# Module 5:
# Relating the Conjugate to the System Matrix

**Course 1 of *Optical Engineering*: First Order Optical System Design**

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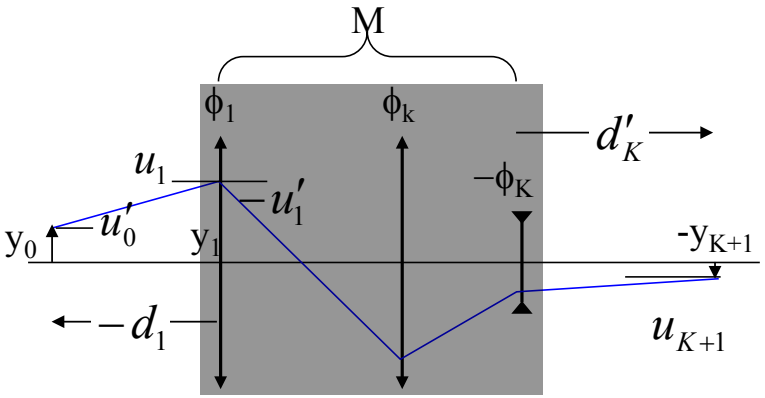
# Relating M & N

Given a system matrix **M**, find the image distance $d'_k$ given the object distance $d_0 = -d_1$




"Black box"

$$\mathbf{N} = \mathbf{T}_K \mathbf{M} \mathbf{T}_0$$

Relation between **M** and **N**

$$= \begin{bmatrix} 1 & d'_K \\ 0 & 1 \end{bmatrix} \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} 1 & -d_1 \\ 0 & 1 \end{bmatrix}$$

Let M be given by ABCD terms

$$= \begin{bmatrix} A + d'_K C & B + d'_K D - d_1 (A + d'_K C) \\ C & D - d_1 C \end{bmatrix}$$

$$= \begin{bmatrix} A + d'_K C & 0 \\ C & D - d_1 C \end{bmatrix}$$

Enforce conjugate condition, $N_{12} = 0$

$$\boxed{d'_K = -\frac{d_1 A - B}{d_1 C - D}}$$

…which gives the image location in terms of object distance and elements of **M**

$$d'_K = -\frac{d_1 1 - 0}{d_1(-\phi) - 1} \Rightarrow \frac{1}{d'_K} = \frac{1}{d_1} + \phi$$

Check for a single lens