

## Main Code Screenshots, from top to bottom:

**All of the docstrings written are/were leveraged with copilot for prompt engineering.**

```
battleship_game_EE.py X
C:\Users\logan> OneDrive > Documents > CS111 > Project files > battleship_game_EE.py > ...
1  """ Zachary Cornthwaite
2  """ Logan Harris
3  """ 12/9/24
4  """ Battleship game
5  """ This is a simple battleship game that we created. It is a two player game where each player has a board with ships on it that they placed.
6  """ The players take turns to hit the ships on the opponent's board. The player who hits all the ships first wins the game.
7
8
9  import matplotlib.pyplot as plt
10 import random
11 import time
12
13 """
14 Void function that visualize the board using matplotlib. Creates a 10x10 board with grid lines and markers for ships. Creates a legend for the ship types/hits and misses.
15 Takes a "board" input which is a 10x10 list of strings representing the board state.
16 This function will be used to visualize the board after each ship placement and after each turn in the main game loop in main().
17 It also will be called by the place_ships() function to visualize the board after each ship placement.
18 """
19 def visualize_board(board):
20     plt.figure(figsize=(10, 10))
21
22     """ Plot grid lines
23     for i in range(1, 12):
24         plt.axhline(y=i, color='gray', linestyle='-', alpha=0.3)
25         plt.axvline(x=i, color='gray', linestyle='-', alpha=0.3)
26
27     """ Set colors and labels for ships
28     colors = {'C': 'gray', 'B': 'blue', 'R': 'green', 'S': 'red', 'D': 'purple',
29             ' ': 'white', 'H': 'yellow', 'M': 'black'}
30     labels = {'C': 'Carrier', 'B': 'Battleship', 'R': 'Cruiser', 'S': 'Submarine',
31             'D': 'Destroyer', 'H': 'Hit', 'M': 'Miss'}
32
33     """ Plot ships
34     for i in range(10):
35         for j in range(10):
36             ship_type = board[i][j]
37             plt.scatter(j + 1, i + 1, color=colors[ship_type], s=100)
38
39     """ Create legend
40     legend_elements = [plt.Line2D([0], [0], marker='o', color='w',
41                                 markerfacecolor=colors[key], markersize=10,
42                                 label=labels[key])
43                        for key in labels if key != ' ']
44     plt.legend(handles=legend_elements, loc='upper right')
45
46     """ Set axis limits and labels
47     plt.xlim(0.5, 10.5)
48     plt.ylim(0.5, 10.5) """ Reverse the y-axis to match the board
49
50     """ Set x-axis ticks (1-10)
51     plt.xticks(range(1, 11))
52
53     """ Set y-axis ticks (A-J)
54     letters = ['A', 'B', 'C', 'D', 'E', 'F', 'G', 'H', 'I', 'J']
55     plt.yticks(range(1, 11), letters)
56
57     """ Set x-axis label on top, similar to battleship board
58     ax = plt.gca()
59     ax.xaxis.set_label_position('top')
60     ax.xaxis.tick_top()
61
62     plt.xlabel('Number')
63     plt.ylabel('Letter')
64     plt.title('Battleship Board', pad=20)
65     plt.show()
66
67 """
68 Non-void function that returns "board" per the player parameter that is it given (determined by the coin_flip in main). Asks the player to create a board by placing their ships.
69 Shows the board after each placement and asks for confirmation. If the player is not satisfied with the placement, they can try again.
70 If the ship goes out of bounds or overlaps with another ship, the player is asked to try again. If any input is invalid, the player is asked to try again.
71 This function should only be called twice by main() to get the boards for both players at the start of the game.
72 """
73 def place_ships(player):
74     print(player + ", place your ships.")
75     ships = ["Carrier", "Battleship", "Cruiser", "Submarine", "Destroyer"]
76     ship_lengths = [5, 4, 3, 3, 2]
77     ship_codes = {'Carrier': 'C', 'Battleship': 'B', 'Cruiser': 'R',
78                 'Submarine': 'S', 'Destroyer': 'D'}
79
80     """ Initialize the board (10x10 grid)
81     board = [[' ' for _ in range(10)] for _ in range(10)]
82
83     """ Dictionary to convert row letters to numbers
84     letter_to_num = {'A': 0, 'B': 1, 'C': 2, 'D': 3, 'E': 4,
85                    'F': 5, 'G': 6, 'H': 7, 'I': 8, 'J': 9}
86
87     """ Place each ship
88     for i in range(len(ships)):
89         while True:
90             print(f"\n
```

