



LINEAR ALGEBRA FOR DATA SCIENCE IN R

# Lesson 1.1 Motivation

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# Data - The Atom of Data Science

```
height weight forty vertical bench broad_jump three_cone shuttle
1      71    192  4.38    35.0    14      127      6.71    3.98
2      73    298  5.34    26.5    27       99      7.81    4.71
3      77    256  4.67    31.0    17      113      7.34    4.38
4      74    198  4.34    41.0    16      131      6.56    4.03
5      76    257  4.87    30.0    20      118      7.12    4.23
6      78    262  4.60    38.5    18      128      7.53    4.48
```



# Vectors - Storing Univariate Data

$$\vec{x} = \begin{pmatrix} 1 \\ 5 \\ -2 \\ 4 \end{pmatrix}$$

$$\vec{x}^T = (1 \quad 5 \quad -2 \quad 4)$$

$$\vec{y} = (11 \quad -7 \quad 12 \quad 14 \quad 21)$$

$$\vec{y}^T = \begin{pmatrix} 11 \\ -7 \\ 12 \\ 14 \\ 21 \end{pmatrix}$$



# Vectors - Storing Univariate Data

```
> x <- rep(1, 4)
> x
[1] 1 1 1 1
```

```
> y <- seq(2, 8, by = 2)
> y
[1] 2 4 6 8
```

```
> z <- c(1, 5, -2, 4)
> z
[1] 1 5 -2 4
```

```
> z[3] <- 7
> z
[1] 1 5 7 4
```



# Matrices - Storing Tables of Data

$$A = \begin{pmatrix} -2 & -4 \\ -1 & -2 \\ 0 & 0 \\ 1 & 2 \\ 2 & 4 \end{pmatrix}$$



# Matrices - Storing Tables of Data

Case	Variable 1	Variable 2
A	-2	-4
B	-1	-2
C	0	0
D	1	2
F	2	4

# Matrices - Storing Tables of Data

```
> matrix(2, 3, 2)
      [,1] [,2]
[1,]    2    2
[2,]    2    2
[3,]    2    2
```

```
> matrix(c(1, -1, 2, 3, 2, -2), nrow = 2, ncol = 3, byrow = TRUE)
      [,1] [,2] [,3]
[1,]    1   -1    2
[2,]    3    2   -2
```

```
> matrix(c(1, -1, 2, 3, 2, -2), nrow = 2, ncol = 3, byrow = FALSE)
      [,1] [,2] [,3]
[1,]    1    2    2
[2,]   -1    3   -2
```

```
> A[2, 1] <- 100
> print(A)
      [,1] [,2] [,3]
[1,]    1    2    2
[2,]  100    3   -2
```



## LINEAR ALGEBRA FOR DATA SCIENCE IN R

**Let's practice!**





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# Lesson 1.2 Matrix-Vector Operations

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# How Matrix-Vector Multiplication Works

$$\begin{matrix} & A\vec{x} = \\ \begin{pmatrix} 1 & -1 \\ 2 & 1 \\ 4 & -2 \end{pmatrix} & \times & \begin{pmatrix} 1 \\ 2 \end{pmatrix} & = & \begin{pmatrix} 1 \times 1 + (-1) \times 2 \\ 2 \times 1 + 1 \times 2 \\ 4 \times 1 + (-2) \times 2 \end{pmatrix} & = & \begin{pmatrix} -1 \\ 4 \\ 0 \end{pmatrix} \\ \text{3x2} & & \text{2x1} & & & & \text{3x1} \end{matrix}$$



# How Matrix-Vector Multiplication Works

$$\begin{pmatrix} 1 & -1 \\ 2 & 1 \\ 4 & -2 \end{pmatrix} \times \begin{pmatrix} 1 \\ 2 \end{pmatrix} = \begin{pmatrix} 1 \times 1 + (-1) \times 2 \\ 2 \times 1 + 1 \times 2 \\ 4 \times 1 + (-2) \times 2 \end{pmatrix} = \begin{pmatrix} -1 \\ 4 \\ 0 \end{pmatrix}$$

**3x2**      **2x1**      **3x1**



# How Matrix-Vector Multiplication Works

```
> A
      [,1] [,2]
[1,]    1  -1
[2,]    2   1
[3,]    4  -2
```

```
> b
[1] 1 2
```

```
> A%*%b
      [,1]
[1,]   -1
[2,]    4
[3,]    0
```



# How Matrix-Vector Multiplication Works

$$\begin{pmatrix} 1 & 3 & 2 \\ 1 & 1 & 4 \end{pmatrix} \times \begin{pmatrix} 0 \\ 1 \\ 2 \end{pmatrix} = \begin{pmatrix} 1 \times 0 + 3 \times 1 + 2 \times 2 \\ 1 \times 0 + 1 \times 1 + 4 \times 2 \end{pmatrix} = \begin{pmatrix} 7 \\ 9 \end{pmatrix}$$

$A\vec{x} =$



# How Matrix-Vector Multiplication Works

```
> A[1,] %*% b
      [,1]
[1,]      7

> A[2,] %*% b
      [,1]
[1,]      9

> A %*% b
      [,1]
[1,]      7
[2,]      9
```



# Matrix-Vector Multiplication Motivation

Teams	Johns Hopkins	F & M	Gettysburg	Dickinson	McDaniel
Johns Hopkins	-	Loss, 12 - 14	Win 49-35	Win 49-0	Win 49-7
F & M	Win, 14 - 12	-	Loss, 31-38	Win 36-28	Win 35-10
Gettysburg	Loss 35-49	Win, 38-31	-	Loss 13-23	Win 35-3
Dickinson	Loss 0-49	Loss 28-36	Win 23-13	-	Win 38-31
McDaniel	Loss 7-49	Loss 10-35	Loss 3-35	Loss 31-38	-



