UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2006

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) Fig. 1.1 shows an op-amp integrator.

$R_{in} = 100\ k\Omega$
$C_f = 1.0\ \mu F$

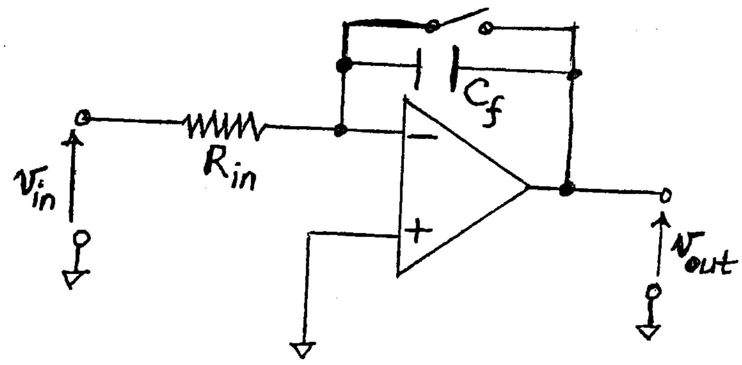

Fig. 1.1

(i) What is the relationship between v_{out} and v_{in} for a circuit of this type? (1 mark)

(ii) Calculate v_{out} as a function of time if $v_{in} = -10$ mV. Sketch a graph of v_{out} and v_{in} as a function of time. Label the graph fully. (5 marks)

(iii) Calculate v_{out} as a function of time if v_{in} is a sinusoidal voltage with a 10 V amplitude and a frequency of 100 Hz. Sketch a graph of v_{out} and v_{in} as a function of time. Label the graph fully. (9 marks)

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

$$v_{out} = -(v_{in} - 2 \times 10^{-4} \int v_{in} dt)$$ (10 marks)

QUESTION 2

(a) (i) What is meant by inverse feedback? (3 marks)

(ii) What is meant by the Barkhauszen criterion? (3 marks)

(b) State the distinct advantages of inverse feedback to an amplifier. (3 marks)

(c) An amplifier has an open-loop gain of magnitude A. A fraction B of its output signal voltage is fed back to the input so as to subtract from the signal at the input.

Derive an expression for the overall voltage gain with feedback. (5 marks)

(d) An amplifier has the following properties:

Open-loop gain = –500
Feedback is applied with a feedback factor of 0.2

(i) What is the loop gain? (2 marks)

(ii) Find the voltage gain with feedback. (2 marks)

(iii) Determine the percentage fall in gain with feedback if the open-loop gain of the amplifier falls by 20 per cent. (7 marks)

QUESTION 3

(a) Consider the RLC bandpass filter shown in Fig. 3.1.

(i) Derive an expression for the magnitude of the transfer function of this filter. (5 marks)

(ii) Derive the expression for the resonant frequency. (4 marks)

(iii) What is the value of the resonant frequency? (2 marks)

(iv) Determine the Q-factor. (2 marks)

(v) Calculate the cut-off frequencies, f_1 and f_2. (6 marks)

(vi) Calculate the bandwidth. (1 mark)

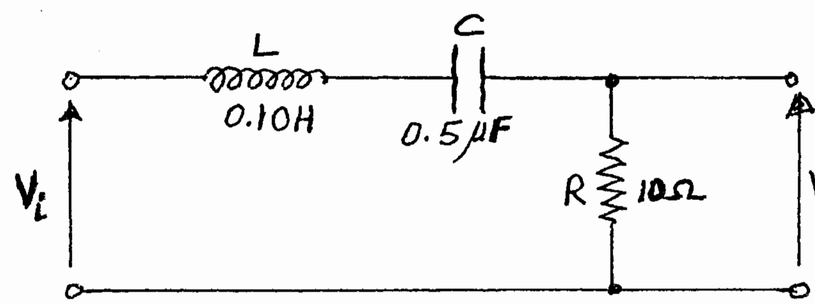

Fig. 3.1

(b) Calculate the phase difference between v_{out} and v_{in}, for the high-pass filter shown in Fig. 3.2, when v_{in} has a frequency of 20 kHz. (5 marks)

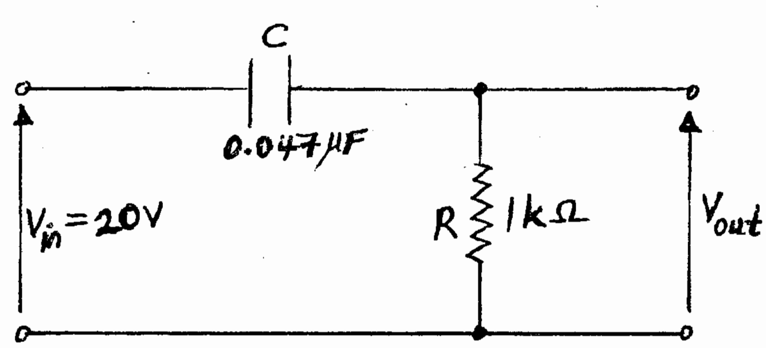

Fig. 3.2

QUESTION 4

(a) Fig. 4.1 shows the circuit diagram of an astable multivibrator.

