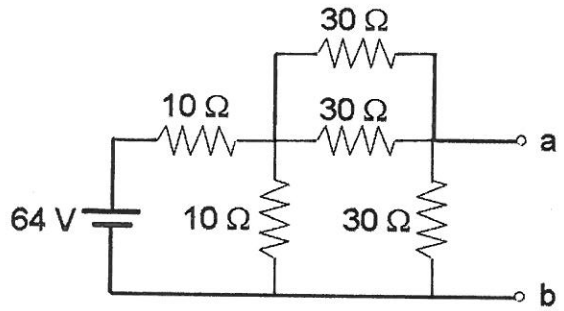
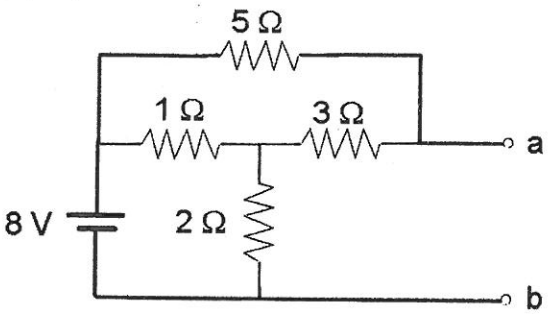
1. (15%) Determine the Thevenin equivalents of the following circuits as seen from nodes a and b.

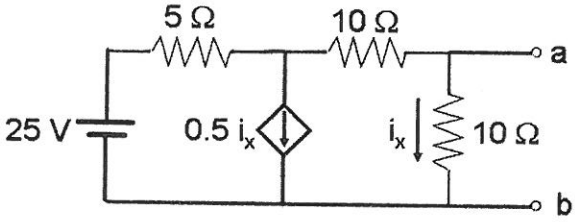
(a) (5%)



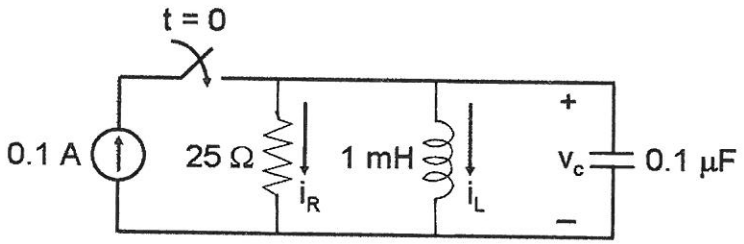
(b) (5%)



(c) (5%)



2. (25%) Consider the following RLC circuit with initial values $i_L(0^-) = 0$ and $v_c(0^-) = 0$.



(a) (5%) Without solving the governing differential equation, determine $i_L(0^+)$, $v_c(0^+)$, and $i_R(0^+)$ immediately after the switch was turned on at t = 0. Justify your answer.

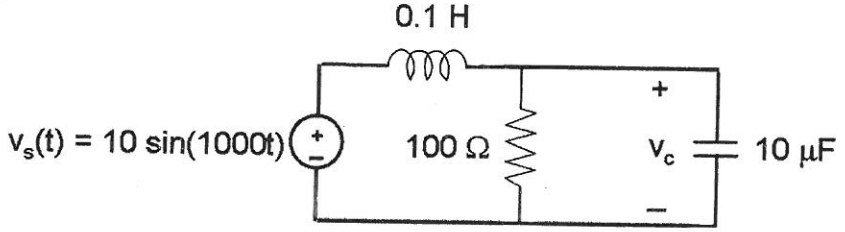
(b) (5%) Without solving the governing differential equation, determine the steady states of $i_L(t)$, $v_c(t)$, and $i_R(t)$ as t goes to infinity. Justify your answer.

(c) (5%) Write down the governing differential equation of the circuit in terms of $v_c(t)$.

(d) (5%) What are the natural frequency and damping ratio of the circuit.

(e) (5%) Solve explicitly for $v_c(t)$, $t > 0$.

3. (10%) Consider the following RLC circuit.

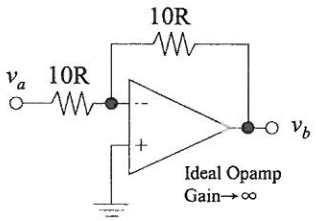


(a) (5%) Express the circuit in terms of phasor and impedance.

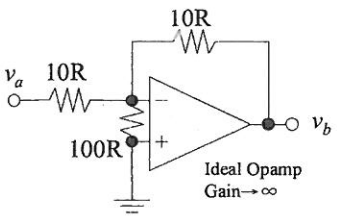
(b) (5%) Determine the phasor and corresponding time function of $v_c(t)$.

4. (22%) Find the small signal gain $\frac{\hat{v}_b}{\hat{v}_a}$ for each of the following circuits.

