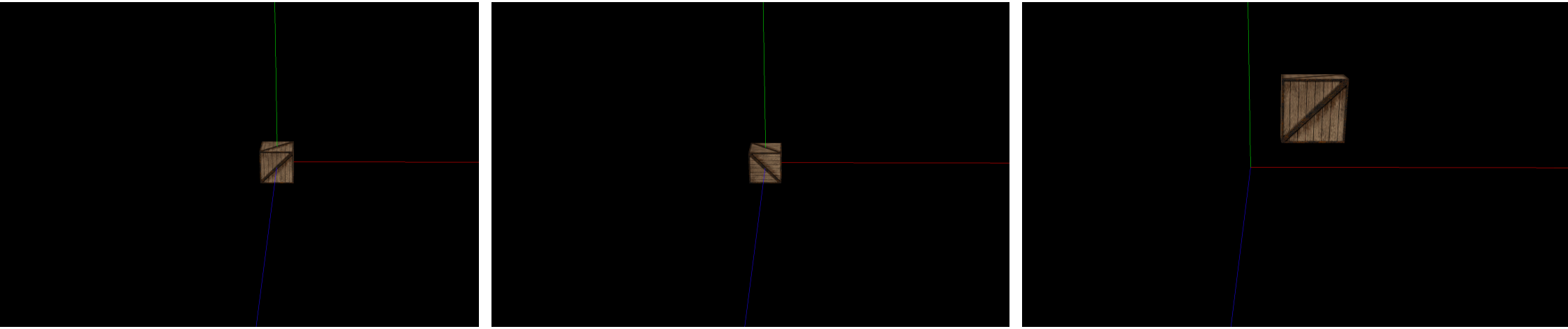
COSC342:
Computer Graphics

2017



Tutorial

TRANSFORMATIONS IN 3D

Stefanie Zollmann

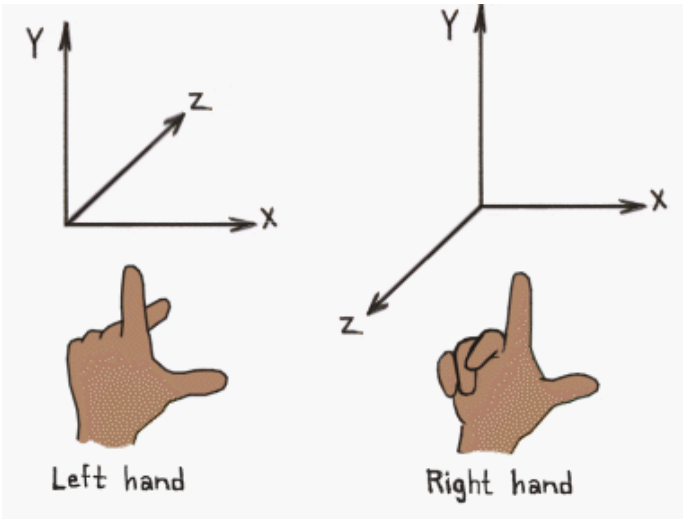
3D COORDINATE SYSTEMS

- What is the difference between a left- and a right handed coordinate system?

- Where are left-handed coordinate system used? Where are right-handed used?

3D COORDINATE SYSTEMS

- What is the difference between a left- and a right handed coordinate system?



http://viz.aset.psu.edu/gho/sem_notes/3d_fundamentals/html/3d_coordinates.html

- Where are left-handed coordinate system used? Where are right-handed used?

TRANSFORMATIONS: SCALE

- Describe scale in 3D:

TRANSFORMATIONS: SCALE

- Describe scale in 3D:

$$\begin{bmatrix} s & 0 & 0 & 0 \\ 0 & s & 0 & 0 \\ 0 & 0 & s & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} sx \\ sy \\ sz \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: TRANSLATION

- Describe translation in 3D:

