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$$\begin{bmatrix} a & b & 1 & 0 \\ c & d & 0 & 1 \end{bmatrix} \xrightarrow{R_1 \leftarrow \frac{1}{a} R_1} \begin{bmatrix} 1 & b/a & 1/a & 0 \\ c & d & 0 & 1 \end{bmatrix}$$

$$\downarrow R_2 \leftarrow R_2 - c R_1$$

$$\begin{bmatrix} 1 & b/a & 1/a & 0 \\ 0 & 1 & -\frac{cb}{a} & \frac{1}{d - \frac{cb}{a}} \end{bmatrix} \xleftarrow{R_2 \leftarrow \frac{1}{d - \frac{cb}{a}} R_2} \begin{bmatrix} 1 & b/a & 1/a & 0 \\ 0 & d - \frac{cb}{a} & -\frac{c}{a} & 1 \end{bmatrix}$$

$$\left\{ -\frac{cb}{a} \frac{1}{d - \frac{cb}{a}} = -\frac{cb}{ad - \frac{abc}{a}} = \frac{cb}{ad - bc} \right\}$$

$$\begin{bmatrix} 1 & b/a & 1/a & 0 \\ 0 & 1 & \frac{cb}{ad - bc} & \frac{1}{d - \frac{cb}{a}} \end{bmatrix} \xrightarrow{R_1 \leftarrow R_1 - \frac{b}{a} R_2} \begin{bmatrix} 1 & 0 & \frac{1}{a} - \frac{b}{a} \frac{cb}{ad - bc} & -\frac{b}{a} \left(d - \frac{cb}{a}\right)^{-1} \\ 0 & 1 & \frac{cb}{ad - bc} & \left(d - \frac{cb}{a}\right)^{-1} \end{bmatrix}$$