p.180 WARM-UPS $w = 0$

Find the value of each variable.

37. $\begin{bmatrix} x & y-2 \\ z & w+4 \end{bmatrix} + \begin{bmatrix} 2 & 5 \\ -2 & 4 \end{bmatrix} = \begin{bmatrix} 6 & 1 \\ 4 & 8 \end{bmatrix}$

$x = 4$

$y = -2$

$z = 6$

$z + -2 = 4$

$+2 \quad +2$

$z = 6$

$y - 2 + 5 = 1$

$y + 3 = 1$

$-3 \quad -3$

$y = -2$

38. $\begin{bmatrix} x & 3 \\ x & -2 \end{bmatrix} + \begin{bmatrix} y & 6 \\ -y & 3 \end{bmatrix} = \begin{bmatrix} 6 & 9 \\ 4 & 1 \end{bmatrix}$

$x =$

$y =$

$x + y = 6$

$x + -y = 4$

$2x = 10$

$\frac{2x}{2} = \frac{10}{2}$

$x = 5$

$5 + y = 6$

$-5 \quad -5$

$y = 1$

Oct 1-9:50 AM

4-3 Matrix Multiplication

Check Skills You'll Need GO for Help Lesson 4-2

Find each sum.

1. $\begin{bmatrix} 3 & 5 \\ 2 & 8 \end{bmatrix} + \begin{bmatrix} 3 & 5 \\ 2 & 8 \end{bmatrix} + \begin{bmatrix} 3 & 5 \\ 2 & 8 \end{bmatrix} = \begin{bmatrix} 9 & 15 \\ 6 & 24 \end{bmatrix}$

2. $\begin{bmatrix} -4 \\ 7 \end{bmatrix} + \begin{bmatrix} -4 \\ 7 \end{bmatrix} + \begin{bmatrix} -4 \\ 7 \end{bmatrix} + \begin{bmatrix} -4 \\ 7 \end{bmatrix}$

3. $\begin{bmatrix} -1 & 3 & 4 \\ 0 & -2 & -5 \end{bmatrix} + \begin{bmatrix} -1 & 3 & 4 \\ 0 & -2 & -5 \end{bmatrix} + \begin{bmatrix} -1 & 3 & 4 \\ 0 & -2 & -5 \end{bmatrix} + \begin{bmatrix} -1 & 3 & 4 \\ 0 & -2 & -5 \end{bmatrix}$

You can also find the sum using scalar multiplication

$3\begin{bmatrix} 3 & 5 \\ 2 & 8 \end{bmatrix} = \begin{bmatrix} 9 & 15 \\ 6 & 24 \end{bmatrix}$ $5\begin{bmatrix} -4 \\ 7 \end{bmatrix} = \begin{bmatrix} -20 \\ 35 \end{bmatrix}$

$4\begin{bmatrix} -1 & 3 & 4 \\ 0 & -2 & -5 \end{bmatrix} = \begin{bmatrix} -4 & 12 & 16 \\ 0 & -8 & -20 \end{bmatrix}$

Oct 1-7:51 AM

1 Multiplying a Matrix by a Scalar

You can multiply a matrix by a real number.

$$3\begin{bmatrix}3 & 5\\ 2 & 8\end{bmatrix} = \begin{bmatrix}9 & 15\\ 6 & 24\end{bmatrix}$$

The real number factor (such as 3) is called a **scalar.**

Definition **Scalar Multiplication**

Scalar multiplication multiplies a matrix A by a scalar c. To find the resulting matrix cA, multiply each element of A by c.

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	SMALL	LARGE
LOWFAT MILK	$.35	$.67
ORANGE JUICE	$.65	$.89
TOMATO JUICE	$.58	$.75

$$1.5\begin{bmatrix}.35 & .67\\ .65 & .89\\ .58 & .75\end{bmatrix} = \begin{bmatrix}.53 & 1.01\\ .98 & 1.34\\ .87 & 1.13\end{bmatrix}$$

1 EXAMPLE **Real-World Connection**

Prices Use the price list. The cafeteria plans to raise the cost of each beverage to one and a half times the current cost. How much will each beverage cost?

```
1.5[A]
[[.525 1.005]
 [.975 1.335]
 [.87  1.125]]
```

1 Find $-3\begin{bmatrix}15 & -12 & 10 & 0\\ 20 & -10 & 7 & 0\end{bmatrix}$.

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2 EXAMPLE Using Scalar Products

Find the difference $5A - 3B$ for $A = \begin{bmatrix} 2 & 3 & -7 \\ 1 & 4 & 5 \end{bmatrix}$ and $B = \begin{bmatrix} 3 & 0 & 6 \\ -1 & 8 & 2 \end{bmatrix}$.

```
5[B]-4[A]
                [ 7  -12  58]
                [-9   24 -10]
```

2 Use matrices A and B from Example 2. Find each sum or difference.

a. $5B - 4A$ **b.** $A + 6B$

```
5[A]-3[B]
                [1  15 -53]
                [8  -4  19]
```

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You can use the properties of scalar multiplication to solve matrix equati

3 EXAMPLE Solving Matrix Equations with Scalars

Solve $4X + 2\begin{bmatrix} 3 & 4 \\ -2 & 1 \end{bmatrix} = \begin{bmatrix} 10 & 0 \\ 4 & 2 \end{bmatrix}$.