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73 def place_ships(player):
89     while True:
90         print(f"\n
91 Place your {ships[i]} ({ship_lengths[i]} spaces).")
92
93         ### Create a temporary board for visualization
94         temp_board = [row[:] for row in board]
95
96         try:
97             ### Get input in Battleship coordinates
98             row_letter = input("Enter row (A-J): ").upper()
99             col = int(input("Enter column (1-10): "))
100            orientation = input("Enter orientation (H for horizontal, V for vertical): ").upper()
101
102            ### Validate row letter
103            if row_letter not in letter_to_num:
104                print("Invalid row. Please enter a letter A-J.")
105                continue
106
107            ### Convert to array indices
108            array_row = letter_to_num[row_letter]
109            array_col = col - 1 ### Convert to 0-based index
110
111            ### Validate column input
112            if col < 1 or col > 10:
113                print("Invalid column. Please enter a number between 1 and 10.")
114                continue
115
116            ### Check if ship is already placed in the selected location
117            if orientation == "H":
118                if array_col + ship_lengths[i] > 10:
119                    print("Ship is out of bounds. Try again.")
120                    continue
121                if any(temp_board[array_row][array_col + j] != " "
122                    for j in range(ship_lengths[i])):
123                    print("Ship overlaps with another ship. Try again.")
124                    continue
125                for j in range(ship_lengths[i]):
126                    temp_board[array_row][array_col + j] = ship_codes[ships[i]]
127
128            elif orientation == "V":
129                if array_row + ship_lengths[i] > 10:
130                    print("Ship is out of bounds. Try again.")
131                    continue
132                if any(temp_board[array_row + j][array_col] != " "
133                    for j in range(ship_lengths[i])):
134                    print("Ship overlaps with another ship. Try again.")
135                    continue
136                for j in range(ship_lengths[i]):
137                    temp_board[array_row + j][array_col] = ship_codes[ships[i]]
138
139            else:
140                print("Invalid orientation. Try again.")
141                continue
142
143            ### Visualize the board with the new ship placement
144            visualize_board(temp_board)
145
146            ### Ask for confirmation
147            confirm = input("Is this placement acceptable? (Y/N): ").upper()
148            if confirm == 'Y':
149                board = temp_board
150                break
151            else:
152                print("Place your ship again.")
153                continue
154
155        except ValueError:
156            print("Invalid input. Please enter a letter (A-J) for row and number (1-10) for column.")
157
158    print("\n
159 Here is your final board placement:")
160    visualize_board(board)
161    return board
162
163
164    """
165    Void function that takes the player, the opponent's board, and the tracking board as inputs. The player is asked to enter coordinates, and the function checks if the position was
166    already fired upon. If the position was already fired upon, the player is asked to try again. If the position was not fired upon, the function checks if the position is a hit or a miss.
167    If it is a hit, the player is notified and the tracking board is updated with an 'H'. If it is a miss, the player is notified and the tracking board is updated with an 'M'.
168    Does not communicate which ship is sunk, only updates the board with H or M.
169    """
170    def take_turn(player, opponent_board, tracking_board):
171        print(f"
```

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167 If it is a hit, the player is notified and the tracking board is updated with an 'H'. If it is a miss, the player is notified and the tracking board is updated with an 'M'.
168 Does not communicate which ship is sunk, only updates the board with H or M.
169 """
170 def take_turn(player, opponent_board, tracking_board):
171     print(f"\n{player}'s turn to fire!")
172     print("\nYour tracking board (where you've fired):")
173     visualize_board(tracking_board)
174
175     while True:
176         try:
