Introduction

Phase 10 is a groups and runs based card game where players compete to put down a specific "Phase" (a defined pair or sets, runs, or cards of one color). That round continues until a player is able to build off of the sets, runs, or cards of one color that have been put down and runs out of cards. The winner of the game is the first person to complete all 10 phases. If both players finish the 10th phase on the same round, who ever has the lowest score wins.

The development took about 20 hours for project 1 and an additional 10 for project 2. Altogether, the code is 1517 lines, comprised of 475 lines of C header files and 1042 lines of C++ code. These make up 10 separate classes.

The code can be found on Github https://github.com/Thomas-Kleist/Project_1_Phase_10_Game.

Approach to Development

I approached this design modularly, first by building a card class. Then a display system to show several cards at once in multiple colors. Next, a player class and to hold cards for the player. Next a deck, a way of shuffling, and a way to deal cards to the player. After that, I built a system for players to pick up and discard cards into the appropriate piles. Next, I built a main game class that controls the overall flow of the game and started designing phases for players to lay out cards. Finally, I built a system to hit to play their remaining cards, as well as a system to start and the next round or end the game when a player is out of cards.

Throughout this, I tried to commit the code to Github often, ideally after each feature was developed, so I could easily roll back if something broke, or make a branch to work on a different feature for some time.

For project 2, I looked through the code for places to add the data structures and algorithms.

Game Rules

Each player starts with 10 cards. On a players turn, they draw a card either from the discard pile or the draw pile. At the end of their turn, they will discard a card into the discard pile.

At the start of the round, the players objective is to complete their phase on lay out their cards onto the table. If a player lays out their phase, they will work on the next phase in the following round.

- Phase 1: 2 sets of 3
- Phase 2: 1 set of 3 + 1 run of 4
- Phase 3: 1 set of 4 + 1 run of 4
- Phase 4: 1 run of 7
- Phase 5: 1 run of 8
- Phase 6: 1 run of 9
- Phase 7: 2 sets of 4
- Phase 8: 7 cards of one color
- Phase 9: 1 set of 5 + 1 set of 2
- Phase 10: 1 set of 5 + 1 set of 3

Once a player has played their cards, they can play the rest of their cards by expanding any other phase on the table. The round is over when a player runs out of cards.

At the end of the round, players get a score based on the cards left in their hands. Cards 1-9 are each worth 5 points, cards 10-12 are worth 10 points, a skip card is worth 15 points, and a wild card is worth 25 points.

At the end of the round where one or more people have completed phase 10, the player who has completed phase 10 and has the least amount of points is the winner and the game is over.

A complete set of rules can be found on the Wikipedia page for Phase 10, https://en.wikipedia.org/wiki/Phase_10.

Description of Code

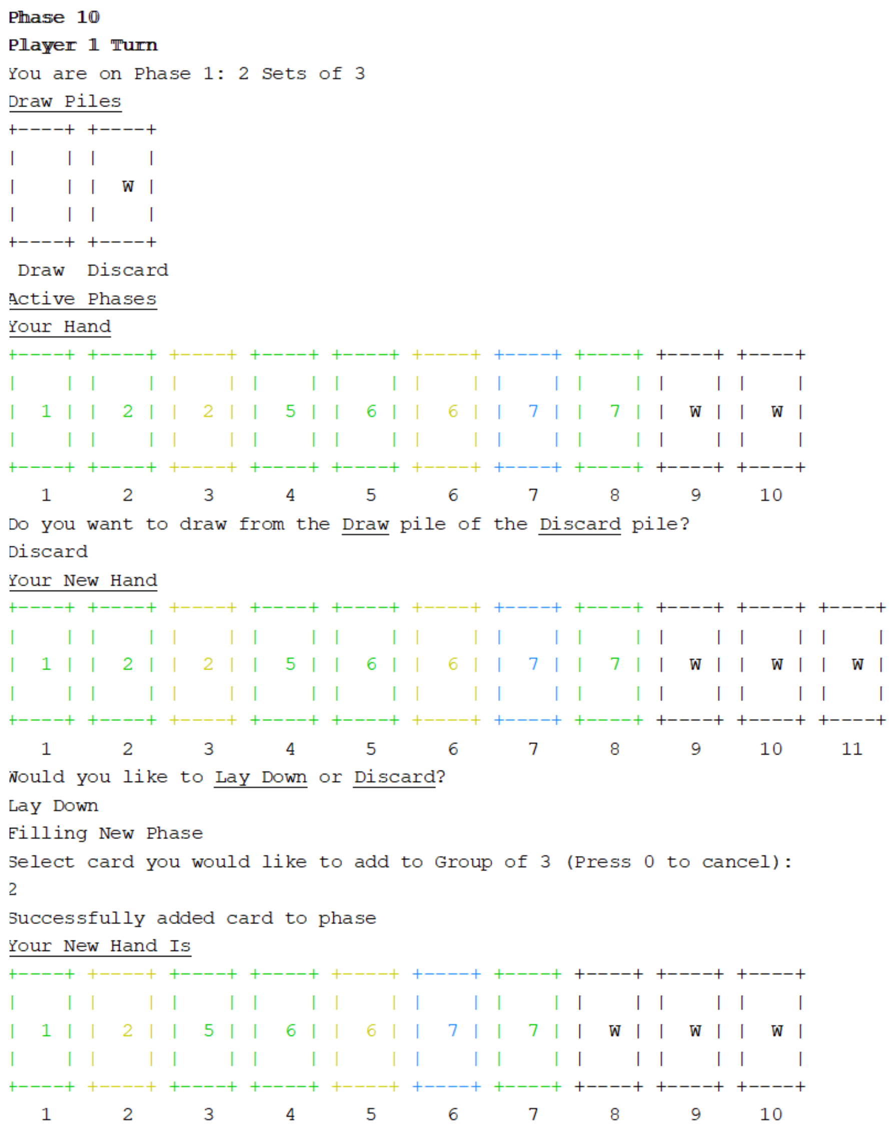
The code is organized into several classes, each with distinct roles.

- Game - The main game object that controls the flow of the game.
- Deck - The object that holds the deck. It is responsible for shuffling, dealing, and holding the draw and discard piles.
- Card - The card class holds details about each card, including its face value, color, and points value.
- Player - The player class handles each players hand, score, and phase.
- Display - A helper class to assist with drawing to the terminal.
    - Color - A helper class of display that is used to nicely handle color on the terminal.

