1. Solve the differential equation (10 分)
\[ y' = (y + 4x)^2. \]

2. Solve the differential equation (15 分)
\[ y'' - 4y' + 4y = (x + 1)e^{2x}. \]

3. Find the eigenvalues and eigenvectors of (15 分)
\[ A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}. \]

4. Solve the initial value problem by the Laplace transform. (15 分)
\[ y'' + 16y = \cos 4t, \quad y(0) = 0, \quad y'(0) = 1 \]

5. Find out what type of conic section the given quadratic form represents and transform it to principal axes: (15 分)
\[ 3x_1^2 + 4\sqrt{3}x_1x_2 + 7x_2^2 = 9. \]

6. Evaluate the principal value (15 分)
\[ \int_{-\infty}^{\infty} \frac{dx}{(x^2 - 3x + 2)(x^2 + 1)}. \]

7. Find the Fourier series of the following function. (15 分)
\[ f(x) = x^2 \quad \text{if} \quad 0 < x < L \]
1. For the circuit in Fig. 1, let $\beta=100$. (a) Find $R_{TH}$ and $V_{TH}$ for the base circuit. (10%) (b) Determine $I_{CQ}$, $V_{CEQ}$. (10%)

2. Obtain the simplified expressions in sum of products for the following Boolean functions: (20%)
   (a) $F(A, B, C, D, E) = \Sigma(0, 1, 4, 5, 16, 17, 21, 25, 29)$
   (b) $F(A, B, C, D, E) = \overline{BDE} + \overline{B} \overline{C} \overline{D} + CDE + \overline{A} \overline{B} \overline{C} \overline{E} + \overline{A} \overline{B} \overline{C} + \overline{B} \overline{C} \overline{D} \overline{E}$

3. Design a circuit of vote machine for five persons. “0” represents opposition, “1” represents agreement. (20%)

4. Describe an intrinsic semiconductor material and calculate the intrinsic carrier concentration in Gallium arsenide at $T=300 \, ^\circ K$. (10%)

5. Describe an extrinsic semiconductor material and calculate the thermal equilibrium electron and hole concentrations for considering Gallium arsenide at $T=300 \, ^\circ K$ doped with nitrogen at a concentration of $10^{10} \, cm^{-3}$. (10%) What is the type for the semiconductor material? (5%)

6. Determine the small-signal voltage gain of a multistage cascade circuit. Consider the circuit shown in Fig. 2. The transistor parameters are $K_{n1}=0.5 \, mA/V^2$, $K_{n2}=0.2 \, mA/V^2$, $V_{TN1}=V_{TN2}=1.2 \, V$, and $\lambda_1=\lambda_2=0$. The quiescent drain currents are $I_{D1}=0.2 \, mA$ and $I_{D2}=0.5 \, mA$. (15%)

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**Fig. 1**

**Fig. 2**
1. A positive point charge $Q$ is at the center of a spherical dielectric shell of an inner radius $R_i$ and an outer radius $R_o$. The dielectric constant of the shell is $\varepsilon_r$. Determine $E$, $V$, $D$, and $P$ as functions of the radial distance $R$. (20 points)

2. Determine the capacitance per unit length between two long, parallel, circular conducting wires of radius $a$. The axes of the wires are separated by a distance $D$. (15 points)

3. An unchanged metal sphere of radius $R$ is placed in an otherwise uniform field $\vec{E} = E_0\hat{a}_z$. Find the potential in the region outside the sphere. (15 points)

4. By using stored magnetic energy, determine the inductance per unit length of an air coaxial transmission line that has a solid inner conductor of radius $a$ and a very thin outer conductor of inner radius $b$. (15 points)

5. Consider the magnetic circuit. Steady currents and flow in windings of $N_1$ and $N_2$ turns,
respectively, on the outside legs of the ferromagnetic core. The core has a cross-sectional area $S_c$ and a permeability $\mu$. Determine the magnetic flux in the center leg. (10 points)

6. An infinitely long straight wire carries a slowly varying current $I(t)$. Determine the induced electric field, as a function of the distance $s$ from the wire. (10 points)

7. An $h$ by $w$ rectangular conducting loop is situated in a changing magnetic field $\vec{B} = \hat{a}_y B_0 \sin \omega t$. The normal of the loop initially makes an angle $\alpha$ with $a_x$. Find the induced emf in the loop: (a) when the loop is at rest (5 points); (b) when the loop rotates with an angular velocity $\omega$ about the $x$-axis (10 points).