177             row_letter = input("Enter target row (A-J): ").upper() ## Targeting row
178             col = int(input("Enter target column (1-10): ")) ## Targeting column
179
180             ## Convert coordinates
181             letter_to_num = {'A': 0, 'B': 1, 'C': 2, 'D': 3, 'E': 4,
182                             'F': 5, 'G': 6, 'H': 7, 'I': 8, 'J': 9}
183
184             if row_letter not in letter_to_num: ## Error handling for invalid row
185                 print("Invalid row. Please enter a letter A-J.")
186                 continue
187
188             array_row = letter_to_num[row_letter] ## Convert row letter to array index
189             array_col = col - 1 ## Convert column number to 0-based index
190
191             if col < 1 or col > 10: ## Error handling for invalid column
192                 print("Invalid column. Please enter a number between 1 and 10.")
193                 continue
194
195             ## Check if this position was already fired upon
196             if tracking_board[array_row][array_col] in ['H', 'M']:
197                 print("You've already fired at this position! Try again.")
198                 continue
199
200             ## Check hit or miss
201             if opponent_board[array_row][array_col] != ' ':
202                 print("\nHIT!")
203                 tracking_board[array_row][array_col] = 'H' ## Update tracking board with hit
204                 return True, (array_row, array_col)
205             else:
206                 print("\nMiss!")
207                 tracking_board[array_row][array_col] = 'M' ## Update tracking board with miss
208                 return False, (array_row, array_col)
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219 Void function that takes the player and the tracking board as inputs. Prints the player's name and the tracking board. The tracking board shows the player's hits and misses.
220 Done at the end of each turn to show the player's progress. Prints a legend for the tracking board, calls the visualization function to show the board.
221 """
222 def status_update(player, tracking_board):
223     print(f"\n{player}'s Status Update:")
224     visualize_board(tracking_board)
225     print("Legend: H = Hit, M = Miss")
226
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229
230 Void time function to get the current time in seconds, with no inputs. Used to calculate the total game time at the end of the game. Edited due to the complexity of forcing a turn timer due to
231 the fact that matplotlib essentially "pauses" the game.
232 """
233 def turn_time():
234     return time.time()
235
236
237 Non-void function that takes the board state and checks to see if a user won or not. Returns True if the game is over (all ships are sunk), and False if the game is not over.
238 Ran after each players turn. If the game is over, the game ends and the final scoreboard is printed.
239 """
240 def check_game_over(board):
241     ship_codes = {'C', 'B', 'R', 'S', 'D'}
242     for row in board:
243         for cell in row:
244             if cell in ship_codes:
245                 return False
246     return True
247
248
249 Void function that takes the winner, player names, hits, and total time as inputs. Prints the final scoreboard at the end of the game. Ran by main() once the game is over
250 by the check_game_over() function. Prints the winner, final statistics, and the total game time.
251 """
252 def final_scoreboard(winner, p1_name, p2_name, p1_hits, p2_hits, total_time): ## Pretty self-explanatory function. Prints out some headers and stats that are tracked by main().
253     print("\n== GAME OVER ==")
254     print(f"\nWinner: {winner}!")
255     print(f"\nFinal Statistics:")
256     print(f"{p1_name}'s hits: {p1_hits}")
257     print(f"{p2_name}'s hits: {p2_hits}")
258     print(f"Total game time: {int(total_time)} seconds")
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```

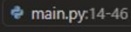
[illegible]




## Feedback, editing, bug finding, and error crushing using CoPilot (mostly from Zach):

 ZacharyCornthwaite

@workspace /explain Expected indented block

 main.py:14-46

 Workspace


> Used 1 reference

It looks like there is an indentation error in your `main()` function. The `print` statements at the beginning of the file are not properly indented, and there is a duplicate `def main():` line. Here is the corrected version of your code:

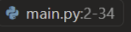
```
import random


