Problem 1 (6 points)
For \( a = 0 \), \( b = 1 \) and \( c = 1 \), give the results of each of the following logical operations:

(a) \( d = a \lor (b \land c) = 0 \lor (1 \land 1) = 0 \lor 1 = 1 \)

(b) \( e = \text{and}(a, b) \lor c = \text{and}(0, 1) \lor 1 = 0 \lor 1 = 1 \)

(c) \( f = (a \land c) \lor (b \land \neg a) = (0 \land 1) \lor (1 \land \neg 0) = 0 \lor 1 = 1 \)

(d) \( g = (a \land b) \lor (c \land \neg b) = (0 \land 1) \lor (1 \land \neg 1) = 0 \lor 0 = 0 \)

(e) \( h = (b \land c) \lor (b \lor a) = (1 \land 1) \lor (1 \lor 0) = 1 \lor 1 = 1 \)

(f) \( q = a \lor \text{or}(\neg b, c) = 0 \lor \text{or}(\neg 1, 1) = 0 \lor 1 = 0 \)

Problem 2 (4 points)
We are given the voltage signal \( v(t) = 2 \cos(10\pi t) \) Volts. Draw a sketch of \( v(t) \) showing three cycles and only three cycles. Include the vertical and horizontal labels and scales for the axes.

Amplitude \( A = 2V \) (range from 2V to -2V)

Angular frequency \( \omega = 10\pi \) rad/s

Frequency \( f = \frac{\omega}{2\pi} = 5 \) Hz (5 cycles per second)

Period \( T = \frac{1}{f} = 0.2s \) (duration of 1 cycle)
Problem 3 (7 points)
You are given the circuit shown below with the dc (constant) voltage source \( V_{in} = 7\text{V} \) and resistors \( R_1 = 5\Omega \) and \( R_2 = 8\Omega \). Given this information, answer the following questions (using the correct units):

(a) Find \( I_1 \).
\[ I_1 = I = \frac{7}{13} \text{A} \]

(b) Find \( I_2 \).
\[ I_2 = I = \frac{7}{13} \text{A} \]

(c) Find \( V_1 \).
\[ \text{Ohm's Law } \Rightarrow V_1 = R_1 I_1 = 5\Omega \left( \frac{7}{13} \text{A} \right) = \frac{35}{13} \text{V} \]

(d) Find \( V_2 \).
\[ \text{Ohm's Law } \Rightarrow V_2 = R_2 I_2 = 8\Omega \left( \frac{7}{13} \text{A} \right) = \frac{56}{13} \text{V} \]

(e) What is the power dissipated in resistor \( R_1 \)?
\[ P_{diss, R_1} = V_1 I_1 = \left( \frac{35}{13} \text{V} \right) \left( \frac{7}{13} \text{A} \right) = \frac{245}{169} \text{W} \]

(f) What is the power dissipated in resistor \( R_2 \)?
\[ P_{diss, R_2} = V_2 I_2 = \left( \frac{56}{13} \text{V} \right) \left( \frac{7}{13} \text{A} \right) = \frac{392}{169} \text{W} \]

(g) How much power is being dissipated in the voltage source \( V_{in} \)?
\[ P_{diss, V_{in}} = V_{in} I_{in} = (7\text{V}) \left( \frac{7}{13} \text{A} \right) = \frac{-49}{13} \text{W} \]

Problem 4 (3 points)
Consider the following circuit with generic elements whose voltages and currents are marked as shown.

(a) Write a KVL equation in the left loop.
\[ V_2 + V_1 - V_4 - V_3 = 0 \]

(b) Write a KVL equation in the right loop.
\[ -V_7 + V_4 + V_5 - V_6 = 0 \]

(c) Write a KCL equation at node \( a \).
\[ \sum i_{out} = 0 \]
\[ I_5 - I_1 - I_4 = 0 \]
Problem 5 (7 points)
You are given the following matrices:

\[ A = \begin{bmatrix} 2 & -1 & 2 \\ -2 & 1 & 0 \\ -1 & 1 & -2 \end{bmatrix}, \quad B = \begin{bmatrix} -2 & 1 \\ 1 & 0 \\ -1 & 2 & -4 \end{bmatrix}, \quad C = \begin{bmatrix} 3 & 2 & -1 \\ -1 & 2 & 4 \end{bmatrix}, \quad x = \begin{bmatrix} 2 \\ 1 \\ -4 \end{bmatrix} \]

(a) Matlab is used to find \( D = B' \ast A \ast C' \). What is the dimension of \( D \)?

\[ \text{dimension of } D = (2 \times 3)(3 \times 3)(3 \times 2) \Rightarrow 2 \times 2 \]

(b) What does Matlab return as an answer to \( E = \text{size}(B) \)?

\[ 3 \times 2 \]

(c) What does Matlab return as an answer to \( F = \text{size}(C) \)?

\[ 2 \times 3 \]

(d) What does Matlab return as an answer to \( g = \text{min}(x) \)?

\[ -4 \]

(e) What does Matlab return as an answer to \( h = 1 \times x \)?

\[ \begin{bmatrix} 0.5 \\ 1 \\ -0.25 \end{bmatrix} \text{ or } \begin{bmatrix} 0.5 \\ 1 \\ -0.25 \end{bmatrix} \]

(f) What does Matlab return as an answer to \( P = C' \ast x \)?

\[ \text{dimension of } P = (2 \times 3)(3 \times 1) \Rightarrow 2 \times 1 \]

\[ P = \begin{bmatrix} 3 & 2 & -1 \\ -1 & 2 & 4 \end{bmatrix} \begin{bmatrix} 2 \\ 1 \\ -4 \end{bmatrix} = \begin{bmatrix} 6 + 2 + 4 \\ -2 + 2 - 16 \end{bmatrix} = \begin{bmatrix} 12 \\ -16 \end{bmatrix} \]

Problem 6 (3 points)
Consider the following circuit.

The two 20\Omega resistors are in parallel

\[ 20 \parallel 20 = \frac{(20)(20)}{20 + 20} = \frac{400}{40} = 10\Omega \]

\[ 30V \quad \underline{\begin{array}{c} \text{I}_x \\ \text{5\Omega} \end{array}} \quad 10\Omega \Rightarrow 30V \quad \underline{\begin{array}{c} \text{315\Omega} \end{array}} \]

\[ \text{Note that } V_x = 5I_x = 10V \]

(a) Determine the current \( I_x \).

\[ \text{Ohm's law } \Rightarrow \text{I}_x = \frac{30V}{15\Omega} = 2A \]

(b) How much power is dissipated in the 5\Omega resistor?

\[ P_{\text{diss}, 5\Omega} = V_x I_x = (10V)(2A) = 20W \]

or \[ P_{\text{diss}, 5\Omega} = (5\Omega)I_x^2 = 5(2A)^2 = 20W \]
Problem 7 (4 points)
Determine output y for all combinations of the input a and b to complete the truth table.

<table>
<thead>
<tr>
<th>a</th>
<th>b</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Each set of numbers is to be read from left to right. For example, \((a=0, b=0)\) is the leftmost set and represent the 1st row of the table.

Problem 8 (3 points)
Design a logic circuit with two inputs a and b and a single output y that implements the following logic expression \(y = (\overline{a} + b) \cdot (a + \overline{b})\). You are allowed to use all standard gates (AND, OR, NOT, NAND, NOR).

Problem 9 (3 points)
Design a logic circuit with two inputs a and b and a single output y that implements the following logic expression \(y = (a \cdot \overline{b}) + (\overline{a} \cdot b)\). You are allowed to use all standard gates (AND, OR, NOT, NAND, NOR).