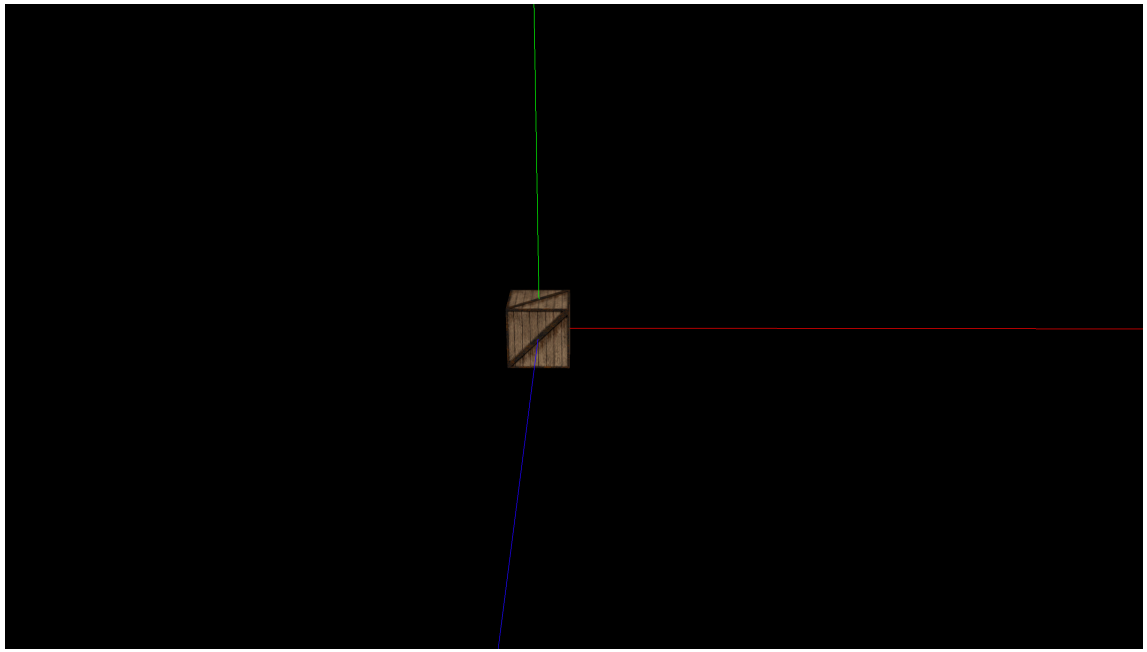
TRANSFORMATIONS: TRANSLATION

- Describe translation in 3D:

$$\begin{bmatrix} 1 & 0 & 0 & \Delta x \\ 0 & 1 & 0 & \Delta y \\ 0 & 0 & 1 & \Delta z \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix} = \begin{bmatrix} x + \Delta x \\ y + \Delta y \\ z + \Delta z \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: TRANSLATION

- With the following starting 3D scene what would be the difference of applying $M = S_1 T_1$ or $M = T_1 S_1$?