def calculate_score(board):
    """
    It calculates the score of the player based on the number of ships hit.
    """
    return sum(cell == 2 for row in board for cell in row)

def count_ships_left(board):
    """
```

 ZacharyCornthwaite

will this main function wait to say who won until all the ships are sunk?

 main.py:2-34

 GitHub Copilot


> Used 1 reference

The provided `main` function does not yet include the complete game loop logic to ensure that the game waits until all ships are sunk before declaring a winner. To achieve this, you need to implement a game loop that continues until one player's ships are all sunk.


Here is the complete code with the necessary game loop logic to ensure the game waits until all ships are sunk before declaring a winner:


```
import time
import random
import matplotlib.pyplot as plt
import numpy as np

def update_status(player_1_board, player_2_board, player_1_score, player_2_score):
    """
    It will update the status of the game after each player's turn.
    """
    print("Player 1's Board:")
    print_board(player_1_board)
    print("Player 2's Board:")
    print_board(player_2_board)
    print(f"Player 1's Score: {player_1_score}")
    print(f"Player 2's Score: {player_2_score}")
```

 ZacharyCornthwaite

create the timer to be on its own function instead of apart of the players turn

 main.py:12-44

 GitHub Copilot

> Used 1 reference

To create a timer function that can be used independently of the player's turn, you can define a separate function for the timer and then call this function within the player's turn function. Here's how you can do it:

1. Define a `start_timer` function that handles the timing logic.
2. Modify the `player_turn` function to use the `start_timer` function.

Here's the updated code:


```
import time
import random

def start_timer(duration):
    start_time = time.time()
    end_time = start_time + duration
    while time.time() < end_time:
        remaining_time = end_time - time.time()
        print(f"Time left: {remaining_time:.2f} seconds", end='\r')
        time.sleep(1)
    print("\nTime's up!")

def player_turn(player_name):
    print(f"{player_name}'s turn. You have 15 seconds.")


    # Start the 15-second timer
    start_timer(15)
```



 ZacharyCornthwaite

use the `mplot` as the end of game end credits so after the player wins and shows the board with the average time it then calls `create_plot_with_logo_and_names`

 `main.py:25-184`

 GitHub Copilot

> Used 1 reference

To use the `create_plot_with_logo_and_names` function as the end credits after the game ends, you can call this function at the end of the `main` function. Here is the updated code:

```
start_timer(duration):
    """
    Its a timer that will start when the player's turn starts and will end after 15 seconds. We wanted to a
    """
    start_time = time.time()
    end_time = start_time + duration
    while time.time() < end_time:
        remaining_time = end_time - time.time()
        print(f"Time left: {remaining_time:.2f} seconds", end='\r')
        time.sleep(1)
    print("\nTime's up!")

player_turn(player_name):
    print(f"{player_name}'s turn. You have 15 seconds.")


    # Start the 15-second timer
    start_timer(15)

    # Simulate player's turn (replace this with actual game logic)
    turn_time = random.uniform(1, 15) # counts the time it takes you to make a move and in the end it will
    print(f"{player_name} completed the turn in {turn_time:.2f} seconds")


    return turn_time


create_scatter_plot_with_logo()
```



 ZacharyCornthwaite

why is my photo file not being found?

 wsu matplotlib.py:1-26

 GitHub Copilot

> Used 1 reference

The issue might be that the file path to the logo image is incorrect or the file is not in the expected directory. Here are a few steps to troubleshoot and fix the issue:

1. **Check the File Path:** Ensure that the file path to `wsu_logo` is correct. If the image is in the same directory as your script, you should include the file extension (e.g., `wsu_logo.png`).
2. **Verify the File Exists:** Make sure the image file actually exists in the specified directory.
3. **Use an Absolute Path:** If the image is in a different directory, use an absolute path or a relative path from the script's location.
4. **Check for Typos:** Ensure there are no typos in the file name or path.

Here's an updated version of your code with a more explicit file path:

```
import matplotlib.pyplot as plt
import numpy as np
import matplotlib.image as mpimg

def create_scatter_plot_with_logo():
    # Create some random data for the scatter plot
    x = np.random.rand(50)
    y = np.random.rand(50)
    colors = np.random.rand(50)
    area = (30 * np.random.rand(50))**2 # 0 to 15 point radii

    # Create the scatter plot
    plt.scatter(x, y, s=area, c=colors, alpha=0.5)

    # Add the Washington State University logo
    logo = mpimg.imread('wsu_logo.png') # Ensure the correct file extension
    plt.imshow(logo, aspect='auto', extent=[0.6, 1.0, 0.6, 1.0], zorder=-1)

    # Add the names
```



ZacharyCornthwaite

'unicodeescape' codec can't decode bytes in position 2-3: truncated \UXXXXXXXX escape

wsu matplotlib.py:10:21

GitHub Copilot

> Used 1 reference

The error occurs because the backslashes in the file path are being interpreted as escape characters. To fix this, you can either use raw strings or replace backslashes with forward slashes.

#### Using Raw Strings

```
logo = mpimg.imread(r'C:\Users\zacha\OneDrive\Desktop\Python Projects\wsu logo.png')
```

#### Replacing Backslashes with Forward Slashes

```
logo = mpimg.imread('C:/Users/zacha/OneDrive/Desktop/Python Projects/wsua logo.png')
```

#### Complete Code