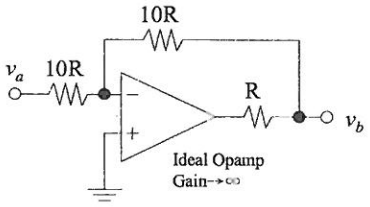
(a) (4%)



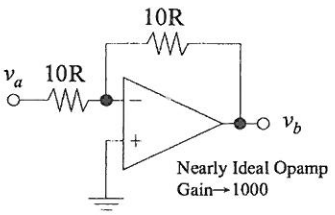
(b) (4%)



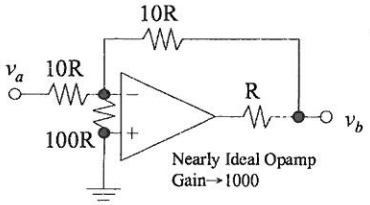
(c) (4%)



(d) (5%)



(e) (5%)



5. (12%) A common-source amplifier with its corresponding input and output waveforms are shown in Fig. 5-1. The input signal (v_a) is a 1V peak to peak sinusoid biased at V_{OP} with 500 μs period; the output signal (v_b) is also a sinusoid signal with the same frequency but nearly 180 degree phase shift. R_0=30 kΩ and R_1=20 kΩ. The drain characteristic (I-V curve) of MOSFET (M) is shown in Fig. 5-2. For each question in the follows, please select the best answer from the provided options. Remember to provide justifications for your answers.

(a) (4%) What is the value of R_2 ? (A) $1k\Omega$; (B) $2k\Omega$; (C) $3k\Omega$; (D) $5k\Omega$.

(b) (4%) What is the value of the capacitor C? (A) $1\mu F$; (B) $1nF$; (C) $1pF$; (D) $1fF$.

(c) (4%) What is the value of the MOSFET threshold voltage V_{TH}? (A) 3.2V; (B) 1.5V; (C) 0.7V; (D) 0.2V.

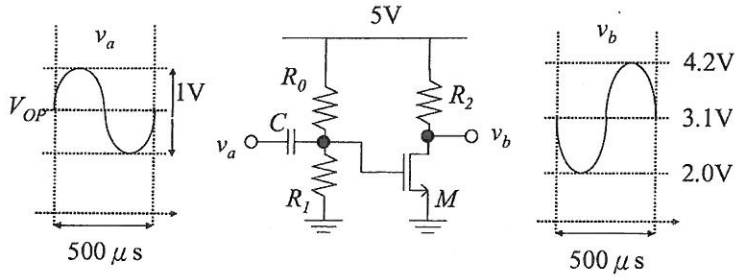


Fig. 5-1

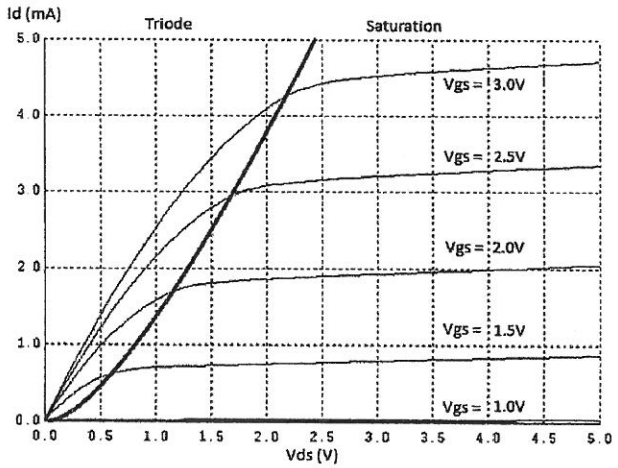


Fig. 5-2

6. (16%) Now, replace the circuit in Fig. 5-1 with the one in Fig. 6. The input (v_a) and output signals (v_b) are same as those in Problem 5. The drain characteristics of both MOSFETs (M) are the same and shown in Fig. 5-2. Both pnp transistors (Q) are operated in linear-active region with the base-emitter voltage V_{BE}=0.7V and the collector to base current gain β=10. The voltage drop of the diode (D) is 1V (V_D=1V). R_3=10kΩ and R_4=4kΩ. For each question in the following, please select the best answer from the provided options. Remember to provide justifications for your answers.

(a) (4%) What it the value of V_{op}? (A)2.7V; (B)3.0V; (C)0.7V; (D)4.0V.

(b) (4%) What is the DC value of v_c? (A) 3.2V; (B) 2.1V; (C) 1.0V; (D) 3.6V.

(c) (4%) What is the DC value of load current i_L? (A) 10mA; (B)11mA; (C) 12mA; (D) 110mA.

(d) (4%) If R_3 is removed, what is the possible DC value of v_c? (A) 3.2V; (B) 2.1V; (C)1.0V; (D) 3.6V.

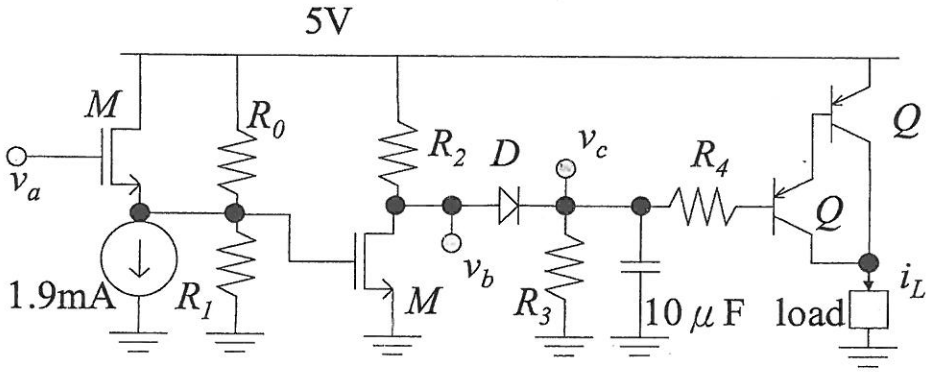


Fig. 6