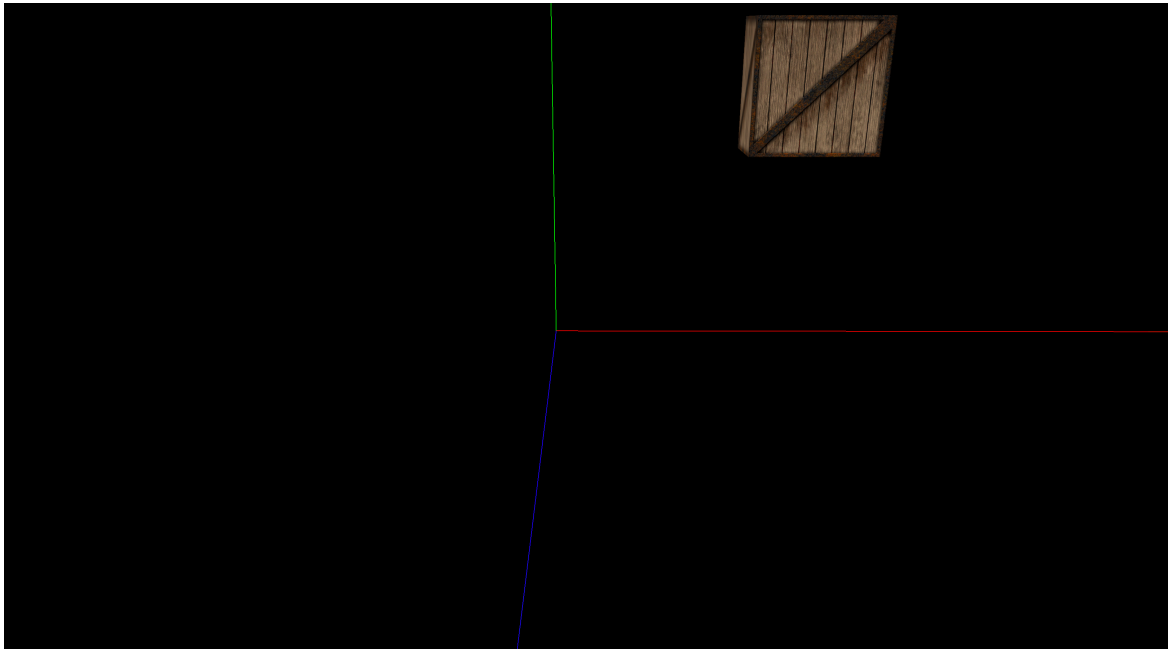


$$S_1 = \begin{bmatrix} 2 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_1 = \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATIONS: TRANSLATION

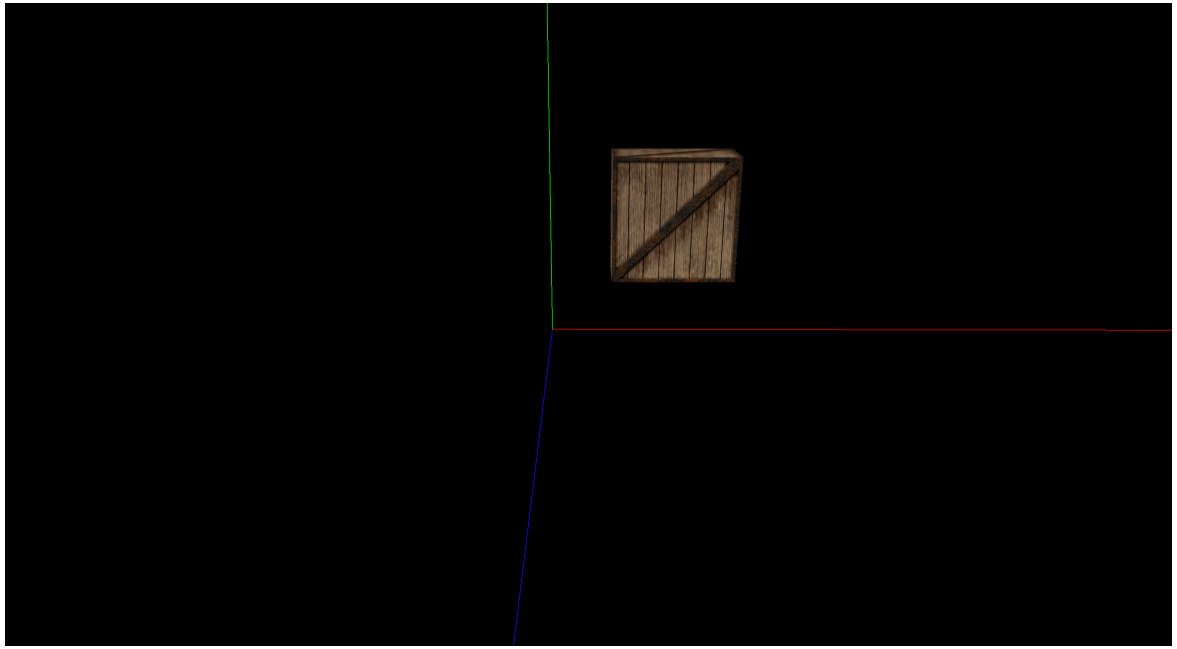
- With the following starting 3D scene what would be the difference of applying **$M = S_1 T_1$** or $M = T_1 S_1$?



$$M = \begin{bmatrix} 2 & 0 & 0 & 4 \\ 0 & 2 & 0 & 4 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATIONS: TRANSLATION

- With the following starting 3D scene what would be the difference of applying $M = S_1 T_1$ or $\mathbf{M = T_1 S_1}$?



