# Programming Project 2

Lawrence Ho
CS6364.001

**Program Output Examples for all 4 Programs**:

- Starting position: WwwwxxxxxxxxbbbB        Depth: 2

```
Board Position: xwwwWxxxxxxxbbbB
Positions evaluated by static estimation: 16
MINIMAX estimate: 0

Process finished with exit code 0
```

```
Board Position: xwwwWxxxxxxxbbbB
Positions evaluated by static estimation: 7
ALPHA-BETA estimate: 0

Process finished with exit code 0
```

```
Board Position: WwwwxxxxxxxxBbbbx
Positions evaluated by static estimation: 16
MINIMAX-Black estimate: 0

Process finished with exit code 0
```

```
Board Position: xwwwWxxxxxxxbbbB
Positions evaluated by static estimation: 16
MINIMAX-Improved estimate: -61

Process finished with exit code 0
```

- Starting position: xwxWxwbwxxBbxbxx        Depth: 5

```
Board Position: xwxWxwbxwxBbxbxx
Positions evaluated by static estimation: 1024
MINIMAX estimate: 1

Process finished with exit code 0
```

```
Board Position: xwxWxwbxwxBbxbxx
Positions evaluated by static estimation: 186
ALPHA-BETA estimate: 1

Process finished with exit code 0
```

```
Board Position: xwxWxwbwxBxbxbxx
Positions evaluated by static estimation: 1024
MINIMAX-Black estimate: -3

Process finished with exit code 0
```

```
Board Position: xwxWxwbxwxBbxbxx
Positions evaluated by static estimation: 1024
MINIMAX-Improved estimate: -17

Process finished with exit code 0
```

**Alpha-Beta vs Minimax**:

- Starting position: xwwxxWxBbxwxxbbx     Depth: 2

```
Board Position: xxwwxWxBbxwxxbbx
Positions evaluated by static estimation: 16
MINIMAX estimate: -4


Process finished with exit code 0
```

```
Board Position: xxwwxWxBbxwxxbbx
Positions evaluated by static estimation: 7
ALPHA-BETA estimate: -4


Process finished with exit code 0
```

- Starting position: xwBwxbxxwbxxbxWx     Depth: 4

```
Board Position: xwBwxbxxwbxxbxxW
Positions evaluated by static estimation: 235
MINIMAX estimate: 100


Process finished with exit code 0
```

```
Board Position: xwBwxbxxwbxxbxxW
Positions evaluated by static estimation: 79
ALPHA-BETA estimate: 100


Process finished with exit code 0
```

- Starting position: WxwxxbxxxwbxbxwB     Depth: 10

```
Board Position: xWwxxbxxxwbxbxwB
Positions evaluated by static estimation: 708006
MINIMAX estimate: -2


Process finished with exit code 0
```

```
Board Position: xWwxxbxxxwbxbxwB
Positions evaluated by static estimation: 17074
ALPHA-BETA estimate: -2


Process finished with exit code 0
```

**My Static Evaluation Function vs Standard Static Evaluation Function**:

- Starting position: xbwxxxwBxWbxbwxx      Depth: 10

```
Board Position: xbwxxxxxwWbxbwxB
Positions evaluated by static estimation: 786065
MINIMAX estimate: 7

Process finished with exit code 0
```

```
Board Position: xbxwxxwBxWbxbwxx
Positions evaluated by static estimation: 785646
MINIMAX-Improved estimate: -13

Process finished with exit code 0
```

- Starting position: xWxbbxxwxxBxxxxx      Depth: 3

```
Board Position: xWxbbxxxwxBxxxxx
Positions evaluated by static estimation: 12
MINIMAX estimate: -2

Process finished with exit code 0
```

```
Board Position: xxWbbxxwxxBxxxxx
Positions evaluated by static estimation: 12
MINIMAX-Improved estimate: -52

Process finished with exit code 0
```

The standard static estimation function only takes into account the position of the White king and Black king. My static estimation function is better as it takes into account the kings' positions as well as the presence and influence of pawn pieces. My estimation function evaluates the kings' position by (whiteKingPos – blackKingPos) * 5. As the kings are evaluated separately from the pawns, the multiplication by 5 gives the evaluation of the kings more weight as the winning condition of the game is determined by the kings and not the pawns.

The pawns are evaluated by whitePawnVal – blackPawnVal, where each value is based on the number of pawns on the board as well as their position. White pawns further right have higher value and black pawns further left have higher value. The pawns are also evaluated as their presence can influence the outcome of the game, such as jumping over a single piece to send it back to its starting side. Once both the kings and pawns are evaluated, the final estimation function returns:

- 100 if the White king is off the board
- -100 if the Black king is off the board
- ((whiteKingPos - blackKingPos) * 5) + (whitePawnVal – blackPawnVal)