(i) Discuss the principle of operation of this type of multivibrator. (Assume that the d.c. power supply is switched on, current rises faster in transistor T_1 in comparison with transistor T_2. (4 marks)

(ii) Draw a table and show the voltages at points A, B, C, and D. Sketch the waveforms observed at these points and label the diagrams fully. (12 marks)

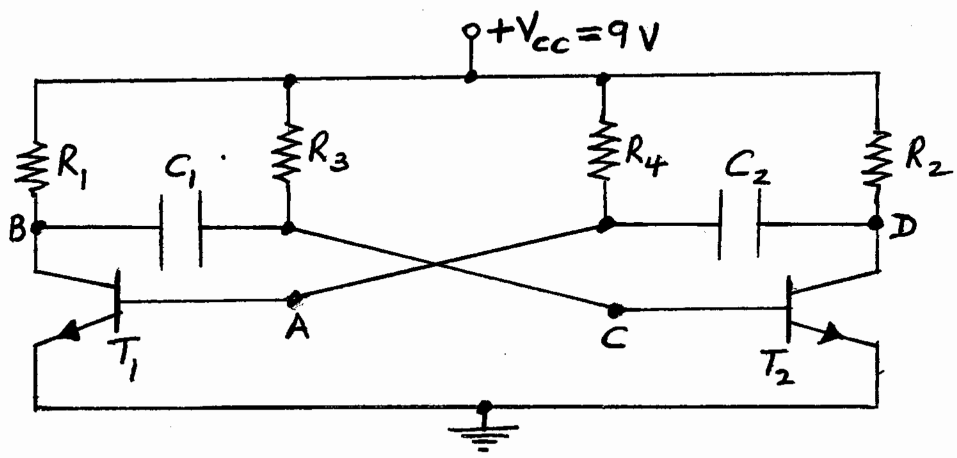

Fig. 4.1

(b) (i) Write an expression for the frequency of oscillation of a phase shift oscillator which consists of a BJT amplifier and a phase-shift ladder network. The ladder network is made up of equal resistors and equal capacitors. (2 marks)

(ii) Consider each of the capacitors to have a fixed capacitance $C = 0.01\ \mu F$ whilst each of the resistances can be varied from $2\ k\Omega$ to $200\ k\Omega$.

Calculate the minimum and maximum frequencies which can be generated by the oscillator. (4 marks)

(iii) Explain why the open-loop gain of the amplifier used in the phase shift oscillator must be greater than or equal to 29. (3 marks)

QUESTION 5

(a) With the aid of a circuit diagram and appropriate equations, explain how you would measure the input resistance of a device, such as an amplifier. (5 marks)

(b) For the low-pass filter shown in Fig. 5.1:

(i) Find the cut-off frequency, in Hertz. (2 marks)

(ii) Find the magnitude of v_o when v_i has a frequency 500 Hz, 1 kHz, and 2 kHz. (7 marks)

(iii) Using the values of v_o calculated in (ii), sketch v_o versus frequency. (3 marks)

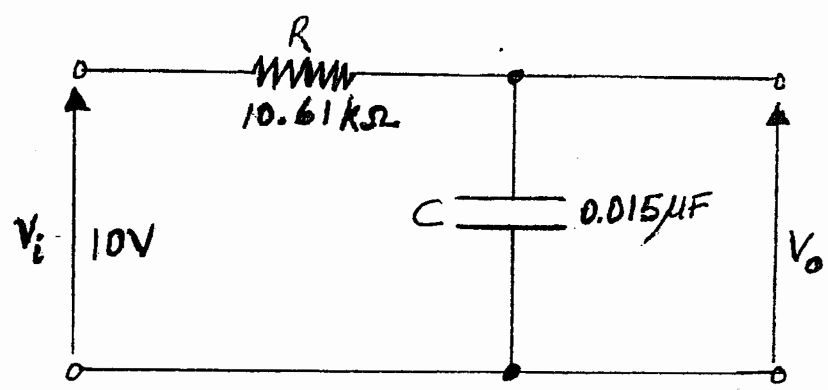

Fig. 5.1

(c) (i) Calculate v_{out} as a function of time for the circuit shown in Fig. 5.2, given that $v_{in} = A\sin\omega t$, $A = 500$ mV and $\omega = 100$ rad.s^{-1}. (4 marks)

(ii) Sketch graphs of v_{in} and v_{out} against time. (4 marks)

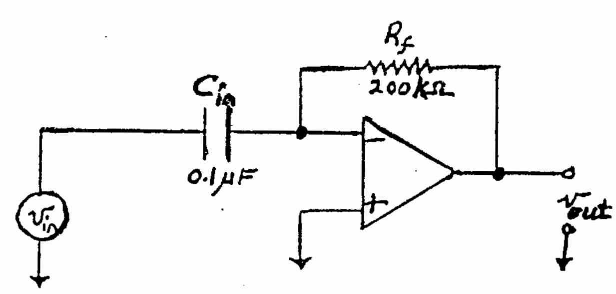

Fig. 5.2