$$M = \begin{bmatrix} 2 & 0 & 0 & 2 \\ 0 & 2 & 0 & 2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

- Describe rotation around the z axis in 3D:

TRANSFORMATIONS: ROTATION

- Describe rotation around the z axis in 3D:

$$\mathrm{R}_Z\mathbf{v} = \begin{bmatrix} \cos(\theta) & -\sin(\theta) & 0 & 0 \\ \sin(\theta) & \cos(\theta) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

- Describe rotation around the x axis in 3D:

TRANSFORMATIONS: ROTATION

- Describe rotation around the x axis in 3D:

$$\mathrm{R}_X\mathbf{v} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & \cos(\theta) & -\sin(\theta) & 0 \\ 0 & \sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

- Describe rotation around the y axis in 3D:

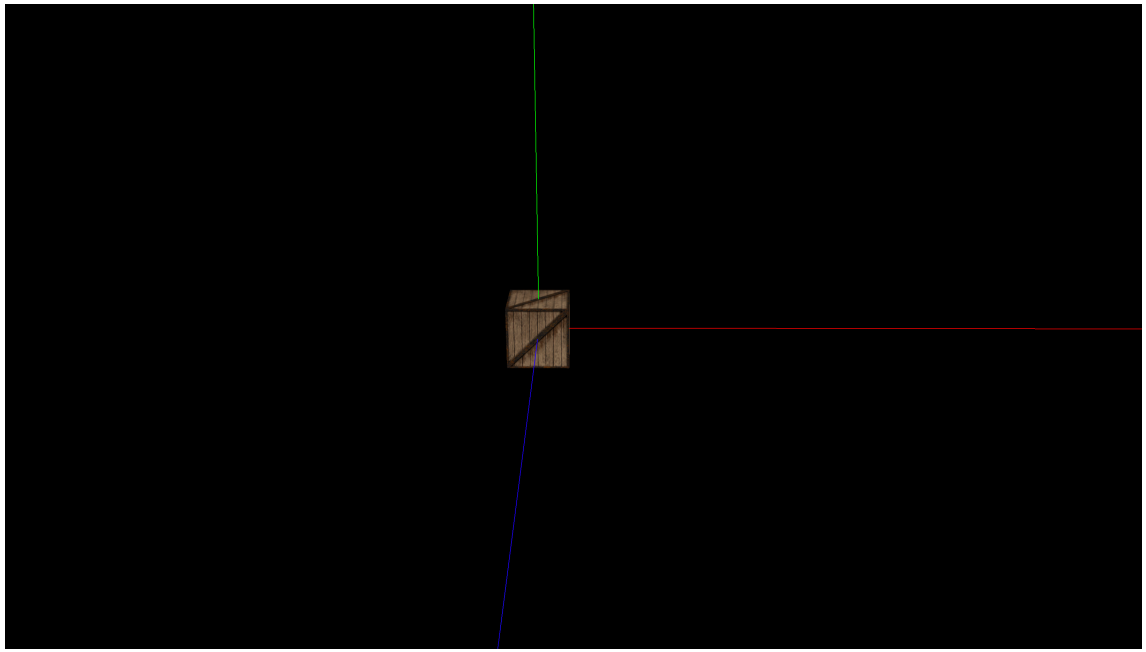
TRANSFORMATIONS: ROTATION

- Describe rotation around the y axis in 3D:

$$\mathrm{R}_Y\mathbf{v} = \begin{bmatrix} \cos(\theta) & 0 & \sin(\theta) & 0 \\ 0 & 1 & 0 & 0 \\ -\sin(\theta) & 0 & \cos(\theta) & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

