1. (30%) In each of the following 10 questions about operational amplifier (op-amp) circuits, pick up the best from the underlined five options and write it (A, B, C, D, or E) to the answer sheet.

(1) An analog computer is usually **not** comprised of (A) operational amplifiers (B) inductors (C) resistors (D) capacitors (E) voltage regulators as components.

(2) Inside an active filters or analog computers, why are operational amplifiers always constructed of *negative feedback* (i.e. the output port is connected back to the inverting input port), instead of positive feedback or no feedback? For (A) wider bandwidth (B) adjustable gains (C) rejection of DC noises (D) removing load-effects (E) closed-loop system stability.

(3) Which of the following is **not** the advantage of op-amps circuits over passive AC circuits serving signal processing? (A) The former is free of load effects (B) The latter needs power supply (C) Every transfer function of non-minimum phase can be implemented by the former (D) The former has communication ports to microcontrollers (E) The latter is merely for low-pass filters.

(4) Instrumentation amplifiers are more popular than one-layer differential amplifiers to obtain the same gains, mainly because the former (A) can reject AC noises (B) has better impedance matching (C) is of virtual grounding (D) is with wider bandwidths (E) free of DC noises.

(5) An op-amp circuit usually plays as a (A) voltage rectifier (B) linear compensator (C) power converter (D) power supply (E) current amplifier in signal processing.

(6) An analog computer does **not** consist of (A) integrators (B) differentiators (C) summing amplifiers (D) constant-gain amplifiers (E) power supply in practice.

(7) To layout a differentiator with op-amp circuit is usually difficult, since the (A) bandwidth (B) power rating (C) DC power supply (D) allowable gain (E) time constant of an operational amplifier is **not** infinite.

(8) The AC electrical characteristic of an op-amp is comprised of (A) slew rate (B) phase margin (C) input offset voltage (D) current leakage (E) power rating.

(9) The DC electrical characteristic of an op-amp is **not** comprised of (A) bias voltage (B) offset voltage (C) time constant (D) resistance variations with temperature (E) power supply currents.

(10) Operation amplifiers are often included into controller design of modern days to (A) implement transfer functions of targeted dynamics (B) do signal conditioning (C) be components of power supply to microcontrollers (D) filter white-noises out of the signal channels (E) amplify the power of signals.

2. (10%) Find the equivalent impedance shown in Fig. 1 at the frequency ω equal to 100 rad/sec.

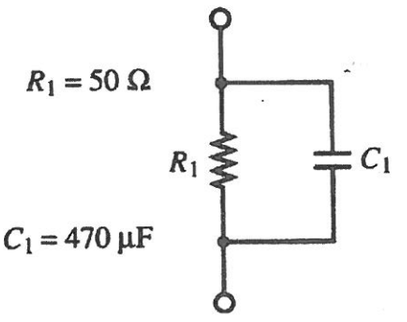

Fig. 1

3. (15%) Figure 2 shows the AC circuit where the **initial conditions** are given as $v(0)$=10V and $i(0)$=0. v is the voltage across the capacitance and i is the current flowing through the inductor.
(a) (5%) Write the ordinary differential equation (ODE) for the circuit by using the current i as the variable.
(b) (10%) Please find the $i(t)$ for $t>0$

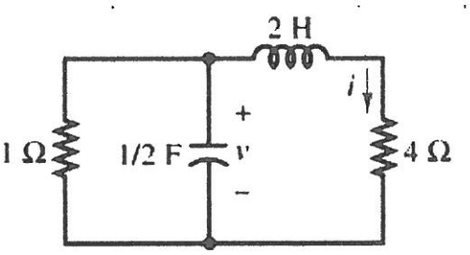

Fig. 2

4. (25%) A common-emitter BJT amplifier is shown in Fig. 3. The transistor has the following *h* parameters: h_{ie}=1,400Ω, and h_{oe}=125μs. The values of the other parameters are shown in Fig. 3. The BJT circuit can be represented by its equivalent circuit model shown in Fig. 4. Please answer the following questions.

(a) (5%) Determine the value of R_B in Fig. 4.

(b) (10%) Find the value of input resistance r_i and output resistance r_o

(c) (10%) Find the actual voltage gain A_v and the current gain A_i.

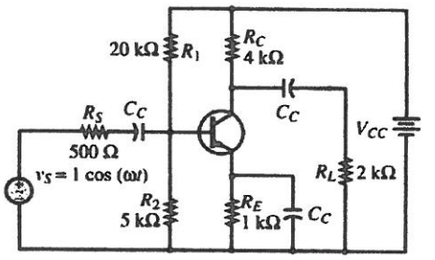

Fig. 3

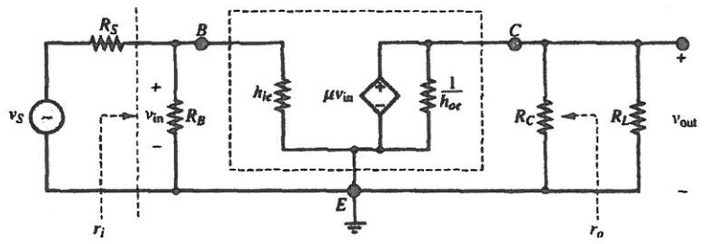

Fig. 4

5. (20%) Apply Mesh Current method to analyze the circuit of Fig. 5, wherein the current i_3 can be formulated by:

$$i_3 = CR^{-1}Bu,$$

where the 3×3 matrix R represents general resistance as $C=[0 \quad 1 \quad -1]$ and $B=[1 \quad 0 \quad 0]^T$.

(a) (13%) What is the resistance matrix R in terms of R_1 R_2, R_3, R_4 and R_5?

(b) (2%) Is the matrix R positive-definite? Prove your answer.

(c) (5%) Show the principle of symmetry: there is no current through the resistance R_3, i.e. $i_3=0$, whenever $R_1=R_2$ and $R_4=R_5$.

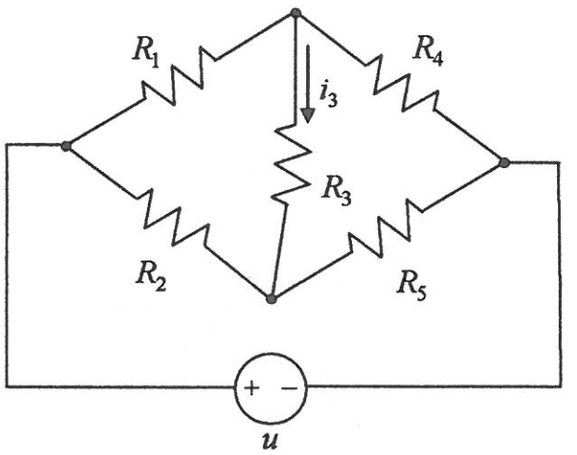

Fig. 5