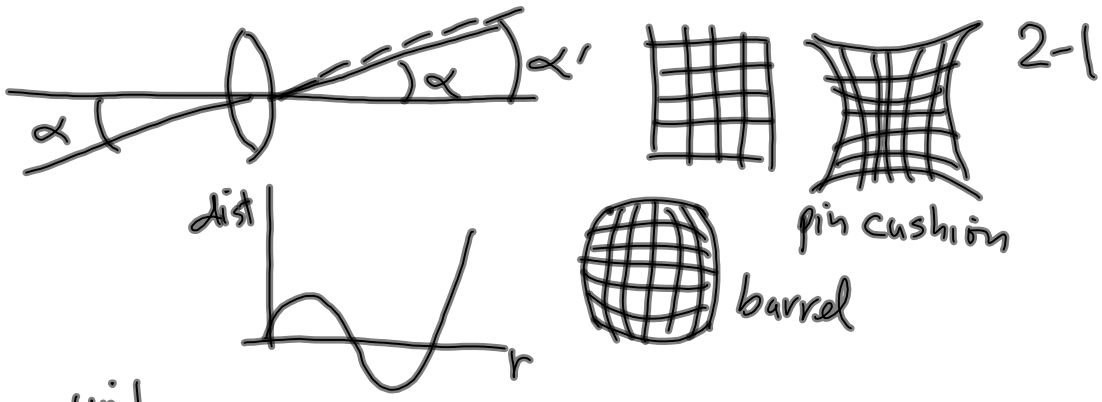

2-1

units: m meter mm 1/1000 m 10^{-3}
Km 1000 m μm 10^{-6} m
cm 1/100 m nm 10^{-9} m

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2-2

25.4 mm/inch } exact
.3048 m/ft. } international foot

39.37 in/m } exact
U.S. survey foot
.3048006... m/ft.

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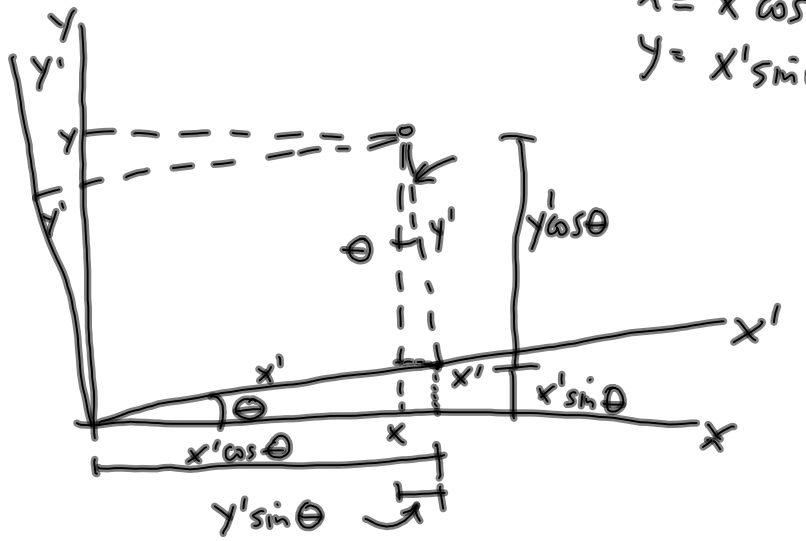
Coordinate Rotations

2-3

$$x = x'\cos\theta - y'\sin\theta$$
$$y = x'\sin\theta + y'\cos\theta$$



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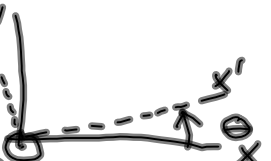
2-4

$$\begin{pmatrix} x \\ y \end{pmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{pmatrix} x' \\ y' \end{pmatrix}$$

$$\begin{pmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$$\boxed{\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix}}$$



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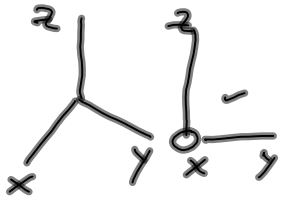
$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} \cos k & \sin k & 0 \\ -\sin k & \cos k & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$

k : about z

2-5

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos w & \sin w \\ 0 & -\sin w & \cos w \end{bmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$



w : rot. about x

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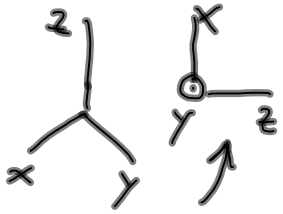
$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} \cos\phi & 0 & -\sin\phi \\ 0 & 1 & 0 \\ \sin\phi & 0 & \cos\phi \end{bmatrix} \begin{pmatrix} x \\ y \\ z \end{pmatrix}$$



2-6

ϕ: rot. about y , $M_x\ M_y\ M_z$

$R_x\ R_y\ R_z$

$M = M_\kappa M_\phi M_w$ $R_1\ R_2\ R_3$

↑ z ↑ y ↑ x roll, pitch, yaw (heading)

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elementary rotations
sequential rotations
euler angles

$M_1 = M_z M_y M_x$

$M_2 = M_x M_y M_z$

$M_2 \neq M_1$

MX

$M_z M_y M_x \cdot X$

x primary
y secondary
z tertiary

2-7

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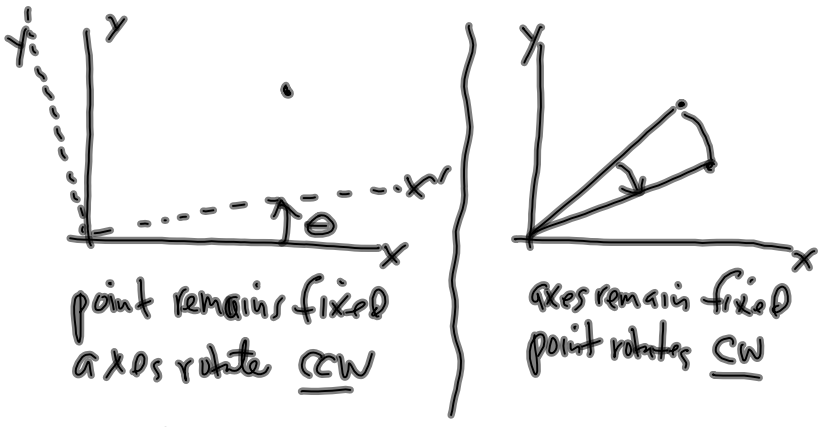

point remains fixed
axes rotate CCW

axes remain fixed
point rotates CW

★★★

MX

2-8

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Suppose given $\begin{bmatrix} m_{11} & m_{12} & m_{13} \\ m_{21} & m_{22} & m_{23} \\ m_{31} & m_{32} & m_{33} \end{bmatrix}$ what are ω, ϕ, k ?

2-9

$M = K_k M_\phi M_\omega$

(z) (y) (x)

$$\begin{bmatrix} \cos\phi\cos k & - & - \\ \cos\phi \sin k & - & - \\ \sin\phi & -\sin\omega\cos\phi & \cos\omega\cos\phi \end{bmatrix}$$

$\phi = \arcsin(m_{31})$ $(-\pi/2 \to +\pi/2)$

$\omega = \arctan(-m_{32}/m_{33})$ ATAN2$(-m_{32}, m_{33})$

$k = \arctan(-m_{21}/m_{11})$ ATAN2$(-m_{21}, m_{11})$

	num	den
+	+	
−	−	

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