1. (30%) Consider the circuit shown in Fig. 1(a).
    (a) (10%) Please find the current i flowing through the resistor $5\,\Omega$.
    (b) (20%) Consider now that a load resistor is added to the circuit, as shown in Fig. 1(b).
    We want to design the load resistance R_L such that it will receive maximum power.
    Please give a procedure for finding R_L. **Note:** You do **not** need to find the value of
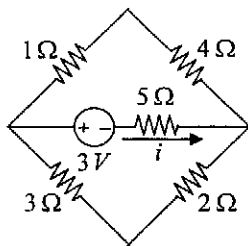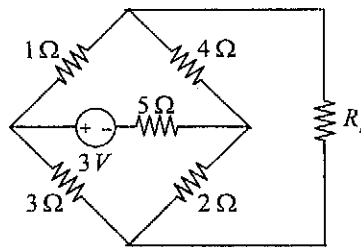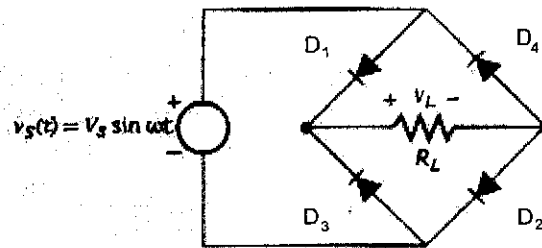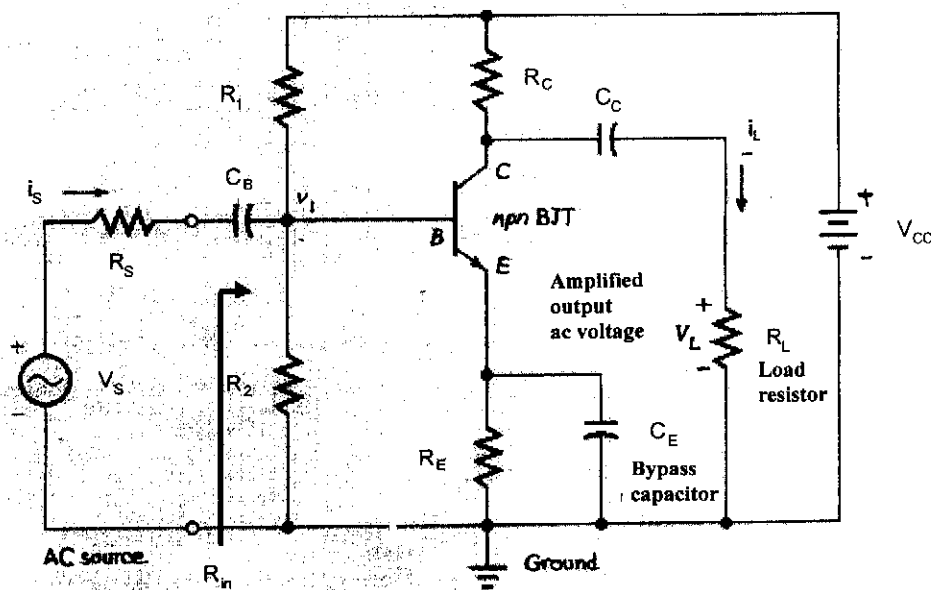 R_L. Only a procedure is required.

Fig. 1(a)　　　　　　　Fig. 1(b)

2. (10%) Consider the following bridge rectifier. Describe its action as a full-wave rectifier, assuming the diodes to be ideal. In the figure, the input $v_s(t) = V_s \sin \omega t$.

3. (20%) Consider the following BJT circuit.

(a) (5%) Describe the purpose of the capacitors C_B, C_C, and C_E

(b) (10%) Let $V_{CC} = 10$ V, $R_1 = 18$ kΩ, $R_2 = 2$ kΩ, $R_C = 1$ kΩ, $R_E = 100$ Ω. When $V_s = 0$.

Estimate the collector current (i.e., the current flowing into the collector) and V_{CE} of the

BJT by assuming $i_B \approx 0$ and $V_{BE} \approx 0.5$ V.

(c) (5%) Draw the small-signal AC equivalent circuit of the BJT circuit.

4. (24%) Figure 4 shows an active circuit comprising Operational Amplifiers.

   (a) (8%) Prove that this circuit, with input voltage e and output voltage u, functions as a phase-lead or phase-lag compensator.

   (b) (8%) Choose parameters: R_1, R_2, R_3, R_4, C_1 and C_2, so that the transfer function of this circuit becomes $C(s) \equiv \dfrac{U(s)}{E(s)} = \dfrac{s+100}{s+10}$.

   (c) (8%) Sketch the frequency response of the compensator $C(s)$ in (b) by means of Bode plot.
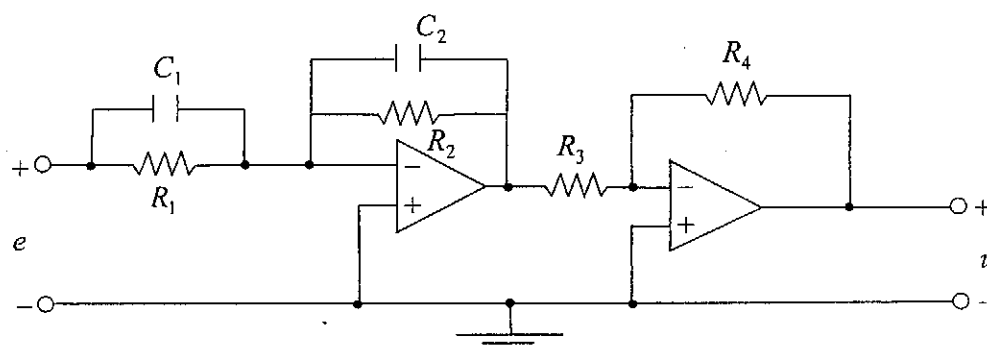

Figure 4. Lead or lag compensator

5. (16%) Answer the following fundamental questions about op-amp circuits:

   (a) (8%) In active filters or analog computers, why is any operational amplifier always of *negative feedback* (i.e. the output is connected back to the Inverting input), instead of positive feedback or no feedback?

   (b) (8%) Under what conditions are active compensators in place of passive filters to do signal processing?