$4X + \begin{bmatrix} 6 & 8 \\ -4 & 2 \end{bmatrix} = \begin{bmatrix} 10 & 0 \\ 4 & 2 \end{bmatrix} - \begin{bmatrix} 6 & 8 \\ -4 & 2 \end{bmatrix}$

A B

$4X + A = B$

$-A \quad -A$

multiply both sides by the reciprocal

$4X = \begin{bmatrix} 4 & -8 \\ 8 & 0 \end{bmatrix}$

$\frac{4X}{4} = \frac{8}{4}$

$\frac{1}{4}4X = \frac{1}{4}\begin{bmatrix} 4 & -8 \\ 8 & 0 \end{bmatrix}$

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

Same as dividing each # by 4

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3 Solve each matrix equation. Check your answer.

a. $2X = \begin{bmatrix} 4 & 12 \\ 1 & -4 \end{bmatrix} + \begin{bmatrix} -2 & 0 \\ 3 & 4 \end{bmatrix}$

$\frac{1}{2} \cdot 2X = \frac{1}{2}\begin{bmatrix} 2 & 12 \\ 4 & 0 \end{bmatrix}$

$X = \begin{bmatrix} 1 & 6 \\ 2 & 0 \end{bmatrix}$

b. $-3X + \begin{bmatrix} 7 & 0 & -1 \\ 2 & -3 & 4 \end{bmatrix} = \begin{bmatrix} 10 & 0 & 8 \\ -19 & -18 & 10 \end{bmatrix}$

$A \qquad B$

$-A \qquad -A$

$-\frac{1}{3}(-3X) = -\frac{1}{3}([B]-[A])$

Oct 1-8:00 AM

2 Multiplying Matrices

To perform **matrix multiplication,** multiply the elements of each *row* of the first matrix by the elements of each *column* of the second matrix. Add the products.

The product of two matrices A and B exists only if the number of *columns* of A is equal to the number of *rows* of B.

$(3\times 2)(2\times 4) = (3\times 4)$ Result

must match, or it's NOT POSSIBLE

Property **Dimensions of a Product Matrix**

If matrix A is an $m \times n$ matrix and matrix B is an $n \times p$ matrix, then the product matrix AB is an $m \times p$ matrix.

Example matrix A • matrix B

$\begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix} \cdot \begin{bmatrix} 7 & 8 & 9 & 10 \\ 11 & 12 & 13 & 14 \end{bmatrix}$

3 rows; 2 columns; 2 rows; 4 columns

2 columns equal 2 rows

dimensions of product matrix: 3 × 4

The dimensions of product matrix AB are 3×4.

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4 EXAMPLE **Multiplying Matrices**

Find the product of $\begin{bmatrix} -1 & 0 \\ 3 & -4 \end{bmatrix}$ and $\begin{bmatrix} -3 & 3 \\ 5 & 0 \end{bmatrix}$.

$= \begin{bmatrix} 3 & -3 \\ -29 & 9 \end{bmatrix}$

$(2\times2)\ (2\times2) = (2\times2)$

1st row × 1st column: $(-1)(-3) + 0(5) = 3$

1st row × 2nd column: $-1(3) + 0(0) = -3$

2nd R 1st C: $3(-3) + -4(5) = -29$

2nd R 2nd C: $3(3) + (-4)(0) = 9$

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4 a. Find the product of $\begin{bmatrix} -3 & 3 \\ 5 & 0 \end{bmatrix}$ and $\begin{bmatrix} -1 & 0 \\ 3 & -4 \end{bmatrix}$.

A B

$[A][B] = \begin{bmatrix} 12 & -12 \\ -5 & 0 \end{bmatrix}$

OR

$[A] * [B]$

$[B][A] = \begin{bmatrix} 3 & -3 \\ -29 & 9 \end{bmatrix}$

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5 Find each product if it exists.

a. $\begin{bmatrix}12 & 3\end{bmatrix}\begin{bmatrix}10\\-5\end{bmatrix}$

$(1\times2)(2\times1)=(1\times1)$

ORDER OR dimensions

b. $\begin{bmatrix}10\\-5\end{bmatrix}\begin{bmatrix}12 & 3\\0 & 0\end{bmatrix}$

$(2\times1)(2\times2)$

NOT possible

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6 EXAMPLE **Determining Whether a Product Matrix Exists**

Use matrices $G = \begin{bmatrix}2 & 3\\-1 & 8\\4 & 0\end{bmatrix}$ and $H = \begin{bmatrix}8 & 0\\2 & -5\end{bmatrix}$. Determine whether products GH and HG are *defined* (exist) or *undefined* (do not exist).

3×2 2×2

Find the dimensions of each product matrix.

GH

$(3\times2)(2\times2)$

(3×2)

HG

$(2\times2)(3\times2)$

$\neq$ NOT possible

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