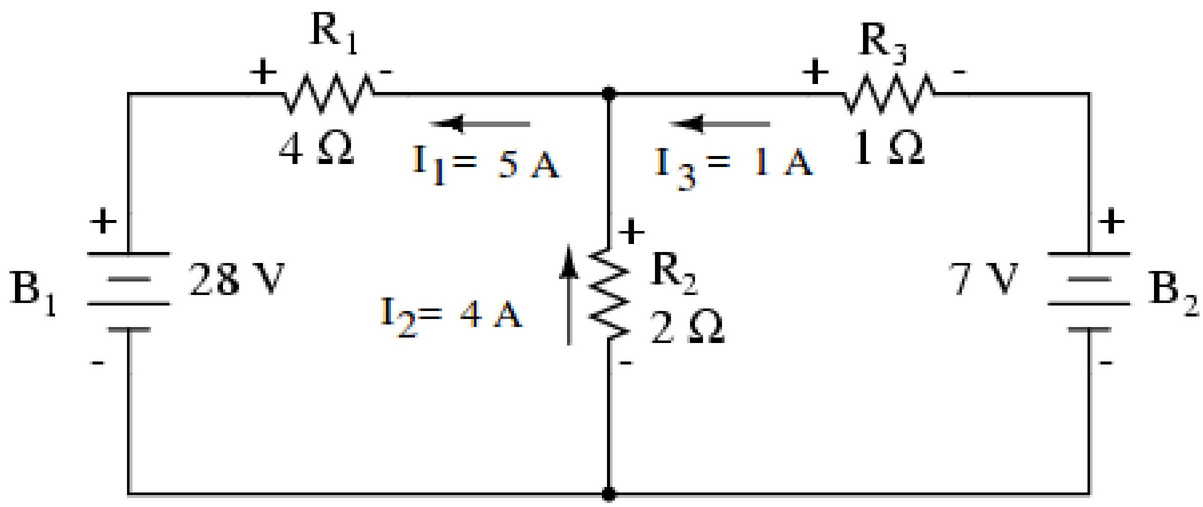
Sample Quiz 6

Sample Quiz6 Problem 1. **Resistive Network** with 2 Loops and DC Sources.



The **Branch Current Method** can be used to find a 3×3 linear system for the **branch currents** I_1, I_2, I_3.

$$\begin{array}{rcrcrcrl} I_1 & - & I_2 & - & I_3 & = & 0 & \text{KCL, upper node} \\ 4I_1 & + & 2I_2 & & & = & 28 & \text{KVL, left loop} \\ & & 2I_2 & - & I_3 & = & 7 & \text{KVL, right loop} \end{array}$$

