Last name ________________________

First name ________________________

LARSON—MATH 310–CLASSROOM WORKSHEET 21
Matrix-Matrix Multiplication.

Set up your CoCalc JUPYTER notebook for today's work.

1. Start the Chrome browser.
2. Go to `https://cocalc.com`
3. Log in.
4. You should see an existing Project for our class. Click on that.
5. Copy the folder `CodingTheMatrix-fixed` to your Home directory. This has the new version of `solver`.
6. Make sure you are in your own `CodingTheMatrix-fixed` directory (if you work in the Handouts directory version, your work could get overwritten).
7. Click "New", then "Jupyter Notebook", then call it **310-h08**. This file should be in your `CodingTheMatrix-fixed` directory.
8. Make sure you have PYTHON as the *kernel*.

Review

1. How is matrix-matrix multiplication defined?

From: Chapter 4 of Klein's *Coding the Matrix* text

1. We need to import various modules/libraries.

```
from solver import *
from GF2 import *
from vec import *
from matutil import *
```

2. Do these matrix products make sense? Code them and use the overloaded "*" operator to find out.

Matrix-matrix multiplication: dimensions of matrices

Problem 4.17.5: For each of the following problems, answer whether the given matrix-matrix product is valid or not. If it is valid, give the number of rows and the number of columns of the resulting matrix (you need not provide the matrix itself).

1. $\begin{bmatrix} 1 & 1 & 0 \\ 1 & 0 & 1 \end{bmatrix} \begin{bmatrix} 2 & 1 & 1 \\ 3 & 1 & 2 \end{bmatrix}$
2. $\begin{bmatrix} 3 & 3 & 0 \end{bmatrix} \begin{bmatrix} 1 & 4 & 1 \\ 1 & 7 & 2 \end{bmatrix}$
3. $\begin{bmatrix} 3 & 3 & 0 \end{bmatrix} \begin{bmatrix} 1 & 4 & 1 \\ 1 & 7 & 2 \end{bmatrix}^T$
4. $\begin{bmatrix} 1 & 4 & 1 \\ 1 & 7 & 2 \end{bmatrix} \begin{bmatrix} 3 & 3 & 0 \end{bmatrix}^T$
5. $\begin{bmatrix} 1 & 4 & 1 \\ 1 & 7 & 2 \end{bmatrix} \begin{bmatrix} 3 & 3 & 0 \end{bmatrix}$
6. $\begin{bmatrix} 2 & 1 & 5 \end{bmatrix} \begin{bmatrix} 1 & 6 & 2 \end{bmatrix}^T$
7. $\begin{bmatrix} 2 & 1 & 5 \end{bmatrix}^T \begin{bmatrix} 1 & 6 & 2 \end{bmatrix}$

3. Use the matrix-column and row-matrix definitions to find AB and BA. Compute to check.

Problem 4.17.7: Let

$$A = \begin{bmatrix} 2 & 0 & 1 & 5 \\ 1 & -4 & 6 & 2 \\ 3 & 0 & -4 & 2 \\ 3 & 4 & 0 & -2 \end{bmatrix}$$

For each of the following values of the matrix B, compute AB and BA. (I recommend you not use the computer to compute these.)

1. $B = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \end{bmatrix}$ 2. $B = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$ 3. $B = \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 \end{bmatrix}$

4. Use the last A and B matrices to test the built-in `Mat` class methods.

operation	syntax
Matrix addition and subtraction	`A+B` and `A-B`
Matrix negative	`-A`
Scalar-matrix multiplication	`alpha*A`
Matrix equality test	`A == B`
Matrix transpose	`A.transpose()`
Getting and setting a matrix entry	`A[r,c]` and `A[r,c] = alpha`
Matrix-vector and vector-matrix multiplication	`v*A` and `A*v`
Matrix-matrix multiplication	`A*B`

5. Use the last A and B matrices to test the claim that $(AB)^T = B^T A^T$.

6. What is the *inverse* of a matrix A (if the inverse exists, the notation for the inverse matrix is A^{-1}, read "A inverse", and A is called *invertible*).

7. Is the identity matrix invertible?

Getting your classwork recorded
When you are done, before you leave class...

1. Click the “Print” menu choice (under “File”) and make a pdf of this worksheet (html is OK too).

2. Send me an email (`clarson@vcu.edu`) with an informative header like
“Math 310 - c21 worksheet attached” (so that it will be properly recorded).

3. Remember to attach today’s classroom worksheet!