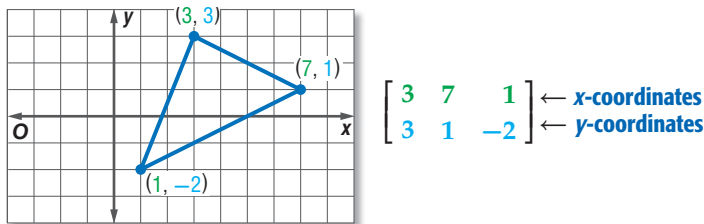


Graphing Technology Lab

Transformations Using Matrices

Sharp EL-9900C

In past lessons, you dilated images by multiplying the x - and y -coordinates by a scale factor and graphing the resulting image. Transformations can also be performed by using a matrix, which is a rectangular group of numbers arranged in rows or columns. A matrix can represent a figure in the coordinate plane in which the first row corresponds to the x -coordinates of the figure and the second row corresponds to the y -coordinates, as shown below.



In the following activities you will perform transformations by using matrix operations on a Sharp EL-9900C graphing calculator.

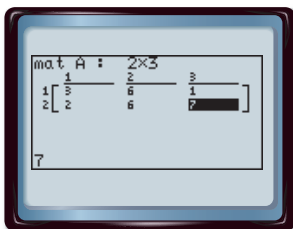
ACTIVITY 1 Perform Transformations by Using Matrix Addition

Clear the calculator memory first.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{OPTION}]}$ $\boxed{[\text{ALPHA}]}$ $\boxed{[E]}$ $\boxed{2}$ $\boxed{[\text{CL}]}$ $\boxed{[\text{ENTER}]}$

Step 1 Enter a 2×3 matrix that represents a triangle with vertices (3, 2), (6, 6), and (1, 7) as **mat A**. Press $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$ to enter the matrix menu. Press $\boxed{[B]}$ to select the **EDIT** option, then press $\boxed{1}$ to select **mat A**. To set the dimensions of the matrix, enter the number of rows and then the number of columns. Then enter the x -coordinates of each vertex in row 1 and the y -coordinates of each vertex in row 2.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRX}]}$ **B: EDIT 1: mat A**
 $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$ $\boxed{6}$ $\boxed{[\text{ENTER}]}$
 $\boxed{1}$ $\boxed{[\text{ENTER}]}$ $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{6}$ $\boxed{[\text{ENTER}]}$ $\boxed{7}$ $\boxed{[\text{ENTER}]}$

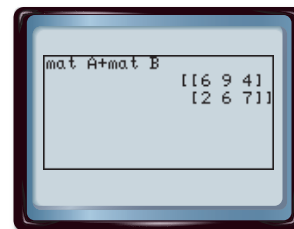


Step 2 Enter $\begin{bmatrix} 3 & 3 & 3 \\ 0 & 0 & 0 \end{bmatrix}$ into **mat B** on your calculator.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRX}]}$ **B: EDIT 2: mat B**
 $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$
 $\boxed{3}$ $\boxed{[\text{ENTER}]}$

Then find **mat A + mat B**.

KEYSTROKES: $\boxed{[\frac{+}{-}]}$ $\boxed{[\text{CL}]}$ $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$ **A: NAME**
 $\boxed{1}$ **mat A** $\boxed{+}$ $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$ **A: NAME**
 $\boxed{2}$ **mat B** $\boxed{[\text{ENTER}]}$



Analyze the Results

- Graph the triangle from Step 1. Use the result from **mat A + mat B** to graph a second triangle. What kind of transformation do you observe?
- Enter $\begin{bmatrix} 2 & 2 & 2 \\ -6 & -6 & -6 \end{bmatrix}$ into **mat C**. Then find **mat A + mat C**.
Graph the triangle from Step 1 and the sum of **mat A + mat C**. Describe the type of transformation that occurs.
- What matrix would you add to **mat A** in order to get $\begin{bmatrix} 7 & 10 & 5 \\ 5 & 9 & 10 \end{bmatrix}$?

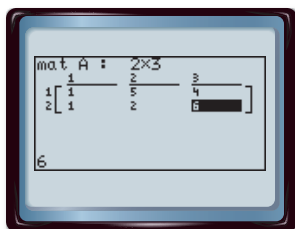
ACTIVITY 2 Perform Transformations by Using Matrix Multiplication

Step 1 Clear the calculator memory first.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{OPTION}]}$ $\boxed{[\text{ALPHA}]}$ $\boxed{[E]}$ $\boxed{2}$
 $\boxed{[\text{ENTER}]}$

Enter a 2×3 matrix as **mat A** that represents a triangle with vertices (1, 1), (5, 2), and (4, 6).