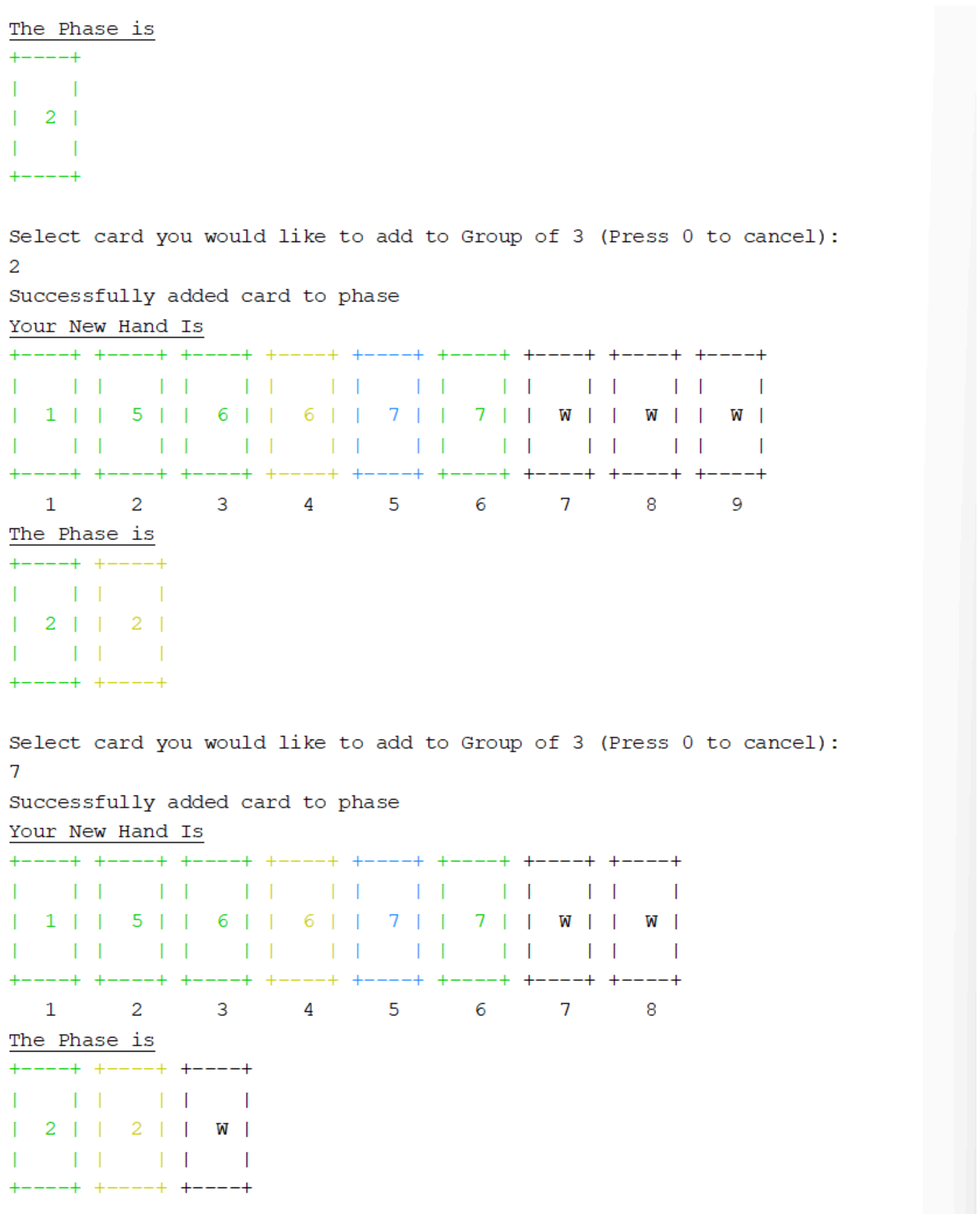
- Phase - The base class used for the three types of phases. Each phase is responsible for ensuring that only the correct cards are added.
  - Group - This class checks that only sets can be made.
  - Run - This class checks that only runs can be made.
  - ColorPhase - This class checks that only cards of one color are added to the phase.
- Hash map
  - A helper class for the hash map used.

