Note: Problems 1-6 are from the Kassakian et al text.

1) Construct a regulation curve for the circuit of Fig. 3.9 if we replace $L_C$ with a resistor of value $R_C = X_C$.

![Circuit Diagram](image)

Figure 3.9  (a) A half-wave rectifier with commutating inductance $L_c$. (b) The behavior of branch variables.

2) Figure 3.19 is a schematic drawing of a full-wave, centertapped rectifier. The two ac sources are usually created by a transformer with a centertapped secondary winding.

(a) Assume that $L_C = 0$ and sketch $v_d(t)$.

(b) Determine and sketch $i_{d_1}$ and $i_{d_2}$ for $0 < \omega t < 2\pi$. 
(c) Determine and sketch the load regulation curve for this circuit and compare it quantitatively to that in Fig. 3.12 for the half-wave rectifier of Fig. 3.9.

![Fig. 3.19](image)

**Figure 3.19** The full-wave, centertapped rectifier of Problem 3.10.

3) In some applications a rectifier is supplied from an ac current source instead of a voltage source. If the frequency is high enough, the junction capacitance of the rectifiers has an appreciable effect on the dc output current. Consider the circuit of Fig. 4.21, in which the diode junction capacitance $C_j$ has been modeled as constant and in parallel with an ideal diode. Determine the load regulation characteristic for this circuit,

$$i_d = f \left( \frac{V_d}{X_j I_s} \right)$$

where $X_j$ is the reactance of the junction capacitance $X_j = 1/\omega C_j$. The junction capacitance of a 20 A, 100 V Schottky diode is approximately 200 pF. At what frequency would you expect the effects of $C_j$ to become important?

![Fig. 4.21](image)

**Figure 4.21** The current-fed bridge rectifier of Problem 4.12, including the diode junction capacitances $C_j$, which have an important effect at high frequencies.
4) Figure 20.24 represents the basic operating principle of a self-oscillating, or regenerative, inverter. The transformer core is made of a highly permeable square-loop material. A square-loop magnetic material is one that exhibits a sharply defined saturation region. The sense winding senses when the core enters saturation. One switch is always on, and the switches change state when saturation is reached. For example, if \( S_1 \) is on, the core is being driven toward \(+B_S\) and the output voltage is \( (N_2/N_1)V_{dc} \). When saturation is reached, the sense winding signals the control circuit which turns \( S_1 \) off and \( S_2 \) on. The derivative of the flux now changes sign, and the output voltage is \(- (N_2/N_1)V_{dc} \).

The core on which the transformer is wound is a toroid with the parameters shown in Figure 20.24. If \( V_{dc} = 100 \text{ V} \), how many primary turns, \( N_I \) are necessary to yield an output frequency of 25 kHz?

![Figure 20.24](image)

5) A three-winding transformer is constructed on a three-legged core, as shown in Fig. 20.25(a). The cross-sectional area of the core is uniform, and the windings have \( N_1, N_2, \) and \( N_3 \) turns. Winding \( N_3 \) is terminated in a resistor of value \( R \). If sinusoidal voltages with amplitudes \( V_1 \) and \( V_2 \) are applied to windings \( N_1 \) and \( N_2 \), respectively, what is the amplitude \( I_3 \) of the current \( i_3 \) in winding \( N_3 \)? Assume that no leakage occurs.
6) The three legs of the transformer of Problem 20.11 are now modified to have uniform gaps as shown in Fig. 20.25(b). Assuming that the permeability of the core is infinite, determine the amplitude of the currents $i_1$ and $i_2$ in terms of $V_1$, $V_2$, $N_1$, $N_2$ and $\omega$. (Hint: Use a circuit analog and make sure that your answer does not depend on the core cross section.)

7) As shown below, an electromagnet is to be used to lift a 130-kg slab of iron. The surface roughness of the iron is such that when the iron and the electromagnet are in contact, there is a minimum air gap of 0.015 cm in each leg. The coil resistance is 3Ω. Calculate the minimum coil voltage which must be used to lift the slab against the force of gravity. Neglect the reluctance of the iron.
8) A long, thin solenoid of radius $r_0$ and height $h$ is shown below. The magnetic field inside such a solenoid is axially directed and essentially uniform and equal to $H = Ni/h$. The magnetic field outside the solenoid is negligible. Calculate the radial pressure in newtons per square meter acting on the sides of the solenoid for constant coil current $i = I_0$. 

![Solenoid coil diagram]