# Matrix-Vector Multiplication Motivation

$$\begin{array}{c} \text{JH} \\ \text{F\&M} \\ \text{G} \\ \text{D} \\ \text{McD} \end{array} \begin{array}{ccccc} & \text{JH} & \text{F\&M} & \text{G} & \text{D} & \text{McD} \\ \left( \begin{array}{ccccc} 4 & -1 & -1 & -1 & -1 \\ -1 & 4 & -1 & -1 & -1 \\ -1 & -1 & 4 & -1 & -1 \\ -1 & -1 & -1 & 4 & -1 \\ -1 & -1 & -1 & -1 & 4 \end{array} \right) & \times & \begin{pmatrix} r_{\text{JH}} \\ r_{\text{F\&M}} \\ r_{\text{G}} \\ r_{\text{D}} \\ r_{\text{McD}} \end{pmatrix} & = & \begin{pmatrix} 103 \\ 28 \\ 15 \\ -40 \\ -106 \end{pmatrix} \end{array}$$





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**Let's practice!**



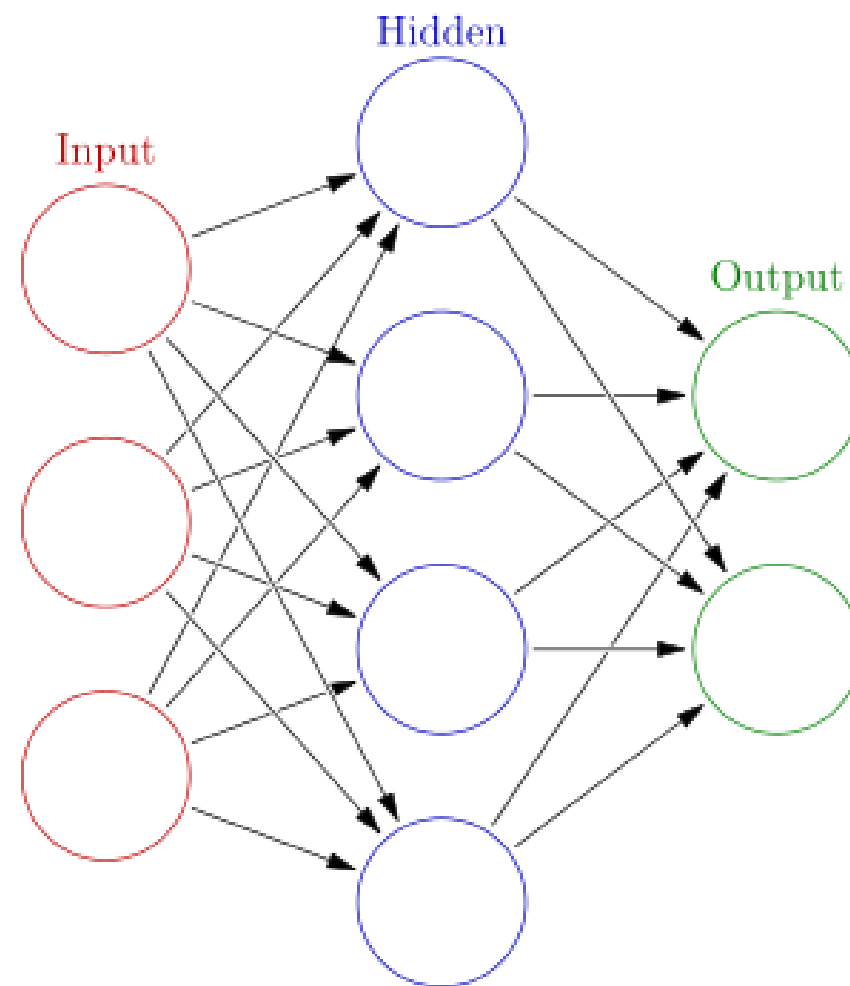
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# Lesson 1.3 Matrix-Matrix Calculations

Data Scientist at Pro Football Focus

Instructor

# Matrix-Matrix Multiplication Motivations





# How Matrix Multiplication Works

$$\begin{aligned} AB &= \\ \begin{pmatrix} \textcircled{1} & \textcircled{2} \\ 2 & 1 \end{pmatrix} \times \begin{pmatrix} \textcircled{0} & 1 \\ 1 & 2 \end{pmatrix} &= \\ \begin{pmatrix} \textcircled{1 \times 0 + 2 \times 1} & 1 \times 1 + 2 \times 2 \\ 2 \times 0 + 1 \times 1 & 2 \times 1 + 1 \times 2 \end{pmatrix} &= \\ \begin{pmatrix} \textcircled{2} & 5 \\ 1 & 4 \end{pmatrix} \end{aligned}$$



# How Matrix Multiplication Works

```
> A%*%B
      [,1] [,2]
[1,]     2     5
[2,]     1     4
```

```
> B%*%A
      [,1] [,2]
[1,]     2     1
[2,]     5     4
```

```
> A*B
      [,1] [,2]
[1,]     0     2
[2,]     2     2
```



# The Identity Matrix

$$I_3 = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$



# The Identity Matrix

```
> A
      [,1] [,2]
[1,]     1     2
[2,]     2     1
> I <- diag(2)
> I
      [,1] [,2]
[1,]     1     0
[2,]     0     1

> I%*%A
      [,1] [,2]
[1,]     1     2
[2,]     2     1
> A%*%I
      [,1] [,2]
[1,]     1     2
[2,]     2     1
```



# Additional Importance Concepts for Matrices

1. Square Matrices
2. The Matrix Inverse
3. Singular Matrices
4. Diagonal and Triangular Matrices





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**Let's practice!**