Game Theory Coding Assignment

- You are allowed to work alone or in a group of maximum size of 2.
- **IMPORTANT -** You need to write the program in Java and use the newest version of Netbeans IDE. If you do not do this, you will get a zero for the project.

  Normally, I would let you write the code in any language and IDE that you like because you would be showing the code running on your machine. But since this is not the case you will need use Java 13 and the newest version of Netbeans, so I can run it on my machine without an issue, thanks.

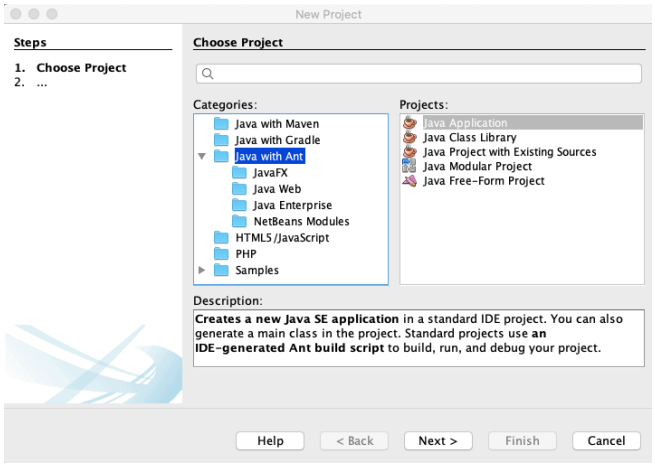
  Download Netbeans here: https://netbeans.apache.org/download/index.html

  Download Java here: https://www.oracle.com/java/technologies/javase-jdk13-downloads.html

- You must zip your entire Netbeans Project folder and upload it to canvas using the assignment link. **Important, if your group has two people in it each person must upload the zipped project to canvas.**
- If you have any questions please email and I will gladly help you. ☺

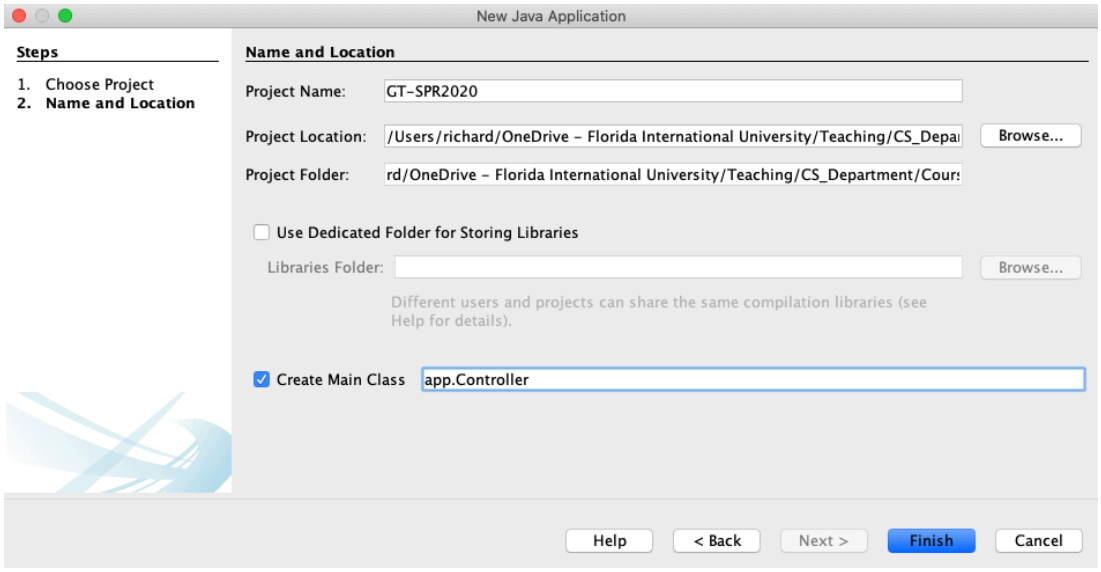
If you email me this project, I will not except it. Do not wait until 11:58pm to upload it. If you are late and you email it to me your project stating, there was issues with canvas uploading it. I will not except it. So please make sure to plan accordingly.

1) When setting up your Netbeans Project go to the File menu and select: New Project then select "Java with Ant" with "Java Application" then click on the next button. See figure below:

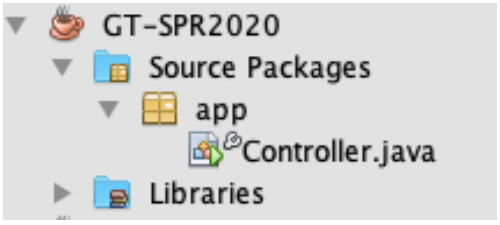


2) A new dialog window will appear. Please do the following:
   - Set the Project Name to: “GT-SPR2020”
   - Set the Create Main Class to: “app.Controller”
   - Make sure that the Create Main Class checkbox is checked

The Project Location and Project Folder field are set to your machine, so they will be different from mine. Also pay attention to the case sensitivity of “app.Controller”, see figure below.