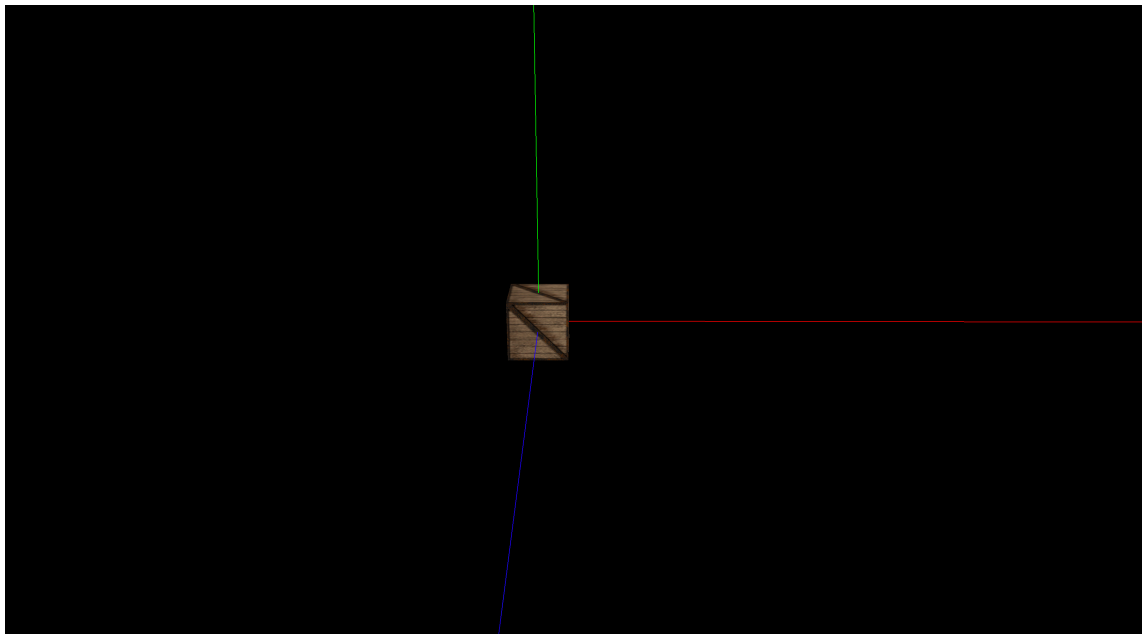
- What is the result of applying rotation matrix R1 to the following scene?



$$R_1 = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

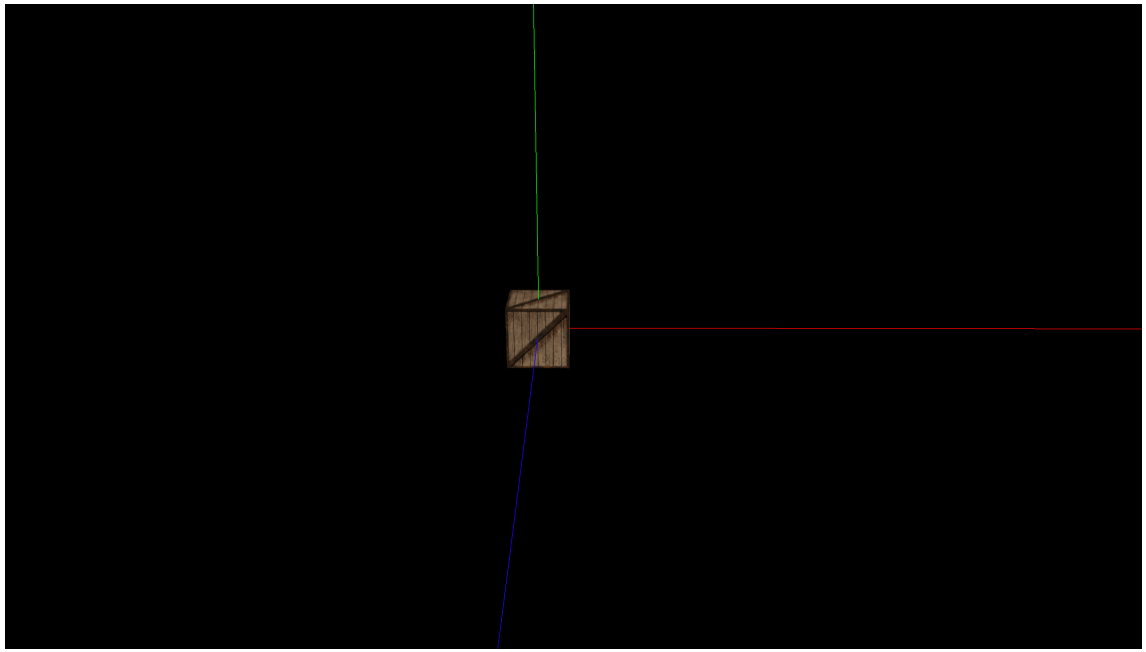
- What is the result of applying rotation matrix R1 to the following scene?



$$R_1 = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \\ 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

- What is the result of applying rotation matrix M= $\mathbf{R_1 T_1}$ to the following scene?

