# BIOL 274 Homework 5

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Define each of the following scalars, vectors, and matrices:

$$s = 3, r = -2, q = \frac{1}{4}$$

$$v = \begin{bmatrix} -8 \\ 4 \\ -16 \end{bmatrix}, \quad w = \begin{bmatrix} 2 \\ -1 \\ 3 \\ 4 \end{bmatrix}, \quad A = \begin{bmatrix} -1 & 3 & 2 \\ 2 & 0 & -1 \\ 3 & 5 & -4 \end{bmatrix},$$

$$B = \begin{bmatrix} 0 & -2 & 7 & 4 \\ 6 & 0 & -5 & 1 \\ 0 & 1 & 4 & -2 \end{bmatrix}, \quad \text{and} \quad C = \begin{bmatrix} 11 & -3 & 1 & 0 \\ -2 & 5 & 0 & -1 \\ 1 & 3 & 0 & 4 \end{bmatrix}$$

We will also define them in R, for use later in checking our manual computations

```r
#scalars
s=3
r=-2
q=(1/4)

#vectors
v=c(-8, 4, -16)
w=c(2,-1,3,4)

#matrices
A = matrix(c(-1, 2, 3, 3, 0, 5, 2, -1, -4), nrow=3, ncol=3)
B = matrix(c(0,6,0,-2,0,1,7,-5,4,4,1,-3), nrow=3)
C = matrix(c(11,-2,1,-3,5,3,1,0,0,0,-1,-4), nrow=3)
```

Use these to determine each of the following, if possible. If not possible, state why.

## 1. $sw$

$$sw = 3 \begin{bmatrix} 2 \\ -1 \\ 3 \\ 4 \end{bmatrix} = \begin{bmatrix} 3(2) \\ 3(-1) \\ 3(3) \\ 3(4) \end{bmatrix} = \begin{bmatrix} 6 \\ -3 \\ 9 \\ 12 \end{bmatrix}$$

Check our manual computation:

```r
as.vector(s*w)
```

```
## [1]  6 -3  9 12
```

## 2. $qv$

$$qv = \frac{1}{4}\begin{bmatrix}-8\\4\\-16\end{bmatrix} = \begin{bmatrix}-8/4\\4/4\\-16/4\end{bmatrix} = \begin{bmatrix}-2\\1\\-4\end{bmatrix}$$

Check our manual computation:

```r
as.vector(q*v)
```

```
## [1] -2  1 -4
```

##3. $v + w$

This is not possible, because $v \in \mathbb{R}^3$ while $w \in \mathbb{R}^4$, and in order to add two vectors, they must be in the same n-dimensional space $\mathbb{R}^n$, where $n$ is the same for both vectors. In other words, $v$ has three elements while $w$ has four. To add vectors, they must be the same size.

When we try to do this in R, we should get an error:

```r
# the "error=TRUE" argument allows it to show errors without halting R
as.vector(v+w)
```

```
## Warning in v + w: longer object length is not a multiple of shorter object
## length
```

```
## [1]  -6   3 -13  -4
```

##4. $(s + r)w$

$$(s + r)w = (3 - 2)w = w = \begin{bmatrix}2\\-1\\3\\4\end{bmatrix}$$

Check our manual computation:

```r
as.vector((s+r) %*% w)
```

```
## [1]  2 -1  3  4
```

##5. $Aw$

This is not possible, because $A$ is a 3 by 3 matrix while $w$ is a vector in $\mathbb{R}^4$. In order for this to be possible, $w$ would need to have three elements, not four.

