UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE & ENGINEERING

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	:	2012/2013
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.

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

QUESTION 1

(a) Define the term 'inverse feedback' with respect to an amplifier. (2 marks)

(b) Consider a voltage amplifier with an open-loop gain of -500. Negative feedback is applied to the amplifier and the feedback factor is 5×10^{-3}. When the transistor used in this amplifier is replaced, due to ageing, the open-loop gain of the amplifier falls by 20%. What will be the percentage change in closed-loop gain as a result of the decrease in the open-loop gain. (10 marks)

(c) (i) Sketch the circuit of a phase-shift oscillator that utilises a Darlington pair, resistors and capacitors and explain how it works. (7 marks)

(ii) The attenuation coefficient of the RC ladder network of a phase shift oscillator is given by

$$B = \frac{1}{\left[1 - 5\lambda^2\right] + j\left[\lambda^3 - 6\lambda\right]},$$

where $\lambda = (\omega CR)^{-1}$ and the other symbols have their usual meanings.

Show that the frequency of oscillation of the oscillator is given by

$$f_0 = \frac{1}{2\pi\sqrt{6}RC}$$ (4 marks)

(iii) Find the numerical value of the attenuation coefficient at the frequency of oscillation. (2 marks)

QUESTION 2

(a) With reference to the circuit shown in Fig. 1, calculate the output voltage when $R_1 = R_2 = R_3 = 10\text{k}\Omega$, $R_4 = 100\ \text{k}\Omega$, $V_1 = 0.1$ V, $V_2 = 0.5$ V and $V_3 = 0.25$ V.
(4 marks)

(b) Calculate v_{out} as a function of time for an op-amp differentiator, given that $v_{in} = A\sin \omega t$, where A = 500 mV, $\omega = 100$ rads^{-1}, $C_{in} = 0.1\ \mu$F and $R_f = 200\ \text{k}\Omega$. (6 marks)

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

(c) (i) Sketch the circuit diagram of a logarithmic amplifier which utilises a pn diode.
(2 marks)

(ii) Derive an expression to show that the output voltage, V_{out} of a logarithmic amplifier is proportional to the logarithm of the input voltage, V_{in} as follows:

$$V_{out} = -\eta V_T \ln\left(\frac{V_{in}}{I_S R}\right)$$

where the symbols have their usual meanings. (8 marks)

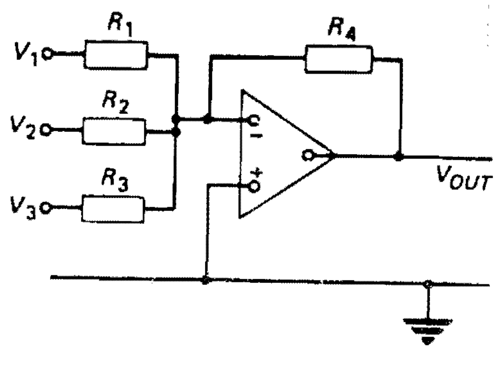

Fig. 1

QUESTION 3

(a) Show that the magnitude of the transfer function of the band-reject filter shown in Fig. 2 is given by the following relationship:

$$|H(s)| = \frac{1}{\sqrt{1+\left[\frac{\omega L}{R} - \frac{1}{\omega RC}\right]^{-2}}}$$ (6 marks)

(b) Given the values of the components shown in Fig. 2, calculate the following:

(i) the resonant frequency, f_0 of the filter; (3 marks)

(ii) the quality factor, Q_S; (3 marks)

(iii) the cut-off frequencies, f_1 and f_2. (5 marks)

(iv) the bandwidth, BW. (2 marks)

(c) For the high-pass filter shown in Fig. 3,

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

(ii) Find the phase angle between v_{out} and v_{in}, when v_{in} has a frequency of 20 kHz. (3 marks)

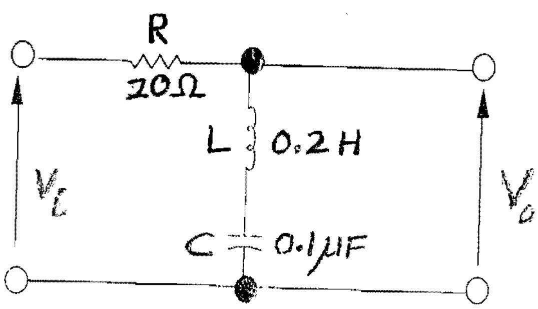

Fig. 2

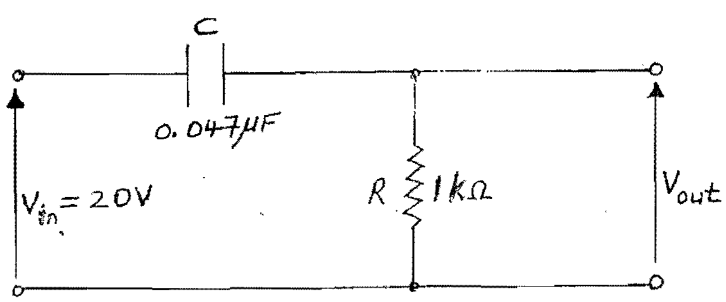

Fig. 3

QUESTION 4

(a) (i) Draw the circuit diagram of an emitter follower. (2 marks)

(ii) With the aid of the small signal equivalent circuit, derive an expression for the voltage gain of the emitter follower. (10 marks)

(iii) Show that the output resistance of the emitter follower is given by

$$R_0 = \frac{r_\pi + R_S}{h_{fe} + 1}$$

where r_π represents the input resistance of the transistor
R_S is the internal resistance of the voltage source and
h_{fe} is the current gain of the transistor. (7 marks)

(b) A common-collector amplifier has a load resistance of 2.7 kΩ. The a.c. current gain and input resistance of the transistor in the amplifier are 200 and 700 Ω, respectively. The internal resistance of the voltage source is 600 Ω. Calculate the voltage gain and output resistance of the amplifier. (6 marks)

QUESTION 5

(a) Use operational amplifiers to design circuits which correspond to the following ideal relationships between the output and input voltages.

(i) $v_{out} = 500\int v_{in(1)}dt + \left(3 \times 10^{-3}\right)\frac{dv_{in(2)}}{dt}$ (13 marks)

(ii) $v_{out} = -10v_{in(1)} + 5v_{in(2)} - 20v_{in(3)}$ (8 marks)

Label the circuit diagrams you have designed, showing the values of the components used.

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

(4 marks)

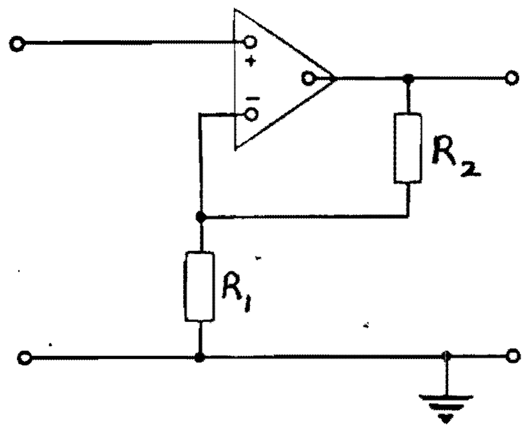

Fig. 4