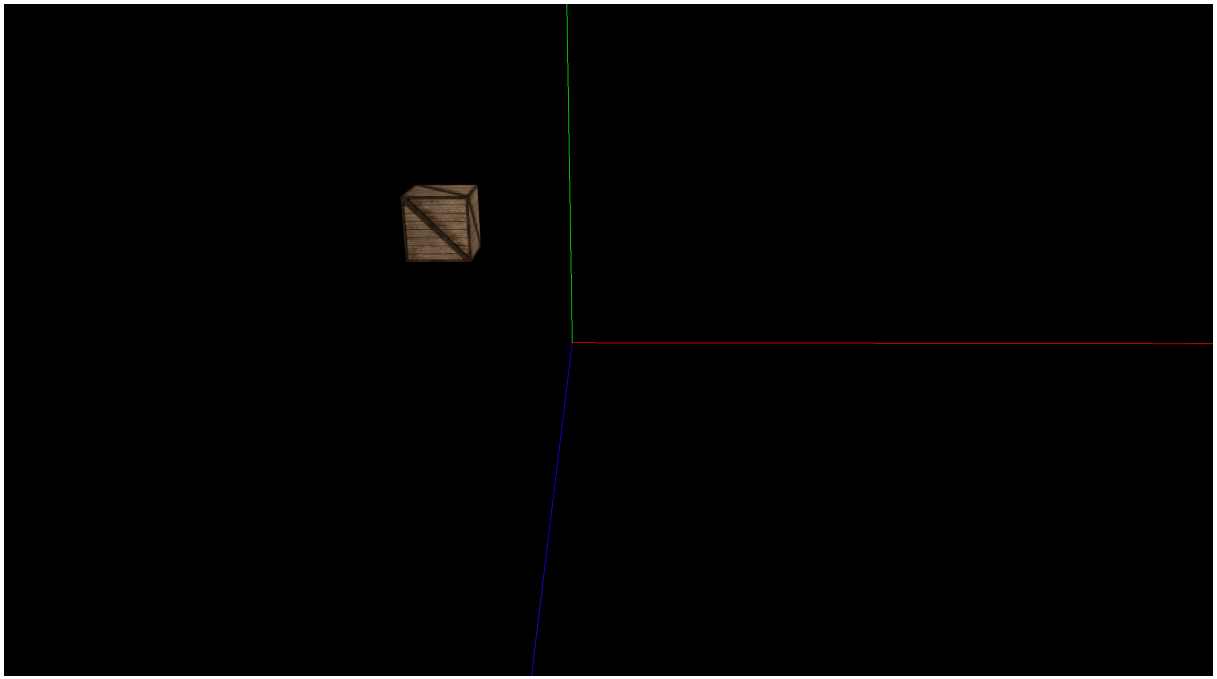


$$R_1 = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$T_1 = \begin{bmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

TRANSFORMATIONS: ROTATION

- What is the result of applying rotation matrix M= $\mathbf{R_1 T_1}$ to the following scene?



$$M = \begin{bmatrix} 0 & -1 & 0 & -2 \\ 1 & 0 & 0 & 2 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

COLUMN-MAJOR VS ROW-MAJOR ORDER

- What is the difference between column major and row-major order matrices?

COLUMN-MAJOR VS ROW-MAJOR ORDER

- What is the difference between column major and row-major order?

```
0  4   8  12
1  5   9  13
2  6  10  14
3  7  11  15
```

- column-major order

```
0   1   2   3
4   5   6   7
8   9  10  11
12 13 14 15
```

- row-major order

Thank You!

For more material visit
http://www.cs.otago.ac.nz/cosc342/