Sample

The following screenshots are a sample of a player drawing a card, then laying down the first phase of the game.



```
Phase 10
Player 1 Turn
You are on Phase 1: 2 Sets of 3
Draw Piles
+----+ +----+
|    | |    |
|    | | W  |
|    | |    |
+----+ +----+
 Draw  Discard
Active Phases
Your Hand
+----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+
|    | |    | |    | |    | |    | |    | |    | |    | |    | |    |
| 1  | | 2  | | 2  | | 5  | | 6  | | 6  | | 7  | | 7  | | W  | | W  |
|    | |    | |    | |    | |    | |    | |    | |    | |    | |    |
+----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+
  1      2      3      4      5      6      7      8      9     10
Do you want to draw from the Draw pile of the Discard pile?
Discard
Your New Hand
+----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+
|    | |    | |    | |    | |    | |    | |    | |    | |    | |    | |    |
| 1  | | 2  | | 2  | | 5  | | 6  | | 6  | | 7  | | 7  | | W  | | W  | | W  |
|    | |    | |    | |    | |    | |    | |    | |    | |    | |    | |    |
+----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+
  1      2      3      4      5      6      7      8      9     10     11
Would you like to Lay Down or Discard?
Lay Down
Filling New Phase
Select card you would like to add to Group of 3 (Press 0 to cancel):
2
Successfully added card to phase
Your New Hand Is
+----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+
|    | |    | |    | |    | |    | |    | |    | |    | |    | |    |
| 1  | | 2  | | 5  | | 6  | | 6  | | 7  | | 7  | | W  | | W  | | W  |
|    | |    | |    | |    | |    | |    | |    | |    | |    | |    |
+----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+ +----+
  1      2      3      4      5      6      7      8      9     10
```



```
The Phase is
+-----+
|     |
|  2  |
|     |
+-----+

Select card you would like to add to Group of 3 (Press 0 to cancel):
2
Successfully added card to phase
Your New Hand Is
+-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+
|     | |     | |     | |     | |     | |     | |     | |     | |     |
|  1  | |  5  | |  6  | |  6  | |  7  | |  7  | |  W  | |  W  | |  W  |
|     | |     | |     | |     | |     | |     | |     | |     | |     |
+-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+
   1       2       3       4       5       6       7       8       9
The Phase is
+-----+ +-----+
|     | |     |
|  2  | |  2  |
|     | |     |
+-----+ +-----+

Select card you would like to add to Group of 3 (Press 0 to cancel):
7
Successfully added card to phase
Your New Hand Is
+-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+
|     | |     | |     | |     | |     | |     | |     | |     |
|  1  | |  5  | |  6  | |  6  | |  7  | |  7  | |  W  | |  W  |
|     | |     | |     | |     | |     | |     | |     | |     |
+-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+ +-----+
   1       2       3       4       5       6       7       8
The Phase is
+-----+ +-----+ +-----+
|     | |     | |     |
|  2  | |  2  | |  W  |
|     | |     | |     |
+-----+ +-----+ +-----+
Filling New Phase
Select card you would like to add to Group of 3 (Press 0 to cancel):
5
Successfully added card to phase
Your New Hand Is
+----+ +----+ +----+ +----+ +----+ +----+ +----+
|    | |    | |    | |    | |    | |    | |    |
| 1  | | 5  | | 6  | | 6  | | 7  | | W  | | W  |
|    | |    | |    | |    | |    | |    | |    |
+----+ +----+ +----+ +----+ +----+ +----+ +----+
  1      2      3      4      5      6      7
The Phase is
+----+
|    |
| 7  |
|    |
+----+

Select card you would like to add to Group of 3 (Press 0 to cancel):
5
Successfully added card to phase
Your New Hand Is
+----+ +----+ +----+ +----+ +----+ +----+
|    | |    | |    | |    | |    | |    |
| 1  | | 5  | | 6  | | 6  | | W  | | W  |
|    | |    | |    | |    | |    | |    |
+----+ +----+ +----+ +----+ +----+ +----+
  1      2      3      4      5      6
The Phase is
+----+ +----+
|    | |    |
| 7  | | 7  |
|    | |    |
+----+ +----+

Select card you would like to add to Group of 3 (Press 0 to cancel):
5
Successfully added card to phase
```

```
Your New Hand Is
+-----+ +-----+ +-----+ +-----+ +-----+
|     | |     | |     | |     | |     |
|  1  | |  5  | |  6  | |  6  | |  W  |
|     | |     | |     | |     | |     |
+-----+ +-----+ +-----+ +-----+ +-----+
   1       2       3       4       5
The Phase is
+-----+ +-----+ +-----+
|     | |     | |     |
|  7  | |  7  | |  W  |
|     | |     | |     |
+-----+ +-----+ +-----+

Phase Laid Down
Active Phases
1. Group of 3
+-----+ +-----+ +-----+
|     | |     | |     |
|  2  | |  2  | |  W  |
|     | |     | |     |
+-----+ +-----+ +-----+

2. Group of 3
+-----+ +-----+ +-----+
|     | |     | |     |
|  7  | |  7  | |  W  |
|     | |     | |     |
+-----+ +-----+ +-----+

Your Hand
+-----+ +-----+ +-----+ +-----+ +-----+
|     | |     | |     | |     | |     |
|  1  | |  5  | |  6  | |  6  | |  W  |
|     | |     | |     | |     | |     |
+-----+ +-----+ +-----+ +-----+ +-----+
   1       2       3       4       5
Would you like to Hit or Discard?
Discard
Select card you would like to discard:
1
```

Checkoff Sheet

1. Container Classes
   - Sequences
     - `std::list<>` is used to store the hand in player the player class. This is in 'player.h' line 33.
   - Associative Containers
     - `std::set<std::string>` is used to store the available cards that the player can hit. This is in 'game.cpp' line 175.
     - `std::map<std::string, Color>` is used as a map from strings to colors, so we can use the string "Red" to easily

        get the corresponding ANSI color value. This is in 'color.h' line 33.
    - Container Adapters
        - `std::stack<Card>` is used to the discard pile in the deck class. This is in 'Deck.h' line 31.
        - `std::deque<Card>` is used to store the draw pile in the deck class. This is in 'Deck.h' line 30.
2. Iterators
    - `std::list<Phase*>::iterator` is used to access a specific phase in a list of phases. This is in 'Game.cpp' line 203.
    - `std::list<Phase*>::iterator` is used to fill all the phases in a list. This is in 'Game.cpp' line 143.
    - `std::list<Card>::iterator` is used to access a specific card in a list of cards. This is in 'player.cpp' line 125.
3. Algorithms
    - Non-mutating Algorithms
        - `std::for_each` is used to display all the cards in a list. This is in `Display.h` line 61, 67, 73, 81, 87.
    - Mutating Algorithms
        - `std::shuffle` is used to shuffle the draw pile at the start of the round and when reshuffling the discard pile. This is in `Deck.cpp` line 47.
    - Organization
        - `std::list::sort` is used to sort the list of cards that represents the players hand. This is in `Player.cpp` line 38 and line 40. (This was replaced with a merge sort implementation and a tree for project 2)

Project 2 Additions

1. Operator Overloading
    - Overloading the < operator for the cards object for sorting on line 28 of `Card.h`
2. Recursion
    - The `turn` function of the `game` class is recursive, so the next turn is called at the end of the turn.
3. Recursive Sort
    - Merge sort is implemented to sort the players hand on line 69 of `Player.cpp`
4. Hashing
    - A hash map is used to print the phase the player is on. The hash map is implemented in `HashMap.h`, setup in `Game.cpp` on line

20-29, and used in `Game.cpp` on line 382.

5. Trees
    - A tree is used to sort the players hand by color. This isn't really how a tree should be used (I am filling a tree, then reading from it in order, then deleting it as a sorting algorithm), but it shows how it works. It is in the `treeSort` function on line 122 in `Player.cpp`

Documentation

The majority of the game logic is in `Game::turn`.

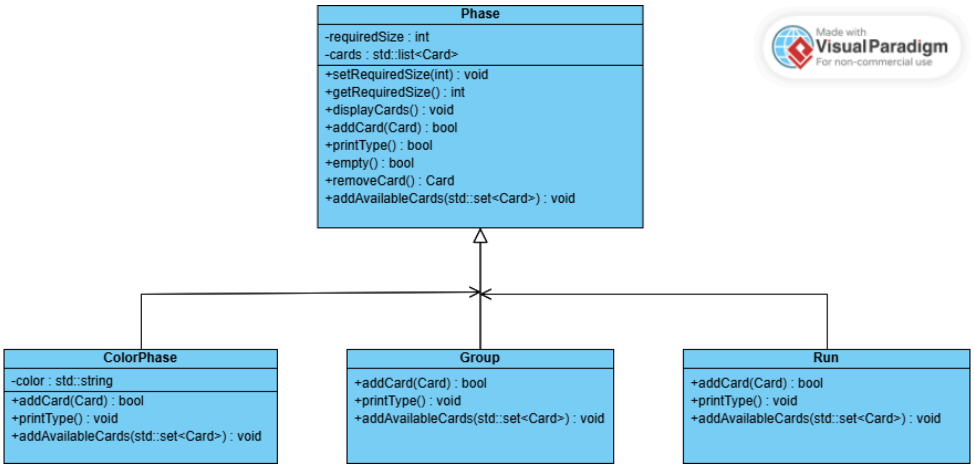
Pseudocode:

```
Game::turn
    Display which players turn it is
    If player had not laid out
        Print which phase they are working on
    Display draw and discard piles.
    Display active phases on the table.
    Display players hand.
    Ask if player will draw from draw or discard pile.
    If play selects discard
        pop card from discard pile and add to player hand
    Else
        pop card from draw pile and add to player hand
    If player has not laid out
        Ask user if they want to lay out cards or discard
        If player wants to lay out
            Get the phases in the players current phase
            Fill each phase with player input
            If player fills out all phase
                Add phases to active phases on table
                Mark that player has laid out and can now hit
            Else
                Move cards back into player hand
        Else if player wants to discard
            Ask player which card
            Remove card from player hand and push to discard pile
```