3) Your Project should look like this in the IDE:



4) Add this header to the top of the Controller.java file. Please note that if you do not put the header in your code, I will deduct 40% off your assignment grade.

File Header

```
//===========================================================================
//PROGRAMMER1:      Your name
// PANTHER ID1:           Your panther ID
// CLASS:            Your class: example CAP4506
//
//PROGRAMMER2:      Your name
// PANTHER ID2:           Your panther ID
// CLASS:            Your class: example CAP5706
//
// SEMESTER:         The current semester: example Spring 2020
// CLASSTIME:        Your COP2210 course meeting time :example T/TH 9:00-10:15 am
//
// Project:          Description of project
// DUE:              Sunday, April 19, 2025
//
// CERTIFICATION:    I certify that this work is my own and that
//                                none of it is the work of any other person.
//===========================================================================
```

What your code should do when running:

1) Your code should ask the user for input to run in Random or Manual mode. Next, regardless of the mode the user entered the code ask the user for the number of rows and columns of the normal form. Your code should be able to handle sizes of 1x1 to 9x9 without any display issues. I will be checking this.

Example:

```
Enter (R)andom or (M)anual payoffs enteries
R
Enter the number of rows: 5
Enter the number of cols: 7
```

RANDOM MODE

2) If the random mode is selected the application will display the strategy spaces and payoffs of players 1 and 2. Note in random mode the random payoffs are integers that range from -99 to 99.

Example:

```
-----------------------------------
Player: Player1's strategies
-----------------------------------
{A1, A2, A3, A4, A5}

-----------------------------------
Player: Player1's payoffs
-----------------------------------
-79,  54,  33,  55, -27,  32, -97
 59, -98, -59, -96,  41,  37,  46
 19, -25,  89, -64,  54, -98,  91
 14,  45, -59,  50,  -5,  83, -48
 28,  32,  33, -75, -13, -50,  44

-----------------------------------
Player: Player2's strategies
-----------------------------------
{B1, B2, B3, B4, B5, B6, B7}

-----------------------------------
Player: Player2's payoffs
-----------------------------------
-92,  -6,  78, -60, -69,   2,  82
 64, -56, -77, -71, -19, -81, -14
 -8, -88, -69, -93, -42, -95,  23
-95,  49,  25, -31, -18,  18,  75
-11, -40, -10, -76, -22,  76,  75
```

3) The application will display the normal form of the game. Make sure your code can handle normal forms of size 1x1 to 9x9 without alignment issues. Notice that player1 strategies are dynamically name A1, A2 … and for player2 B1, B2 …

Example:

```
======================================
Display Normal Form
======================================
          B1            B2            B3            B4            B5            B6            B7
   ---------------------------------------------------------------------------------------------------
 A1 |  (-79,-92)   |  ( 54,-6 )   |  ( 33,78 )   |  ( 55,-60)   |  (-27,-69)   |  ( 32,2  )   |  (-97,82 )  |
   ---------------------------------------------------------------------------------------------------
 A2 |  ( 59,64 )   |  (-98,-56)   |  (-59,-77)   |  (-96,-71)   |  ( 41,-19)   |  ( 37,-81)   |  ( 46,-14)  |
   ---------------------------------------------------------------------------------------------------
 A3 |  ( 19,-8 )   |  (-25,-88)   |  ( 89,-69)   |  (-64,-93)   |  ( 54,-42)   |  (-98,-95)   |  ( 91,23 )  |
   ---------------------------------------------------------------------------------------------------
 A4 |  ( 14,-95)   |  ( 45,49 )   |  (-59,25 )   |  ( 50,-31)   |  ( -5,-18)   |  ( 83,18 )   |  (-48,75 )  |
   ---------------------------------------------------------------------------------------------------
 A5 |  ( 28,-11)   |  ( 32,-40)   |  ( 33,-10)   |  (-75,-76)   |  (-13,-22)   |  (-50,76 )   |  ( 44,75 )  |
   ---------------------------------------------------------------------------------------------------
```

4) Display the Pure Nash Equilibrium by replacing the numerical value of the best response by an ‘H’ in the normal form. Also output the Pure Nash Equilibrium(s). If there is no Pure Nash Equilibrium still output the normal form with replacing the numerical value of the best response by an ‘H’ and stated there are no Pure Nash Equilibrium.

