_{in} of the integrator.

$$v_{out} = -\frac{1}{RC}\int v_{in}\,dt$$ (6 marks)

(b) Use operational amplifiers to design a circuit which corresponds to the following ideal relationship between the output, v_{out} and the input voltages, v_{in}, v_1 and v_2:

(i) $$v_{out} = 4 \times 10^{-3}\frac{dv_{in}}{dt} - \int (v_1 + v_2)\,dt$$ (16 marks)

QUESTION 4

(a) Fig. 4.1 shows the circuit diagram of an emitter follower.

(i) Draw a small signal equivalent circuit of the emitter follower. (3 marks)

(ii) With the aid of the equivalent circuit, show that the voltage gain of the emitter follower is given by the following expression:

$$A_v = \frac{(1 + h_{fe})R_L}{r_\pi + (1 + h_{fe})R_L}$$, where h_{fe} is the a.c. current gain (7 marks)

(iii) State two characteristics of an emitter follower. (2 marks)

(b) Show that the output resistance, r_o of an emitter follower is given as follows:

$$r_o = \frac{r_\pi + R_s}{h_{fe} + 1}$$

where R_s represents the internal resistance of a voltage source (assuming that the source is connected to the input of the emitter follower). The other symbols have the usual meaning. (8 marks)

(c) A bipolar junction transistor amplifier has an input resistance of 120 Ω and a collector load resistor of 500 Ω. The a.c. current gain of the transistor is 100.

(i) Calculate the open-loop voltage gain of the circuit. (2 marks)

(ii) Calculate its voltage gain when negative feedback is applied. Consider the feedback factor to be 0.05. (3 marks)

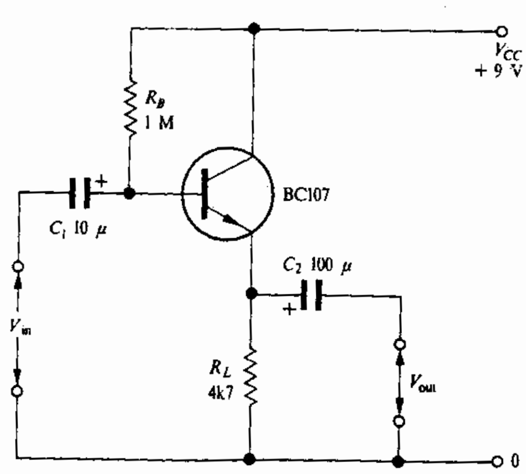

Fig. 4.1

QUESTION 5

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

(b) Draw the circuit diagram of antilog amplifier. Label it. (3 marks)

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

(d) Consider the analogue multiplier shown in Fig. 5.1. The multiplier consists of three inputs V_1, V_2 and V_3 and utilizes operational amplifiers. With the aid of a diagram(s), show that the input voltages and output voltage, v_o are related as follows:

$$v_o = -\frac{V_1 V_2 V_3}{I_0 R}$$

where I_0 refers to the diode reverse saturation current. (15 marks)

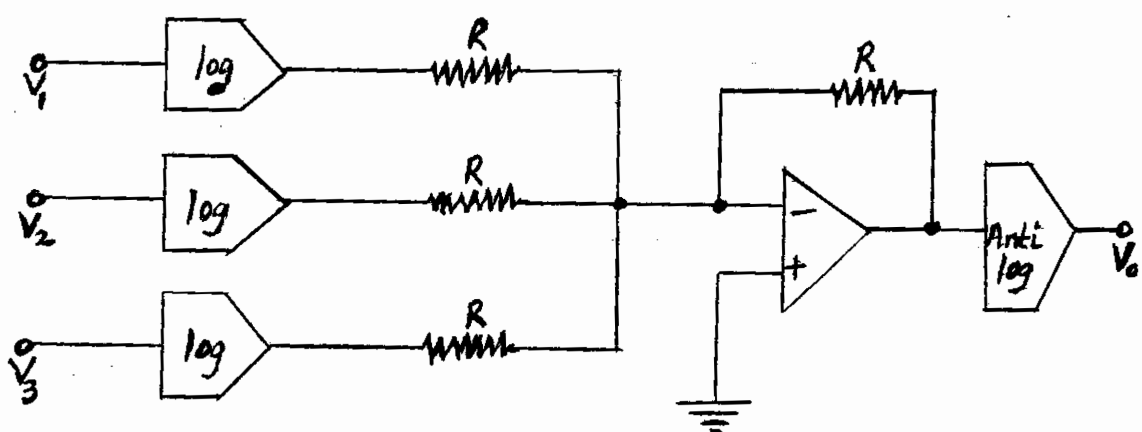

Fig. 5.1