- Else if *player has laid out*
    - Ask player if they want to hit or discard
    - If *player wants to hit*
        - Ask player which phase they want to hit
        - Ask player which card they want to hit
        - If *hit is valid*
            - Remove card from player hand and add to phase
            - If *player hand is empty*
                - End round and continue to next
        - Else *ask player if they want to hit or discard*
    - Else if *player wants to discard*
        - Ask player which card
        - Remove card from player hand and push to discard pile
        - If *player hand is empty*
            - End round and continue to next
- Return to top

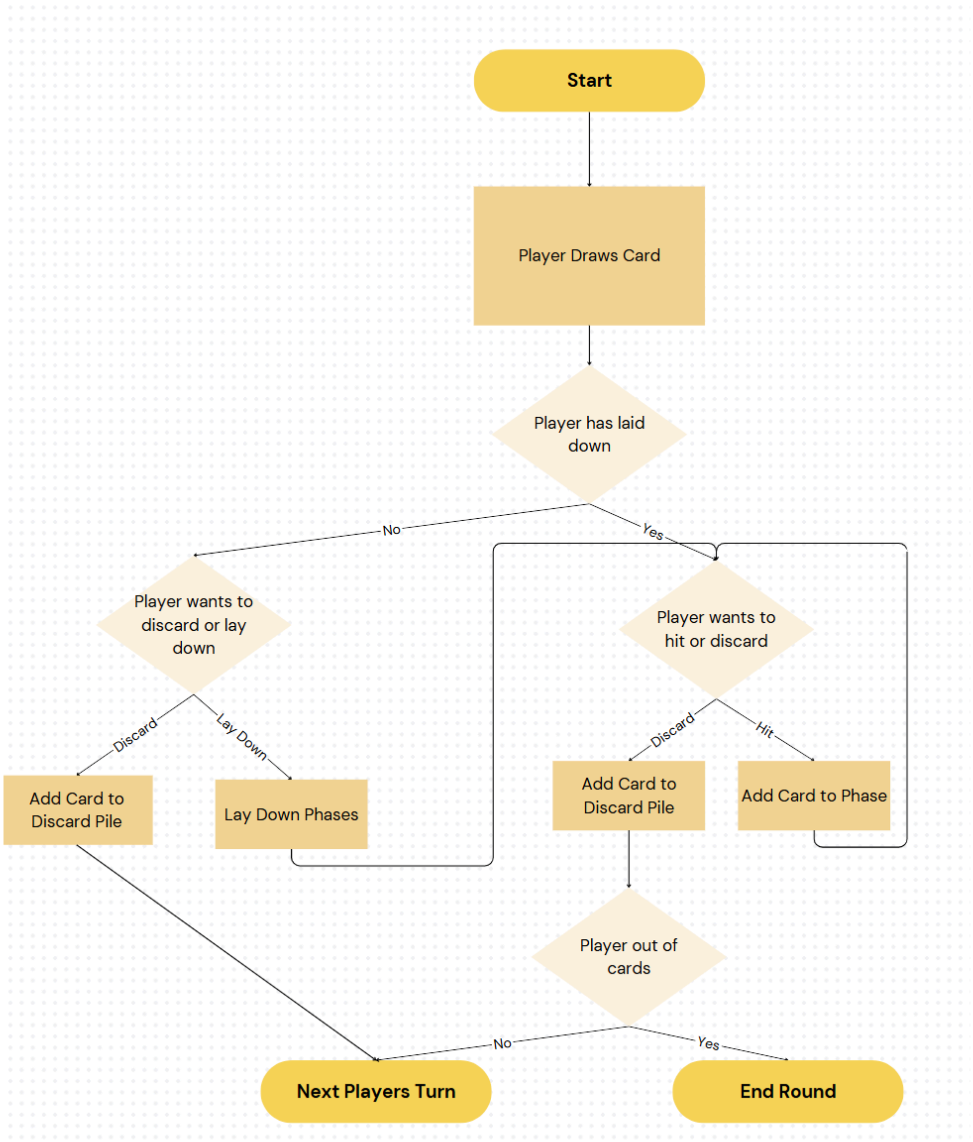
UML Diagram:

A UML Diagram of the Phase class and its subclasses



Flow Chart:

A simplified flowchart of a turn



Code

main.cpp

```cpp
/*
 * File:   main.cpp
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 10:32 AM
 */

#include <cstdlib>
#include <iostream>
#include "Display.h"
#include "Game.h"

using namespace std;

int main(int argc, char** argv) {
    Display::PrintBold("Phase 10");
    Display::NewLine();

    Game *game = new Game();

    game->setupRound();

    int playerTurn = 1;
    game->turn(playerTurn);

    return 0;
}
```

Card.h

```
/*
 * File:   Card.h
 * Author: Thomas Kleist
 *
 *
 * Created on November 2, 2024, 11:10 AM
 */

#ifndef CARD_H
#define CARD_H

#include <string>

class Card {
public:
    // Only to be used for wilds, skips, or blank
    Card(int faceValue);
    Card(int faceValue, std::string colorValue);
    Card(const Card& orig);
    std::string getColor() { return color; }
    int getColorNum() { if (color == "Red") return 0; else if
    std::string getDisplayValue();
    int getFaceValue() { return faceValue; }
    int getPointValue() {if (faceValue <= 12) return 5; if (f
    void setPhaseValue(int value) { phaseValue = value; }
    int getPhaseValue() { return phaseValue; }

    operator<(Card obj) {
        if (getFaceValue() < obj.getFaceValue()) return true;
        if (getFaceValue() == obj.getFaceValue() && getColorN
        return false;
    }

    ~Card();
private:
    int faceValue;
    std::string color;
    int phaseValue;
};

#endif /* CARD_H */
```