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$ B: EDIT 1: mat A
 $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$ $\boxed{1}$ $\boxed{[\text{ENTER}]}$ $\boxed{5}$ $\boxed{[\text{ENTER}]}$
 $\boxed{4}$ $\boxed{[\text{ENTER}]}$ $\boxed{1}$ $\boxed{[\text{ENTER}]}$ $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{6}$ $\boxed{[\text{ENTER}]}$

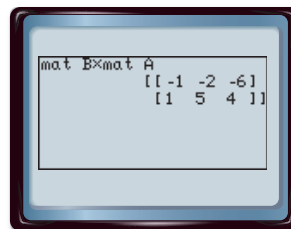


Step 2 Enter $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$ into **mat B** on your calculator.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$ B: EDIT 2: mat B
 $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{0}$ $\boxed{[\text{ENTER}]}$ $\boxed{(-)}$ $\boxed{1}$
 $\boxed{[\text{ENTER}]}$ $\boxed{1}$ $\boxed{[\text{ENTER}]}$ $\boxed{0}$ $\boxed{[\text{ENTER}]}$

Then find **mat B** \times **mat A**.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{QUIT}]}$ $\boxed{[\text{CL}]}$ $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$
A: NAME 2: mat B $\boxed{[X]}$ $\boxed{2\text{ndF}}$
 $\boxed{[\text{MATRIX}]}$ A: NAME 1: mat A $\boxed{[\text{ENTER}]}$



Analyze the Results

- Graph the triangle from Step 1. Use the result from **mat B** \times **mat A** to graph a second triangle. What kind of transformation do you observe?
- Enter $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$ into matrix **mat B**. Then find **mat B** \times **mat A**. Graph the triangle from Step 1 and the product of **mat B** \times **mat A**. Describe the type of transformation that occurs.
- By what matrix would you multiply **mat A** in order to get $\begin{bmatrix} 1 & 2 & 6 \\ 1 & 5 & 4 \end{bmatrix}$?

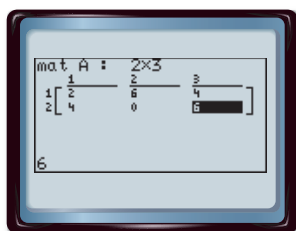
ACTIVITY 3 Perform Transformations by Using Scalar Multiplication

Step 1 Clear the calculator memory first.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{OPTION}]}$ $\boxed{[\text{ALPHA}]}$ $\boxed{[E]}$ $\boxed{2}$
 $\boxed{[\text{ENTER}]}$

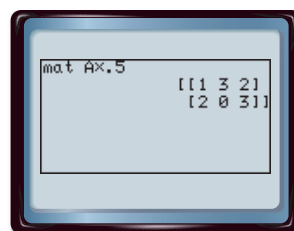
Enter a matrix as **mat A** that represents a triangle with vertices (2, 4), (6, 0), and (4, 6).

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$ B: EDIT 1: mat A
 $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{3}$ $\boxed{[\text{ENTER}]}$ $\boxed{2}$ $\boxed{[\text{ENTER}]}$ $\boxed{6}$ $\boxed{[\text{ENTER}]}$
 $\boxed{4}$ $\boxed{[\text{ENTER}]}$ $\boxed{4}$ $\boxed{[\text{ENTER}]}$ $\boxed{0}$ $\boxed{[\text{ENTER}]}$ $\boxed{6}$ $\boxed{[\text{ENTER}]}$



Step 2 Multiply **mat A** by 0.5 in your calculator.

KEYSTROKES: $\boxed{2\text{ndF}}$ $\boxed{[\text{QUIT}]}$ $\boxed{[\text{CL}]}$ $\boxed{2\text{ndF}}$ $\boxed{[\text{MATRIX}]}$
A: NAME 1: mat A $\boxed{[X]}$ $\boxed{0.5}$ $\boxed{[\text{ENTER}]}$



Analyze the Results

7. Graph the triangle from Step 1. Use the result from $\text{mat A} \times 0.5$ to graph a second triangle. What kind of transformation do you observe?
8. Multiply mat A by 2. Graph the triangle from Step 1 and the product of $\text{mat A} \times 2$. Describe the type of transformation that occurs.
9. **MAKE A CONJECTURE** What type of matrix operation would you use to perform each transformation?
 - a. rotation
 - b. translation
 - c. dilation
 - d. reflection