```
import matplotlib.pyplot as plt
import numpy as np
import matplotlib.image as mpimg

def create_scatter_plot_with_logo():
    # Create some random data for the scatter plot
    x = np.random.rand(50)
    y = np.random.rand(50)
    colors = np.random.rand(50)
    area = (30 * np.random.rand(50))**2 # 0 to 15 point radii

    # Create the scatter plot
```



ZacharyCornthwaite

how can i take the graph part of for the matplotlib to where its just the names and the photo

wsu matplotlib.py:5-26



GitHub Copilot

> Used 1 reference

To display only the names and the photo without the scatter plot, you can remove the code related to creating the scatter plot. Here's the updated function:

```
import matplotlib.pyplot as plt
import matplotlib.image as mpimg

def create_plot_with_logo_and_names():
    # Add the Washington State University logo
    logo = mpimg.imread('C:/Users/zacha/OneDrive/Desktop/Python Projects/wsu_logo.png')
    plt.imshow(logo, aspect='auto', extent=[0.6, 1.0, 0.6, 1.0], zorder=-1)

    # Add the names
    plt.text(0.5, 1.05, 'Zachary Cornthwaite and Logan Harris', fontsize=12, ha='center', transform=plt.

    # Hide axes
    plt.axis('off')

    # Show the plot
    plt.show()

# Call the function to create the plot with the logo and names
create_plot_with_logo_and_names()
```

This code will display only the logo and the names without the scatter plot.



ZacharyCornthwaite

fix the final scoreboard function to where it includes which player missed the most, how many turns each player took, total game time, and which player had the longest turn on average

[main.py:152-185](#)



GitHub Copilot

> Used 1 reference

To include the additional information in the final scoreboard, you need to calculate the number of turns each player took, the total game time, and determine which player missed the most and which player had the longest turn on average. Here's the updated code:

```
update_status(player_1_board, player_2_board, player_1_score, player_2_score)
if player_1_score == sum([5, 4, 3, 3, 2]) or player_2_score == sum([5, 4, 3, 3, 2]):
    game_over = True
    break

print("\nFinal Scoreboard:")
update_status(player_1_board, player_2_board, player_1_score, player_2_score)

player_1_ships_left = count_ships_left(player_1_board)
player_2_ships_left = count_ships_left(player_2_board)

player_1_avg_time = sum(player_1_turn_times) / len(player_1_turn_times) if player_1_turn_times else 0
player_2_avg_time = sum(player_2_turn_times) / len(player_2_turn_times) if player_2_turn_times else 0

player_1_turns = len(player_1_turn_times)
player_2_turns = len(player_2_turn_times)

total_game_time = sum(player_1_turn_times) + sum(player_2_turn_times)

player_1_misses = count_misses(player_1_board)
```



ZacharyCornthwaite

How do I implement `count_misses`?

`main.py:152-185`



GitHub Copilot

> Used 1 reference

To implement the `count_misses` function, you need to iterate through the player's board and count the number of missed shots. Assuming that a miss is represented by a specific marker (e.g., 'M' for miss), you can implement the function as follows:


```
def count_misses(board):
    misses = 0
    for row in board:
        for cell in row:
            if cell == 'M': # Assuming 'M' represents a miss
                misses += 1
    return misses
```

You can then use this function in your final scoreboard calculation. Here's how you can integrate it:


```
# Function to count the number of misses on a player's board
def count_misses(board):
    misses = 0
    for row in board:
        for cell in row:
            if cell == 'M': # Assuming 'M' represents a miss
                misses += 1
    return misses


# Example usage in the final scoreboard
update_status(player 1 board, player 2 board, player 1 score, player 2 score)
```

## Feedback on completed functions, from Copilot (mostly from Logan):

 tankharris606

review my code

 battleship\_game\_EE.py:1-33

 GitHub Copilot

> Used 1 reference

Your code snippet for the `visualize_board` function looks well-structured and clear. Here are a few suggestions for improvement:

1. **Docstring Formatting:** The docstring is informative but could be formatted for better readability.
2. **Variable Naming:** Ensure that variable names are descriptive and consistent.
3. **Functionality:** Ensure that the function completes its intended purpose by plotting the ships and adding a legend.

Here is a revised version of your code with these suggestions:

```
def visualize_board(board):
    """
    Visualize the board using matplotlib.