Card.cpp

```cpp
/*
 * File:   Card.cpp
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 11:10 AM
 */

#include <string>
#include "Card.h"

Card::Card(int faceValue) {
    this->faceValue = faceValue;
    this->phaseValue = faceValue;
    this->color = "Black";
}

Card::Card(int faceValue, std::string colorValue) {
    this->faceValue = faceValue;
    this->phaseValue = faceValue;
    this->color = colorValue;
}

Card::Card(const Card& orig) {
    // Copy Values
    this->faceValue = orig.faceValue;
    this->phaseValue = orig.phaseValue;
    this->color = orig.color;
}

std::string Card::getDisplayValue() {
    // Handle Blank Card
    if (faceValue == 0) return "";
    // Handle Wild Card
    if (faceValue == 13) return "W";
    // Handle Skip Card
    if (faceValue == 14) return "S";
    // Handle Number Cards
    return std::to_string(faceValue);
}

Card::~Card() {

}
```

Color.h

```cpp
/*
 * File:   Color.h
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 10:38 AM
 */

#ifndef COLOR_H
#define COLOR_H

#include <map>
#include <string>
#include <cinttypes>

/* This class represents a Color -- specifically a 4 bit colc
class Color {
public:
    Color() { };
    //Color(std::string);
    Color(uint8_t);
    Color(const Color& orig);

    virtual ~Color();

    uint8_t AsFG() { return inner + 30; }
    uint8_t AsBG() { return inner + 40; }
    static std::map<std::string, Color> CreateColorMap();


    uint8_t inner;
};

extern std::map<std::string, Color> COLOR;

#endif /* COLOR_H */
```

Color.cpp

```cpp
/*
 * File:   main.cpp
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 10:50 AM
 */

#include "Color.h"

#include <map>
#include <string>

std::map<std::string, Color> COLOR = Color::CreateColorMap();

Color::Color(uint8_t val) : inner(val) {
}


Color::Color(const Color& orig) {
}

Color::~Color() {
}

// Creates a map of all of the possible 4-bit ANSI colors.
std::map<std::string, Color> Color::CreateColorMap() {
    std::map<std::string, Color> m;
    m["Black"] = Color(0);
    m["Red"] = Color(1);
    m["Green"] = Color(2);
    m["Yellow"] = Color(3);
    m["Blue"] = Color(4);
    m["Magenta"] = Color(5);
    m["Cyan"] = Color(6);
    m["White"] = Color(7);

    return m;
}
```

ColorPhase.h

```
/*
 * File:   ColorPhase.h
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 3:09 PM
 */

#ifndef COLORPHASE_H
#define COLORPHASE_H

#include <string>
#include "Phase.h"

class ColorPhase : public Phase {
public:
    explicit ColorPhase(int x) : Phase(x) { }
    virtual ~ColorPhase();
    bool addCard(Card);
    void printType() override;
    void addAvailableCards (std::set<std::string>& setOfCards
private:
    std::string color;
};

#endif /* COLORPHASE_H */
```

ColorPhase.cpp

```cpp
/*
 * File:   ColorPhase.cpp
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 3:09 PM
 */

#include "ColorPhase.h"
#include "Display.h"

ColorPhase::~ColorPhase() {
}

bool ColorPhase::addCard(Card card) {
    // Do not add skip cards
    if (card.getFaceValue() == 14) return false;

    if (cards.empty()) {
        // If adding a wild card, ask for which value to use
        if (card.getFaceValue() == 13) {
            std::string colorSel = "";
            Display::Print("Select which color you would like
            Display::NewLine();
            while (!(colorSel == "Red" || colorSel == "Blue"
                std::cin >> colorSel;
            color = colorSel;
        } else {
            color = card.getColor();
        }
        cards.push_back(card);
        return true;
    }

    if (card.getFaceValue() == 13) {
        cards.push_back(card);
        return true;
    }

    if (card.getColor() == color) {
        cards.push_back(card);
        return true;
    }

    return false;
}

void ColorPhase::printType() {
    Display::Print(requiredSize);
    Display::Print(" Cards of One Color");
}
```

Deck.h

```
/*
 * File:   Deck.h
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 5:10 PM
 */

#ifndef DECK_H
#define DECK_H

#include <deque>
#include <stack>
#include "Card.h"
#include "Player.h"

class Deck {
public:
    Deck();
    Deck(const Deck& orig);
    virtual ~Deck();

    void shuffleDraw();
    void deal(Player*);
    void drawPiles();
    Card drawFromDiscard();
    Card drawFromDrawPile();
    void discardCard(Card);

private:
    std::deque<Card> drawPile;
    std::stack<Card> discardPile;
};

#endif /* DECK_H */
```

Deck.cpp

```
/*
 * File:   Deck.cpp
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 5:10 PM
 */

#include <algorithm>
#include "Deck.h"
#include "Player.h"
#include <random>       // std::default_random_engine
#include <chrono>       // std::chrono::system_clock
#include "Display.h"

Deck::Deck() {
    // Push number cards
    for (int i = 1; i <= 12; i++) {
        drawPile.push_front(*(new Card(i, "Blue")));
        drawPile.push_front(*(new Card(i, "Blue")));
        drawPile.push_front(*(new Card(i, "Green")));
        drawPile.push_front(*(new Card(i, "Green")));
        drawPile.push_front(*(new Card(i, "Red")));
        drawPile.push_front(*(new Card(i, "Red")));
        drawPile.push_front(*(new Card(i, "Yellow")));
        drawPile.push_front(*(new Card(i, "Yellow")));
    }
    for (int i = 0; i < 8; i++) {
        drawPile.push_front(*(new Card(13)));
    }
    for (int i = 0; i < 4; i++) {
        drawPile.push_front(*(new Card(14)));
    }
    shuffleDraw();
    discardPile.push(drawPile.front());
    drawPile.pop_front();
}

Deck::Deck(const Deck& orig) {
}

Deck::~Deck() {
}

void Deck::shuffleDraw() {
    unsigned seed = std::chrono::system_clock::now().time_sir

    std::shuffle(drawPile.begin(), drawPile.end(), std::defau
}
```

```cpp
void Deck::deal(Player *player) {
    for (int i = 0; i < 10; i++) {
        player->addCardToHand(drawPile.front());
        drawPile.pop_front();
    }
}

void Deck::drawPiles() {
    std::list<Card> toDisplay;
    toDisplay.push_front(discardPile.top());
    toDisplay.push_front(*(new Card(0)));
    Display::PrintCards(toDisplay);
    Display::BeginColor("Black");
    Display::Print(" Draw  Discard");
    Display::NewLine();
}


Card Deck::drawFromDiscard() {
    Card toReturn = discardPile.top();
    discardPile.pop();
    return toReturn;
}

Card Deck::drawFromDrawPile() {
    Card toReturn = drawPile.front();
    drawPile.pop_front();

    if (drawPile.empty()) {
        while(discardPile.empty() == false) {
            drawPile.push_front(discardPile.top());
            discardPile.pop();
        }
        shuffleDraw();
        discardPile.push(drawPile.front());
        drawPile.pop_front();
    }

    return toReturn;
}

void Deck::discardCard(Card card) {
    discardPile.push(card);
}
```