Example:

```
======================================
Nash Pure Equilibrium Locations
======================================
          B1            B2            B3            B4            B5            B6            B7
   ---------------------------------------------------------------------------------------------------
 A1 |  (-79,-92)   |  (  H,-6 )   |  ( 33,78 )   |  (  H,-60)   |  (-27,-69)   |  ( 32,2  )   |  (-97,H  )  |
   ---------------------------------------------------------------------------------------------------
 A2 |  (  H,H  )   |  (-98,-56)   |  (-59,-77)   |  (-96,-71)   |  ( 41,-19)   |  ( 37,-81)   |  ( 46,-14)  |
   ---------------------------------------------------------------------------------------------------
 A3 |  ( 19,-8 )   |  (-25,-88)   |  (  H,-69)   |  (-64,-93)   |  (  H,-42)   |  (-98,-95)   |  (  H,H  )  |
   ---------------------------------------------------------------------------------------------------
 A4 |  ( 14,-95)   |  ( 45,49 )   |  (-59,25 )   |  ( 50,-31)   |  ( -5,-18)   |  (  H,18 )   |  (-48,H  )  |
   ---------------------------------------------------------------------------------------------------
 A5 |  ( 28,-11)   |  ( 32,-40)   |  ( 33,-10)   |  (-75,-76)   |  (-13,-22)   |  (-50,H  )   |  ( 44,75 )  |
   ---------------------------------------------------------------------------------------------------

Nash Pure Equilibrium(s): (A2, B1)   (A3, B7)
```

4) Create random beliefs then calculate the Expected Payoffs and Best Response(s) for players 1 and 2. Pay attention to the formatting and notation of your output.

Example:

```
-------------------------------------------
Player 1 Expected Payoffs with Player 2 Mixing
-------------------------------------------
U(A1,(0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = -7.37
U(A2,(0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = -8.50
U(A3,(0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = -6.86
U(A4,(0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = 23.02
U(A5,(0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = -5.22

-----------------------------------------
Player 1 Best Response with Player 2 Mixing
-----------------------------------------
BR(0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23) = {A4}


-------------------------------------------
Player 2 Expected Payoffs with Player 1 Mixing
-------------------------------------------
U((0.19, 0.28, 0.16, 0.17, 0.19), B1) = -19.08
U((0.19, 0.28, 0.16, 0.17, 0.19), B2) = -30.17
U((0.19, 0.28, 0.16, 0.17, 0.19), B3) = -15.43
U((0.19, 0.28, 0.16, 0.17, 0.19), B4) = -65.87
U((0.19, 0.28, 0.16, 0.17, 0.19), B5) = -32.39
U((0.19, 0.28, 0.16, 0.17, 0.19), B6) = -20.00
U((0.19, 0.28, 0.16, 0.17, 0.19), B7) = 42.34

-----------------------------------------
Player 2 Best Response with Player 1 Mixing
-----------------------------------------
BR(0.19, 0.28, 0.16, 0.17, 0.19) = {B7}
```

5) Calculate the Expected Payoffs for players 1 and 2 with they actual mix that uses the random generated beliefs in step 6. Pay attention to the formatting and notation of your output.

Example:

```
-----------------------------------------------------
Player 1 & 2 Expected Payoffs with both Players Mixing
-----------------------------------------------------
Player 1 -> U((0.19, 0.28, 0.16, 0.17, 0.19), (0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = -1.96
Player 2 -> U((0.19, 0.28, 0.16, 0.17, 0.19), (0.12, 0.18, 0.01, 0.19, 0.08, 0.19, 0.23)) = -17.04
```

6) In random mode if the normal form is 2x2 and there is no Pure Nash Equilibrium then calculate the indifference probabilities of players 1 and 2.

Example:

```
--------------------------------------------
Player 1 & 2 Indifferent Mix Probabilities
--------------------------------------------
Player 1 probability of strategies (A1) = 0.44
Player 1 probability of strategies (A2) = 0.56
Player 2 probability of strategies (B1) = 1.26
Player 2 probability of strategies (B2) = -0.26


======================================
Nash Equilibrium Locations
======================================
           B1             B2
    ------------------------------
 A1 |  (  H,-54)   |  (-10,H  )  |
    ------------------------------
 A2 |  (-50,H  )   |  (  H,-60)  |
    ------------------------------
Nash Equilibrium(s): None
```

In case there is a Pure Nash Equilibrium

```
======================================
Nash Equilibrium Locations
======================================
           B1             B2
    ------------------------------
 A1 |  ( 47,H  )   |  ( 17,-40)  |
    ------------------------------
 A2 |  (  H,-34)   |  (  H,H  )  |
    ------------------------------
Nash Equilibrium(s): (A2, B2)

--------------------------------------------
Player 1 &  2 Indifferent Mix Probabilities
--------------------------------------------
Normal Form has Pure Strategy Equilibrium
```

1) In manual mode get user input for the rows, columns and payoffs. Then display the Normal form and the Pure Nash Equilibrium information.