    Creates a 10x10 board with grid lines and markers for ships.
    Creates a legend for the ship types/hits and misses.
    Takes a "board" input which is a 10x10 list of strings representing the board state.
    This function will be used to visualize the board after each ship placement and after each turn in t
    It also will be called by the place_ships() function to visualize the board after each ship placemen

    Parameters:
    board (list of list of str): The 10x10 board state.
    """
    plt.figure(figsize=(10, 10))

    # Plot grid lines
    for i in range(1, 12):
        plt.axhline(y=i, color='gray', linestyle='-', alpha=0.3)
        plt.axvline(x=i, color='gray', linestyle='-', alpha=0.3)

    # Set colors and labels for ships
    colors = {'C': 'gray', 'B': 'blue', 'R': 'green', 'S': 'red', 'D': 'purple',
              ' ': 'white', 'H': 'yellow', 'M': 'black'}
```

Can you explain the legend setup?

Ask Copilot



tankharris606

Review my place\_ships function. Suggest edits

[battleship\\_game\\_EE.py:188-220](#)



GitHub Copilot

> Used 1 reference

Please provide the code for the `place_ships` function so I can review it and suggest edits.



tankharris606

This is the code

[battleship\\_game\\_EE.py:73-161](#)



GitHub Copilot

> Used 1 reference

Your `place_ships` function is well-structured and clear. Here are a few suggestions for improvement:

1. **Docstring:** Add a docstring to describe the function.
2. **Input Validation:** Consolidate input validation to reduce redundancy.
3. **Error Handling:** Improve error handling for invalid inputs.
4. **Code Readability:** Minor improvements for readability and consistency.

Here is the revised version of your code:

```
def place_ships(player):  
    """  
    Function to place ships on the board for the given player.  
  
    Parameters:  
    player (str): The name of the player.  
  
    Returns:  
    list: A 10x10 board with ships placed.  
    """
```







tankharris606

Review my main function. Suggest edits

battleship\_game\_EE.py:264-404



GitHub Copilot

Used 1 reference

battleship\_game\_EE.py:264-404 C:\Users\logan\OneDrive\Documents\CS111\Project Files

Your `main` function is well-structured and clear. Here are a few suggestions for improvement:

1. **Docstring:** Add a docstring to describe the function.
2. **Input Validation:** Consolidate input validation to reduce redundancy.
3. **Code Readability:** Minor improvements for readability and consistency.
4. **Function Extraction:** Extract some parts of the code into separate functions to improve readability and maintainability.

Here is the revised version of your code:

```
def main():
    """
    Main function to run the Battleship game.

    The game starts with a welcome message and a prompt to start the game.
    Players are asked to enter their names and a coin flip determines who goes first.
    Players place their ships and then take turns to hit the opponent's ships.
    The game ends when all ships are sunk or an easter egg is found.
    Tracks game statistics and prints the final scoreboard at the end of the game.
    """
    display_welcome_message()

    # Get player names
    player_1 = input("Enter a username (default player 1): ") or "player_1"
    player_2 = input("Enter a username (default player 2): ") or "player_2"

    # Determine who goes first
```



tankharris606

Review my visualize\_board function. Suggest edits

battleship\_game\_EE.py:19-65



GitHub Copilot

> Used 1 reference

Your `visualize_board` function is well-structured and clear. Here are a few suggestions for improvement:

1. **Docstring:** Add a docstring to describe the function.
2. **Code Readability:** Minor improvements for readability and consistency.
3. **Legend:** Ensure the legend is clear and concise.

Here is the revised version of your code:

```
def visualize_board(board):
    """
    Visualize the board using matplotlib.

    Creates a 10x10 board with grid lines and markers for ships.
    Creates a legend for the ship types/hits and misses.
    Takes a "board" input which is a 10x10 list of strings representing the board state.
    This function will be used to visualize the board after each ship placement and after each turn in t
    It also will be called by the place_ships() function to visualize the board after each ship placemen

    Parameters:
    board (list of list of str): The 10x10 board state.
    """
    plt.figure(figsize=(10, 10))

    # Plot grid lines
    for i in range(1, 12):
        plt.axhline(y=i, color='gray', linestyle='--', alpha=0.3)
        plt.axvline(x=i, color='gray', linestyle='--', alpha=0.3)
```