Display.h

```
/*
 * File:   Display.h
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 10:35 AM
 */

#ifndef DISPLAY_H
#define DISPLAY_H

#include <iostream>
#include <list>
#include <iomanip>
#include <string>
#include "Color.h"
#include "Card.h"

class Display {
    public:
      static void BeginBold() { std::cout << "\033[1m"; }

      static void BeginUnderline() { std::cout << "\033[4m";

      static void BeginColor(std::string col) { std::cout <<

      static void NewLine() { std::cout << std::endl; }

      static void EndFormat() { std::cout << "\033[0m"; }

      static void Clear() { NewLine(); NewLine(); NewLine();

      template <typename T> static void Print(T x) {
        std::cout << x;
      }

      template <typename T> static void PrintBold(T x) {
        Display::BeginBold();
        std::cout << x;
        Display::EndFormat();
      }

      template <typename T> static void PrintUnderlined(T x)
        Display::BeginUnderline();
        std::cout << x;
        Display::EndFormat();
      }

      static void PrintCards(Card card) {
            BeginColor(card.getColor());
            Print("+----+\n");
            Print("|    |\n");
            Print("| ");
            std::cout << std::setw(2) << card.getDisplayValue
            Print(" |\n");
            Print("|    |\n");
            Print("+----+\n");
      }

      static void PrintCards(std::list<Card> cards) {
            // print top
            for (Card card : cards) {
                BeginColor(card.getColor());
                Print("+----+ ");
            }
            NewLine();
            // print upper middle
            for (Card card : cards) {
                BeginColor(card.getColor());
                Print("|    | ");
            }
            NewLine();
            // print display value
            for (Card card : cards) {
                BeginColor(card.getColor());
                Print("| ");
                std::cout << std::setw(2) << card.getDisplayV
                Print(" | ");
            }
            NewLine();
            // print lower middle
            for (Card card : cards) {
                BeginColor(card.getColor());
                Print("|    | ");
            }
            NewLine();
            // print bottom
            for (Card card : cards) {
                BeginColor(card.getColor());
                Print("+----+ ");
            }
            NewLine();
      }

};

#endif /* DISPLAY_H */
```

Game.h

```cpp
/*
 * File:   Game.h
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 9:19 PM
 */

#ifndef GAME_H
#define GAME_H

#include "Deck.h"
#include "Player.h"
#include "Phase.h"
#include <list>
#include "HashMap.h"
#include <string>

class Game {
public:
    Game();
    virtual ~Game();
    void turn(int);
    void setupRound();
    void endRound();
    void drawFromPile(int);
    bool discard(int);
    bool fillPhase(int, Phase*);
    bool layDown(int);
    bool hit(int);
    void printPhase(int);
    void printActivePhases();
    std::list<Phase*> getPhase(int);
private:
    Player *player1;
    Player *player2;
    Deck *deck;
    std::list<Phase*> activePhases;
    HashMap<std::string> phaseNameMap;
};

#endif /* GAME_H */
```