Example:

```
Enter (R)andom or (M)anual payoffs enteries
M
Enter the number of rows: 3
Enter the number of cols: 4

Manual Entries
Enter payoff for ( A1, B1 ) = 1,2
Enter payoff for ( A1, B2 ) = 3,2
Enter payoff for ( A1, B3 ) = 5,2
Enter payoff for ( A1, B4 ) = 4,2
--------------------------
Enter payoff for ( A2, B1 ) = 5,2
Enter payoff for ( A2, B2 ) = 8,2
Enter payoff for ( A2, B3 ) = 4,5
Enter payoff for ( A2, B4 ) = 1,2
--------------------------
Enter payoff for ( A3, B1 ) = 4,2
Enter payoff for ( A3, B2 ) = 3,3
Enter payoff for ( A3, B3 ) = 5,6
Enter payoff for ( A3, B4 ) = 1,1
--------------------------
======================================
Display Normal Form
======================================
           B1             B2             B3             B4
    ------------------------------------------------------------
 A1 |  (  1,2  )   |  (  3,2  )   |  (  5,2  )   |  (  4,2  )  |
    ------------------------------------------------------------
 A2 |  (  5,2  )   |  (  8,2  )   |  (  4,5  )   |  (  1,2  )  |
    ------------------------------------------------------------
 A3 |  (  4,2  )   |  (  3,3  )   |  (  5,6  )   |  (  1,1  )  |
    ------------------------------------------------------------
======================================
Nash Equilibrium Locations
======================================
           B1             B2             B3             B4
    ------------------------------------------------------------
 A1 |  (  1,H  )   |  (  3,H  )   |  (  H,H  )   |  (  H,H  )  |
    ------------------------------------------------------------
 A2 |  (  H,2  )   |  (  H,2  )   |  (  4,H  )   |  (  1,2  )  |
    ------------------------------------------------------------
 A3 |  (  4,2  )   |  (  3,3  )   |  (  H,H  )   |  (  1,1  )  |
    ------------------------------------------------------------
Nash Equilibrium(s): (A1, B3)   (A1, B4)   (A3, B3)
```

2) If the Normal Form is 2x2 and the game does not have a Pure Nash Equilibrium then calculate players 1 and 2 Indifferent Mix Probabilities.

Example:

```
Enter (R)andom or (M)anual payoffs enteries
M
Enter the number of rows: 2
Enter the number of cols: 2

Manual Entries
Enter payoff for ( A1, B1 ) = -1,1
Enter payoff for ( A1, B2 ) = 1,-1
---------------------------
Enter payoff for ( A2, B1 ) = 1,-1
Enter payoff for ( A2, B2 ) = -1,1
---------------------------
======================================
Display Normal Form
======================================
           B1             B2
    ------------------------------
 A1 |  ( -1,1  )   |  (  1,-1 )  |
    ------------------------------
 A2 |  (  1,-1 )   |  ( -1,1  )  |
    ------------------------------
======================================
Nash Equilibrium Locations
======================================
           B1             B2
    ------------------------------
 A1 |  ( -1,H  )   |  (  H,-1 )  |
    ------------------------------
 A2 |  (  H,-1 )   |  ( -1,H  )  |
    ------------------------------
Nash Equilibrium(s): None

------------------------------------------------
Player 1 &  2 Indifferent Mix Probabilities
------------------------------------------------
Player 1 probability of strategies (A1) = 0.50
Player 1 probability of strategies (A2) = 0.50
Player 2 probability of strategies (B1) = 0.50
Player 2 probability of strategies (B2) = 0.50
```

In case there are Pure Nash Equilibrium(s)

```
======================================
Display Normal Form
======================================
           B1             B2
    ------------------------------
 A1 |  (  1,1  )   |  (  0,0  )  |
    ------------------------------
 A2 |  (  0,0  )   |  (  2,2  )  |
    ------------------------------
======================================
Nash Equilibrium Locations
======================================
           B1             B2
    ------------------------------
 A1 |  (  H,H  )   |  (  0,0  )  |
    ------------------------------
 A2 |  (  0,0  )   |  (  H,H  )  |
    ------------------------------
Nash Equilibrium(s): (A1, B1)   (A2, B2)

------------------------------------------------
Player 1 &  2 Indifferent Mix Probabilities
------------------------------------------------
Normal Form has Pure Strategy Equilibrium
```

3) Upload you zip code project to canvas using the assignment provided. **Important, if your group has two people in it each person must upload the zipped code to canvas.**