# CSE 423 - Computer Graphics
# 2D Transformation

# Two dimensional transformation

- Translation
- Scaling
- Rotation

# Translation

- Moving object from one position to another position

- Change the position of objects



- Parameters for translation are:
  - $t_x$ - if we move the position with respect to $x$ – axis
  - $t_y$ - If we move the position with respect to $y$ – axis

# Calculate Translation

If we have –

- Original point is $P(x, y)$
- Translated parameters are $t_x$ and $t_y$
- Object translated point is $P'(x', y')$

Then,

Translated $x$ – axis is measured by $x' = t_x + x$

Translated $y$ – axis is measured by $y' = t_y + y$

**Matrix representation**

$$[x' y'] = [x\ y] + [t_x\ t_y]$$

Or,

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}$$

# Scaling

- Resizing the object
- Do maximizing and minimizing the object
- Parameters for scaling are:
  - $s_x$ - if we move the position with respect to $x$ – axis
  - $s_y$ - If we move the position with respect to $y$ – axis



| **Property** | **Result** |
|---|---|
| In between 0 and 1 | Point is closer to origin and size will be decreased |
| $s_x$ and $s_y$ are greater than 1 | Point is away from origin and size will be increase |
| $s_x$ = $s_y$ | Uniformly increases or decreases |

# Calculate Scaling

If we have –

- Original point is $P(x, y)$
- Scaled parameters are $s_x$ and $s_y$
- Object scaled point is $P'(x', y')$

Then,
Scaled $x$ – axis is measured by $x' = s_x . x$
Scaled $y$ – axis is measured by $y' = s_y . y$

**Matrix representation**

$$[x' \quad y'] = [x \quad y] \begin{bmatrix} s_x & 0 \\ 0 & s_y \end{bmatrix}$$

# Rotation

- Rotate the object with a specific angle, $\theta$
- Two types of rotation
  - Clockwise direction and
  - Anti clockwise direction



**Clockwise**

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

**Or,**

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

**AntiClockwise**

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

**Or,**

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

# Problem

**Q: (a)** Find the matrix that represents the rotation of an object by $30^o$ by the origin.

**(b)** What's the new coordinate of the point $\mathrm{P}(2, -4)$ after the rotation?



**Solution**

(a) The matrix $R_{30^o} = \begin{bmatrix} \cos 30^o & -\sin 30^0 \\ \sin 30^0 & \cos 30^o \end{bmatrix}$

(b) New rotated points

$$[x' \quad y'] = [2 \quad -4]\begin{bmatrix} \cos 30^o & -\sin 30^0 \\ \sin 30^0 & \cos 30^o \end{bmatrix}$$

# Problem

**Q:** Transform $(2, 1), (3,4\ )$ and $(5, 3)$points using translation and scaling factors 6 along $x$-axis and 9 along $y$-axis.

**Solution:**

Translation for coordinates A(2,1)

The new coordinate will be $A'(x', y')$

Translation factors are $t_x = 6$ and $t_y = 9$

Therefore,

$$x' = 6 + 2 = 8$$
$$y' = 9 + 1 = 10$$

Thus, the new coordinate for the point A(2,1) is $A'(8, 10)$

# Complete rest part of the problem yourself