Game.cpp

```
/*
 * File:   Game.cpp
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 9:19 PM
 */

#include "Game.h"
#include <cstdlib>
#include "Display.h"
#include <iostream>
#include "Group.h"
#include "Run.h"
#include "ColorPhase.h"

Game::Game() {
    player1 = new Player();
    player2 = new Player();

    phaseNameMap.insert("0", "You are on Phase 1: 2 Sets of 3
    phaseNameMap.insert("1", "You are on Phase 2: 1 Set of 3
    phaseNameMap.insert("2", "You are on Phase 3: 1 Set of 4
    phaseNameMap.insert("3", "You are on Phase 4: 1 Run of 7"
    phaseNameMap.insert("4", "You are on Phase 5: 1 Run of 8"
    phaseNameMap.insert("5", "You are on Phase 6: 1 Run of 9"
    phaseNameMap.insert("6", "You are on Phase 7: 2 Sets of 4
    phaseNameMap.insert("7", "You are on Phase 8: 7 Cards of
    phaseNameMap.insert("8", "You are on Phase 9: 1 Set of 5
    phaseNameMap.insert("9", "You are on Phase 10: 1 Set of 5
}

void Game::setupRound() {
    if (deck != NULL) delete(deck);
    deck = new Deck();

    deck->deal(player1);
    deck->deal(player2);
}


Game::~Game() {
}

void Game::drawFromPile(int player) {
    Player *currentPlayer = (player == 1)?player1:player2;
    Display::PrintUnderlined("Draw Piles");
    Display::NewLine();
    deck->drawPiles();
    Display::PrintUnderlined("Active Phases");
    Display::NewLine();
    printActivePhases();
    Display::PrintUnderlined("Your Hand");
    Display::NewLine();
    currentPlayer->displayHand();
    Display::Print("Do you want to draw from the ");
    Display::PrintUnderlined("Draw");
    Display::Print(" pile of the ");
    Display::PrintUnderlined("Discard");
    Display::Print(" pile?");
    Display::NewLine();
    bool success = false;
    while (success == false) {
        std::string choice;
        std::cin >> choice;
        if (choice == "Draw") {
            currentPlayer->addCardToHand(deck->drawFromDrawPi
            success = true;
        } if (choice == "Discard") {
            currentPlayer->addCardToHand(deck->drawFromDiscar
            success = true;
        }
    }
    Display::PrintUnderlined("Your New Hand");
    Display::NewLine();
    currentPlayer->displayHand();
}

bool Game::discard(int player) {
    Player *currentPlayer = (player == 1)?player1:player2;

    Display::Print("Select card you would like to discard:");
    Display::NewLine();
    while (true) {
        int selected;
        std::cin >> selected;
        try {
            Card discardCard = currentPlayer->removeCard(sele
            deck->discardCard(discardCard);
            return (discardCard.getFaceValue() == 14);
        } catch (...) {
            Display::Print("Value out of range. Select card y
            Display::NewLine();
        }
    }
}

bool Game::fillPhase(int player, Phase *phase) {
    Player *currentPlayer = (player == 1)?player1:player2;
    for (int i = 0; i < phase->getRequiredSize(); i++) {
        Display::Print("Select card you would like to add to
        phase->printType();
        Display::Print(" (Press 0 to cancel):");
        Display::NewLine();
        bool success = false;
        while (!success) {
            int selected;
            std::cin >> selected;
            if (selected == 0) {
                return false;
            }
            try {
                Card card = currentPlayer->removeCard(selecte
                bool addedCard = phase->addCard(card);
                if (addedCard) {
                    Display::Print("Successfully added card t
                    success = true;
                } else {
                    Display::Print("Could not add card");
                    currentPlayer->addCardToHand(card);
                }
                Display::NewLine();
                Display::PrintUnderlined("Your New Hand Is");
                Display::NewLine();
                currentPlayer->displayHand();
                Display::PrintUnderlined("The Phase is");
                Display::NewLine();
                phase->displayCards();
            } catch (...) {
                Display::Print("Value out of range. Select ca
                Display::NewLine();
            }
        }
    }
    return true;
}

bool Game::layDown(int player) {
    Player *currentPlayer = (player == 1)?player1:player2;

    std::list<Phase*> phases = getPhase(currentPlayer->getCur

    std::list<Phase*>::iterator it = phases.begin();

    while (it != phases.end()) {
        Display::Print("Filling New Phase");
        Display::NewLine();
```

```
            bool success = fillPhase(player, *it);
            if (!success) {
                while (it != phases.begin()) {
                    while (!(*it)->empty()) {
                        currentPlayer->addCardToHand((*it)->remov
                    }
                    it--;
                }
                while (!(*it)->empty()) {
                    currentPlayer->addCardToHand((*it)->removeCar
                }
                return false;
            }
            it++;
        }

        while (!phases.empty()) {
            activePhases.push_back(phases.front());
            phases.pop_front();
        }

        return true;
    }

    bool Game::hit(int player) {
        Player *currentPlayer = (player == 1)?player1:player2;

        std::set<std::string> availableToPlay;
        for (Phase *phase : activePhases) {
            phase->addAvailableCards(availableToPlay);
        }
        Display::Print("The available cards to play are: ");
        for (std::string move : availableToPlay)
        {
            Display::Print(move);
            Display::Print(", ");
        }
        Display::NewLine();


        Display::Print("Select Phase to Hit On (Press 0 to cancel
        Display::NewLine();

        int phaseSelected;
        std::cin >> phaseSelected;
        if (phaseSelected == 0) {
            return false;
        }
    phaseSelected--;
    if (phaseSelected < 0 || phaseSelected >= activePhases.si
        Display::Print("Selected Phase is out of range");
        return false;
    }

    std::list<Phase*>::iterator it = activePhases.begin();
    std:advance(it, phaseSelected);

    Display::Print("Select card you would like to hit (Press
    Display::NewLine();

    int cardSelected;
    std::cin >> cardSelected;
    if (cardSelected == 0) {
        return false;
    }
    try {
        Card card = currentPlayer->removeCard(cardSelected-1)
        bool addedCard = (*it)->addCard(card);
        if (addedCard) {
            Display::Print("Successfully added card to phase"
            Display::NewLine();
            return true;
        } else {
            Display::Print("Could not add card");
            Display::NewLine();
            currentPlayer->addCardToHand(card);
            return false;
        }
    } catch (...) {
        return false;
    }
}

void Game::turn(int player) {
    Player *currentPlayer = (player == 1)?player1:player2;

    Display::PrintBold("Player ");
    Display::PrintBold(player);
    Display::PrintBold(" Turn");
    Display::NewLine();
    if (!currentPlayer->getLayDown()) {
        printPhase(currentPlayer->getCurrentPhase());
    }

    drawFromPile(player);

    while (true) {
```

```
if (currentPlayer->getLayDown() == false) {
    Display::Print("Would you like to ");
    Display::PrintUnderlined("Lay Down");
    Display::Print(" or ");
    Display::PrintUnderlined("Discard");
    Display::Print("?");
    Display::NewLine();

    bool success = false;
    while (success == false) {
        std::string choice;
        std::getline(std::cin, choice);
        if (choice == "Lay Down") {
            bool layDownSuccess = layDown(player);

            if (layDownSuccess) {
                currentPlayer->increasePhase();
                currentPlayer->setLayDown();

                Display::Print("Phase Laid Down");
                Display::NewLine();
            } else {
                Display::Print("Phase Not Laid Down")
                Display::NewLine();
            }

            Display::PrintUnderlined("Active Phases")
            Display::NewLine();
            printActivePhases();
            Display::PrintUnderlined("Your Hand");
            Display::NewLine();
            currentPlayer->displayHand();

            success = true;
        } if (choice == "Discard") {
            bool skip = discard(player);
            if (!skip) {
                turn((player==1)?2:1);
                return;
            } else {
                turn(player);
                return;
            }
        }
    }
} else {
    Display::Print("Would you like to ");
    Display::PrintUnderlined("Hit");
    Display::Print(" or ");
    Display::PrintUnderlined("Discard");
```

```
                Display::PrintUnderlined("Discard");
                Display::Print("?");
                Display::NewLine();

                bool success = false;
                while (success == false) {
                    std::string choice;
                    std::cin >> choice;
                    if (choice == "Hit") {
                        hit(player);

                        Display::PrintUnderlined("Active Phases")
                        Display::NewLine();
                        printActivePhases();
                        Display::PrintUnderlined("Your Hand");
                        Display::NewLine();
                        currentPlayer->displayHand();

                        if (currentPlayer->handEmpty()) {
                            endRound();
                            turn((player==1)?2:1);
                            return;
                        }

                        success = true;
                    } if (choice == "Discard") {
                        bool toReturn = discard(player);
                        if (currentPlayer->handEmpty()) endRound(
                        if (!toReturn) {
                            turn((player==1)?2:1);
                            return;
                        } else {
                            turn(player);
                            return;
                        }
                    }
                }
            }
        }
        return;
    }

    void Game::endRound() {
        player1->endRound();
        player2->endRound();

        activePhases.clear();

        if (player1->getCurrentPhase() == 10 && player2->getCurre
        if (player1->getScore() < player2->getScore()) {
            Display::Print("Player 1 Wins!!!!!");
            exit(0);
        } else {
            Display::Print("Player 2 Wins!!!!!");
            exit(0);
        }
    } else if (player1->getCurrentPhase() == 10) {
        Display::Print("Player 1 Wins!!!!!");
        exit(0);
    } else if (player2->getCurrentPhase() == 10) {
        Display::Print("Player 2 Wins!!!!!");
        exit(0);
    }

    Display::NewLine();
    Display::PrintBold("Round Completed");
    Display::NewLine();
    Display::Print("Player 1 Score: ");
    Display::Print(player1->getScore());
    Display::NewLine();
    Display::Print("Player 1 Phase: ");
    Display::Print(player1->getCurrentPhase()+1);
    Display::NewLine();
    Display::NewLine();
    Display::Print("Player 2 Score: ");
    Display::Print(player2->getScore());
    Display::NewLine();
    Display::Print("Player 2 Phase: ");
    Display::Print(player2->getCurrentPhase()+1);
    Display::NewLine();

    setupRound();
}

void Game::printPhase(int phase) {
    Display::Print(phaseNameMap.get(std::to_string(phase)));
    Display::NewLine();
}

void Game::printActivePhases() {
    int count = 1;
    for (Phase *phase : activePhases) {
        Display::Print(count);
        Display::Print(". ");
        phase->printType();
        Display::NewLine();
        phase->displayCards();
        count++;
    }
    }
}

std::list<Phase*> Game::getPhase(int phase) {
    std::list<Phase*> phases;
    switch(phase) {
        case 0:
            phases.push_back(new Group(3));
            phases.push_back(new Group(3));
            break;
        case 1:
            phases.push_back(new Group(3));
            phases.push_back(new Run(4));
            break;
        case 2:
            phases.push_back(new Group(4));
            phases.push_back(new Run(4));
            break;
        case 3:
            phases.push_back(new Run(7));
            break;
        case 4:
            phases.push_back(new Run(8));
            break;
        case 5:
            phases.push_back(new Run(9));
            break;
        case 6:
            phases.push_back(new Group(4));
            phases.push_back(new Group(4));
            break;
        case 7:
            phases.push_back(new ColorPhase(7));
            break;
        case 8:
            phases.push_back(new Group(5));
            phases.push_back(new Group(2));
            break;
        case 9:
            phases.push_back(new Group(5));
            phases.push_back(new Group(3));
            break;
        default:
            // code block
            break;
    }
    return phases;
}
```