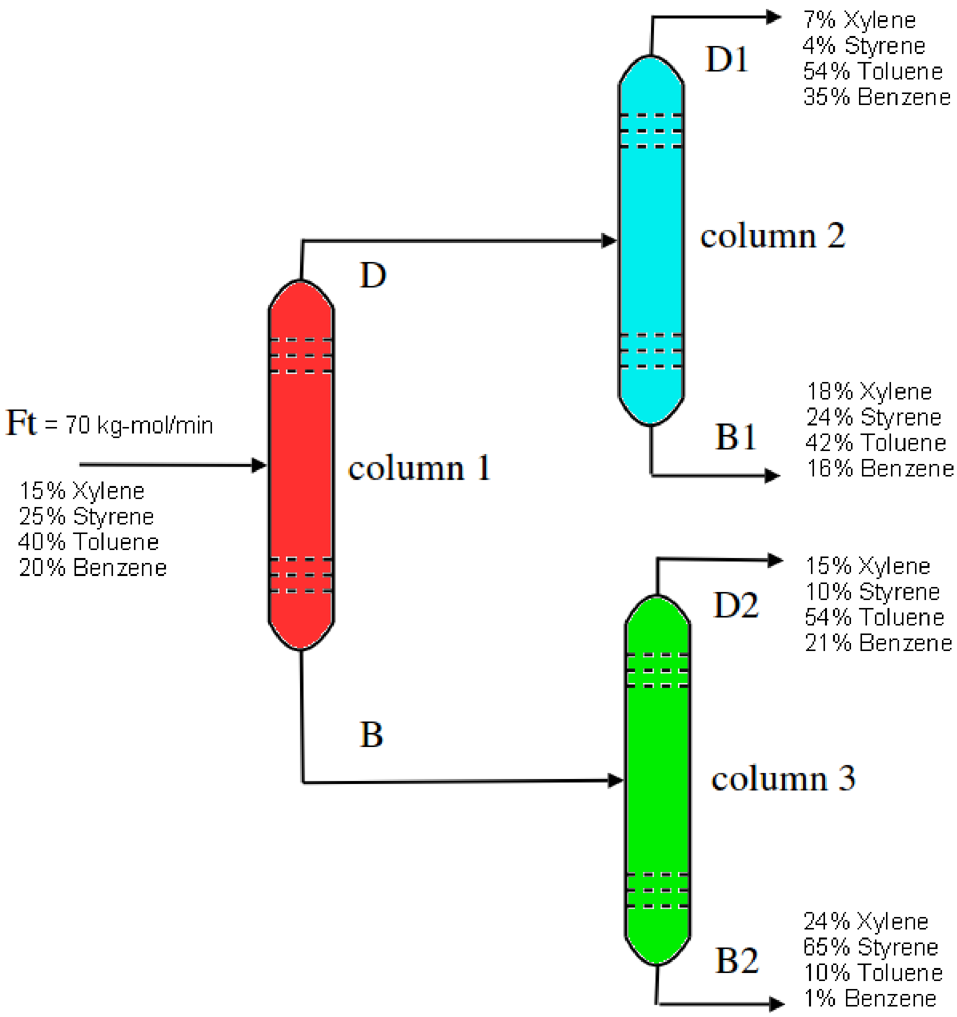
Symbol **KCL** means *Kirchhoff's Current Law*, which says the algebraic sum of the currents at a node is zero. Symbol **KVL** means *Kirchhoff's Voltage Law*, which says the algebraic sum of the voltage drops around a closed loop is zero.

(a) Solve the equations to verify the currents reported in the figure: $I_1 = 5, I_2 = 4, I_3 = 1$ Amperes.

(b) Compute the voltage drops across resistors R_1, R_2, R_3. Answer: $20, 8, 1$ volts.

References. Edwards-Penney BVP 3.7, electric circuit supplement. All About Circuits Volume I – DC, by T. Kuphaldt. Course slides on Electric Circuits. Solved examples of electrical networks can be found in the lecture notes of Ruye Wang.

Sample Quiz6 Problem 2. **Separation train**: Xylene, Styrene, Toluene, and Benzene are separated in 3 distillation columns. Symbols $Ft, D, B, D1, B1, D2, B2$ are molar flow rates in mol/min.



Balance Equations. The four Xylene separations imply balance equation $0.07D1 + 0.18B1 + 0.15D2 + 0.24B2 = 0.15(70)$ kg-mol, based on 1 min of operation. There are 3 other similar equations, for styrene, toluene and benzene. Multiply by 100 to produce the balance equations

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Xylene:   7 D1 + 18 B1 + 15 D2 + 24 B2 = 15(70)
Styrene:  4 D1 + 24 B1 + 10 D2 + 65 B2 = 25(70)
Toluene: 54 D1 + 42 B1 + 54 D2 + 10 B2 = 40(70)
Benzene: 35 D1 + 16 B1 + 21 D2 +  1 B2 = 20(70)
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Molar Flow Rates. Because D flows to column 2, then $D = D1 + B1$. Molar flow rates are computed individually in distillation column 2 as a linear combination of vector separations:

$$\begin{pmatrix} \text{Xylene molar flow rate} \\ \text{Styrene molar flow rate} \\ \text{Toluene molar flow rate} \\ \text{Benzene molar flow rate} \end{pmatrix} = \frac{D1}{100}\begin{pmatrix} 7 \\ 4 \\ 54 \\ 35 \end{pmatrix} + \frac{B1}{100}\begin{pmatrix} 18 \\ 24 \\ 42 \\ 16 \end{pmatrix}.$$

(a) Solve the balance equations for `D1, B1, D2, B2`. Answers: $26.25, 17.50, 8.75, 17.50$

(b) Compute the four individual molar flow rates for distillation column 2.

References. Edwards-Penney Sections 3.1, 3.2, 3.3. Course manuscript Linear Algebraic Equations, No Matrices. Michael Cutlip and Mordecai Shacham, *Problem Solving in Chemical Engineering with Numerical Methods*, Prentice-Hall (1998) ISBN-10: 0138625662.