When we try to do this in R, we should get an error:

```r
A %*% w
```

```
## Error in A %*% w: non-conformable arguments
```

##6. $(-A)v$

$$-A = \begin{bmatrix} 1 & -3 & -2 \\ -2 & 0 & 1 \\ -3 & -5 & 4 \end{bmatrix}$$

$$-Av = \begin{bmatrix} 1 & -3 & -2 \\ -2 & 0 & 1 \\ -3 & -5 & 4 \end{bmatrix} \begin{bmatrix} -8 \\ 4 \\ -16 \end{bmatrix} = \begin{bmatrix} (1)(-8) + (-3)(4) + (-2)(-16) \\ (-2)(-8) + (0)(4) + (1)(-16) \\ (-3)(-8) + (-5)(4) + (4)(-16) \end{bmatrix} = \begin{bmatrix} 12 \\ 0 \\ -60 \end{bmatrix}$$

Now we will check our manual computation:

```r
negA = -1*A #Define -A

negA %*% v #multiply A by v
```

```
##      [,1]
## [1,]   12
## [2,]    0
## [3,]  -60
```

##7. $Bw$

$$Bw = \begin{bmatrix} 0 & -2 & 7 & 4 \\ 6 & 0 & -5 & 1 \\ 0 & 1 & 4 & -3 \end{bmatrix} \begin{bmatrix} 2 \\ -1 \\ 3 \\ 4 \end{bmatrix} = \begin{bmatrix} (0)(2) + (-2)(-1) + (7)(3) + (4)(4) \\ (6)(2) + (0)(-1) + (-5)(3) + (1)(4) \\ (0)(2) + (1)(-1) + (4)(3) + (-3)(4) \end{bmatrix} = \begin{bmatrix} 39 \\ 1 \\ -1 \end{bmatrix}$$

Now we will check our manual computation:

```r
B %*% w #multiply B by w
```

```
##      [,1]
## [1,]   39
## [2,]    1
## [3,]   -1
```

##8. $B + C$

$$B{+}C = \begin{bmatrix} 0 & -2 & 7 & 4 \\ 6 & 0 & -5 & 1 \\ 0 & 1 & 4 & -3 \end{bmatrix} + \begin{bmatrix} 11 & -3 & 1 & 0 \\ -2 & 5 & 0 & -1 \\ 1 & 3 & 0 & -4 \end{bmatrix} = \begin{bmatrix} 0+11 & -2-3 & 7+1 & 4+0 \\ 6-2 & 0+5 & -5+0 & 1-1 \\ 0+1 & 1+3 & 4+0 & -3-4 \end{bmatrix} = \begin{bmatrix} 11 & -5 & 8 & 4 \\ 4 & 5 & -5 & 0 \\ 1 & 4 & 4 & -7 \end{bmatrix}$$

Now we will check our manual computation:

```
B + C #add B and C
```

```
##      [,1] [,2] [,3] [,4]
## [1,]   11   -5    8    4
## [2,]    4    5   -5    0
## [3,]    1    4    4   -7
```

##9. $C - B$

$$C - B = \begin{bmatrix} 11 & -3 & 1 & 0 \\ -2 & 5 & 0 & -1 \\ 1 & 3 & 0 & -4 \end{bmatrix} - \begin{bmatrix} 0 & -2 & 7 & 4 \\ 6 & 0 & -5 & 1 \\ 0 & 1 & 4 & -3 \end{bmatrix} = \begin{bmatrix} 11-0 & -3-2 & 1-7 & 0-4 \\ -2-6 & 5-0 & 0-(-5) & -1-1 \\ 1-0 & 3-1 & 0-4 & -4-(-3) \end{bmatrix} = \begin{bmatrix} 11 & -5 & -6 & -4 \\ -8 & 5 & 5 & -2 \\ 1 & 2 & -4 & -1 \end{bmatrix}$$

Now we will check our manual computation:

```
C-B #add B and C
```

```
##      [,1] [,2] [,3] [,4]
## [1,]   11   -1   -6   -4
## [2,]   -8    5    5   -2
## [3,]    1    2   -4   -1
```

##10. $Cv$

This is not possible, because $C$ is a 3 by 4 matrix while $v$ is a vector in $\mathbb{R}^3$. In order for this to be possible, $v$ would need to have four elements, not three.

When we try to do this in R, we should get an error:

```
C %*% v
```

```
## Error in C %*% v: non-conformable arguments
```

##11. (s-r)B