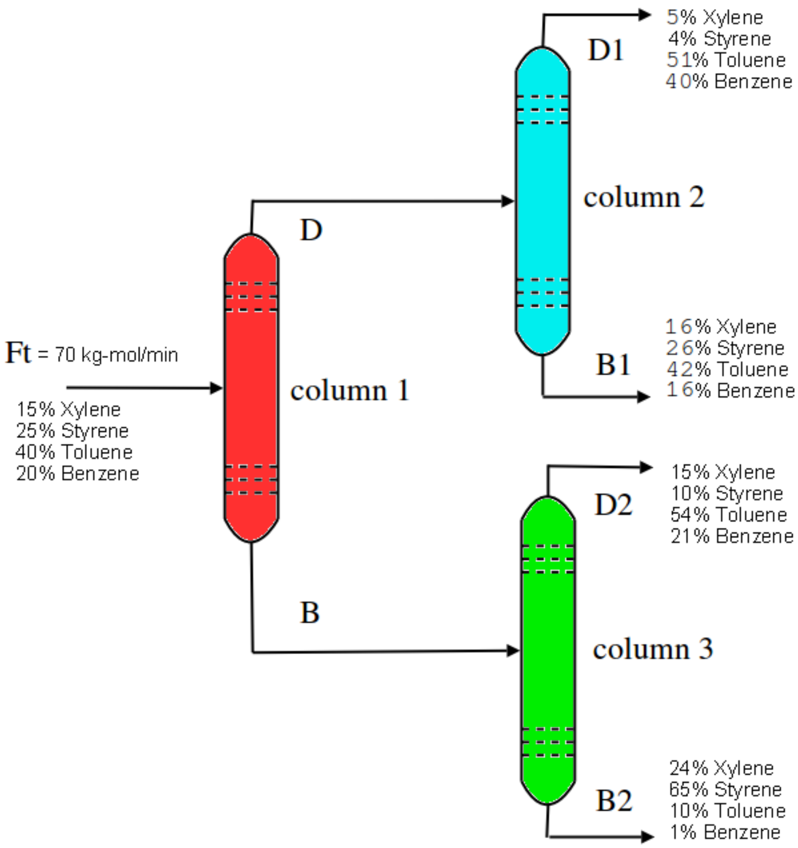
`Chemical Separation Train:` Xylene, Styrene, Toluene, and Benzene are separated in 3 distillation columns. Symbols $Ft, D, B, D1, B1, D2, B2$ are molar flow rates in mol/min.



Balance Equations. The four Xylene separations imply balance equation $0.05D1 + 0.16B1 + 0.15D2 + 0.24B2 = 0.15(70)$ 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

```
Xylene:   5 D1 + 16 B1 + 15 D2 + 24 B2 = 15(70)
Styrene:  4 D1 + 26 B1 + 10 D2 + 65 B2 = 25(70)
Toluene: 51 D1 + 42 B1 + 54 D2 + 10 B2 = 40(70)
Benzene: 40 D1 + 16 B1 + 21 D2 +  1 B2 = 20(70)
```

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:

$$\begin{pmatrix} \text{Xylene molar flow rate} \\ \text{Styrene molar flow rate} \\ \text{Toluene molar flow rate} \\ \text{Benzene molar flow rate} \end{pmatrix} = \frac{D1}{100}\begin{pmatrix} 5 \\ 4 \\ 51 \\ 40 \end{pmatrix} + \frac{B1}{100}\begin{pmatrix} 16 \\ 26 \\ 42 \\ 16 \end{pmatrix}.$$

(a) Solve the balance equations for `D1, B1, D2, B2`.
Answers: About 18.35, 3.91, 27.78, 19.95.

(b) Compute the four individual molar flow rates for distillation column 2.
Answers: About $1.5, 1.75, 11.0, 7.97$.

References: `Linear Algebraic Equations, No Matrices (Math 2250)`

`http://www.math.utah.edu/~gustafso/s2015/2250/linearequDRAFT.pdf`.
Michael Cutlip and Mordecai Shacham, *Problem Solving in Chemical Engineering with Numerical Methods*, Prentice-Hall (1998) ISBN-10: 0138625662.