UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2007/2008

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) Using an op-amp, design a circuit which corresponds to the following relationship between the input and output voltage, v_{in} and v_{out}.

$$v_{out} = -75\int v_{in}\,dt$$

Choose suitable values of R and C. (7 marks)

(b) (i) Draw a schematic diagram of an ideal operational adder with three inputs V_1, V_2 and V_3. Write an expression for the output voltage. (5 marks)

(ii) Calculate the output voltage of the adder given that the voltages V_1, V_2 and V_3 are each applied via the input resistors R_1, R_2 and R_3 respectively.
Let $V_1 = 1V$, $V_2 = -1V$, $V_3 = 2V$ and $R_1 = R_2 = R_3 = R_f = 100k\Omega$.
(2 marks)

(c) (i) Calculate v_0 as a function of time for an op-amp differentiator given that $v_{in} = A\sin\omega t$, where $A = 500$ mV, $\omega = 100$ rad.s^{-1}, $C_{in} = 0.1$ μF and $R_f = 200$ kΩ.
(6 marks)

(ii) Sketch v_{in} and v_{out}, as a function of time. Label the graphs fully.
(5 marks)

QUESTION 2

(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? (3 marks)

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

(b) (i) Derive a general expression for the high-pass filter shown in Fig. 2.1, in terms of the frequency, f and the cut-off frequency f_{co}. (7 marks)

(ii) Calculate the cut-off frequency in Hertz. (2 marks)

(iii) Find the magnitude of v_{out} when v_{in} has a frequency of 15 kHz, 40 kHz and 100 kHz. (10 marks)

QUESTION 3

(a) What is meant by inverse feedback? (2 marks)

(b) (i) With the aid of a diagram, derive a general expression relating the gain with feedback, A_f of an amplifier to the open loop gain A. Distinguish between the cases of negative and positive feedback. (8 marks)

(ii) Explain what the amplifier performance depends on when the feedback is negative and the loop gain is large. (3 marks)

(c) A wide-band amplifier has a gain of -1000 without feedback and -20 with negative feedback. Find:

(i) the feedback factor, β (4 marks)

(ii) the percentage reduction in gain with feedback if the gain without feedback falls by 40%. (8 marks)

QUESTION 4

(a) (i) State the Barkhauszen condition required for sinusoidal oscillations to be sustained. (2 marks)

(ii) A Wien bridge oscillator is made using bipolar junction transistors. Draw the circuit diagram of this type of oscillator and label it. (4 marks)

(iii) The Wien Bridge network shown in Fig. 4.1 is used to build a frequency-dependent sinusoidal oscillator. Describe the principle of operation of this oscillator. Mention the distinctive benefits of using this type of oscillator. (10 marks)

(b) (i) Explain why the amplifier used in a phase shift oscillator which utilises an RC ladder network must have a minimum gain of 29. (3 marks)

(ii) A phase shift oscillator has a variable capacitor ranging from 0.01 μF to 1 μF and a resistor R = 2 kΩ. Find the frequency range of the oscillator. (6 marks)

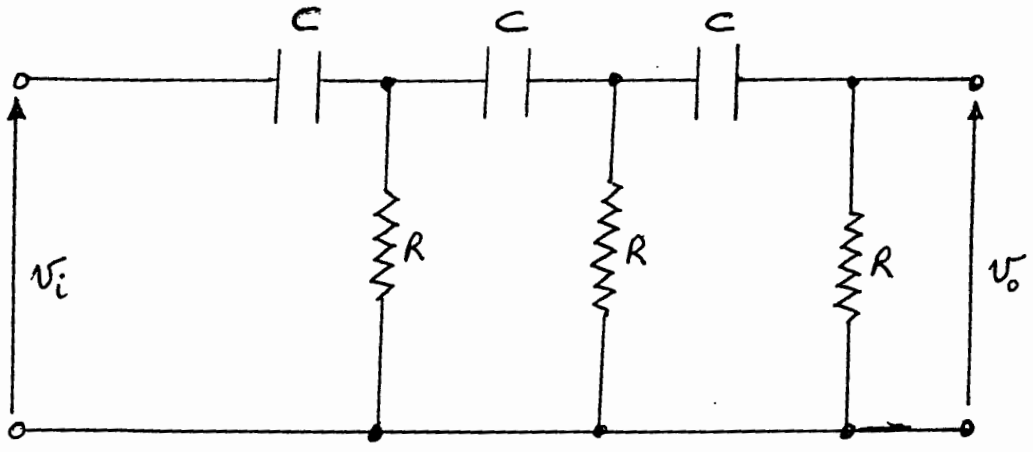

Fig. 4.1

QUESTION 5

(a) Fig. 5.1 shows a circuit consisting of a signal source. The source has an internal resistance R_s = 1 kΩ and generates a voltage V_s. It is connected to a voltage amplifier with an input resistance R_i = 1 kΩ.

(i) Determine the relationship between V_s and V_{in}. Comment on the relationship. (3 marks)

(ii) With the aid of a circuit diagram and mathematical analysis, determine the relationship between V_s and V_{in} when an emitter follower is connected as an interface between the signal source and the amplifier. Comment on the effect of the follower on voltage transfer. (7 marks)

(b) An operational amplifier utilises high current gain composite transistors in the gain stage. Demonstrate that the current gain of a Darlington pair consisting of composite transistors T_1 and T_2 of current gain h_{fe1} and h_{fe2} is given by

$$h_{fe} = h_{fe1} \times h_{fe2}$$ (5 marks)

(c) An amplifier has a voltage gain of -1000. If 3/100 of the output voltage is applied as negative feedback, calculate the change in overall gain if the gain without feedback falls by 50%. (10 marks)

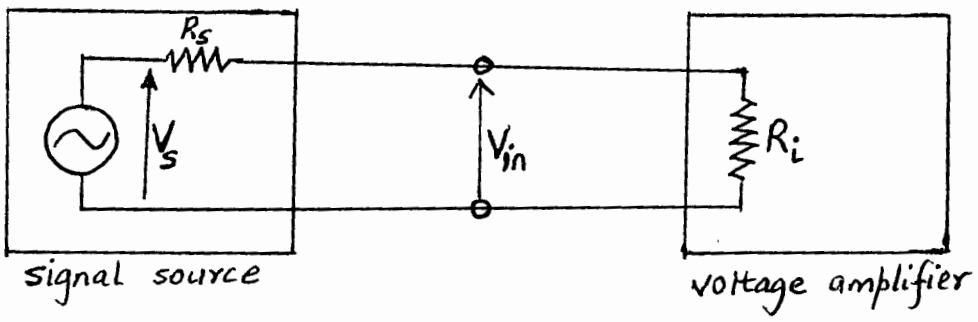

Fig. 5.1