Group.h

```
/*
 * File:   Group.h
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 9:56 AM
 */

#ifndef GROUP_H
#define GROUP_H

#include "Phase.h"
#include "Display.h"

class Group : public Phase {
public:
    explicit Group(int x) : Phase(x) { }
    virtual ~Group();
    bool addCard(Card);
    void printType() override {
        Display::Print("Group of ");
        Display::Print(requiredSize);
    };
    void addAvailableCards (std::set<std::string>& setOfCards
private:

};

#endif /* GROUP_H */
```

Group.cpp

```cpp
/*
 * File:   Group.cpp
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 9:56 AM
 */

#include "Group.h"
#include "Display.h"
#include <iostream>

bool Group::addCard(Card card) {
    // Do not add skip cards
    if (card.getFaceValue() == 14) return false;

    if (cards.empty()) {
        // If adding a wild card, ask for which value to use
        if (card.getFaceValue() == 13) {
            int numSelected = 0;
            Display::Print("Select which number you want the
            Display::NewLine();
            while (!(numSelected >= 1 && numSelected <= 12))
                std::cin >> numSelected;
            card.setPhaseValue(numSelected);
        }
        cards.push_back(card);
        return true;
    }

    if (card.getFaceValue() == 13) {
        card.setPhaseValue(cards.front().getPhaseValue());
        cards.push_back(card);
        return true;
    }

    if (card.getPhaseValue() == cards.front().getPhaseValue()
        cards.push_back(card);
        return true;
    }

    return false;
}

Group::~Group() {
}
```

HashMap.h

```
/*
 * File:   HashMap.h
 * Author: Thomas Kleist
 *
 * Created on December 2, 2024, 11:01 PM
 */

#ifndef HASHMAP_H
#define HASHMAP_H

#include <iostream>
#include <list>
#include <iterator>
#include <stdexcept>
#include <string>

// Template class for HashMap
template <typename ValueType>
class HashMap {
private:
    // Hash table with separate chaining
    std::list<std::pair<std::string, ValueType>> table[10];
    int tableSize = 10;

        // Hash function to map keys to table indices
    size_t hashFunction(const std::string& key) const {
        unsigned int b    = 378551;
        unsigned int a    = 63689;
        unsigned int hash = 0;

        for(std::size_t i = 0; i < key.length(); i++)
        {
           hash = hash * a + key[i];
           a    = a * b;
        }

        return hash % tableSize;
    }

public:
    // Constructor to initialize HashMap with a specific size
    HashMap() {
    }

    // Insert a key-value pair into the map
    void insert(const std::string& key, const ValueType& valu
        size_t index = hashFunction(key);
        for (auto& pair : table[index]) {
            if (pair.first == key) {
                pair.second = value;  // Update existing key-
                return;
            }
        }
        table[index].emplace_back(key, value);  // Insert new
    }

    // Retrieve a value by its key
    ValueType get(const std::string& key) const {
        size_t index = hashFunction(key);
        for (const auto& pair : table[index]) {
            if (pair.first == key) {
                return pair.second;
            }
        }
        throw std::out_of_range("Key not found.");
    }
};

#endif /* HASHMAP_H */
```

Phase.h

```
/*
 * File:   Phase.h
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 8:09 AM
 */

#ifndef PHASE_H
#define PHASE_H

#include "Card.h"
#include <list>
#include <set>
#include <string>

class Phase {
public:
    Phase(int);
    void setRequiredSize(int size) { requiredSize = size; }
    int getRequiredSize() { return requiredSize; }
    void displayCards();
    virtual bool addCard(Card);
    virtual void printType();
    bool empty() { return cards.empty(); }
    Card removeCard();
    virtual void addAvailableCards (std::set<std::string>& se
protected:
    int requiredSize;
    std::list<Card> cards;
};

#endif /* PHASE_H */
```

Phase.cpp

```cpp
/*
 * File:   Phase.cpp
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 8:09 AM
 */

#include "Display.h"
#include "Phase.h"
#include "Card.h"

Phase::Phase(int size) {
    requiredSize = size;
}

bool Phase::addCard(Card card) {
    cards.push_back(card);
    return true;
}

Card Phase::removeCard() {
    Card toReturn = cards.front();
    cards.pop_front();
    return toReturn;
}

void Phase::printType() {
    Display::Print("Default Phase");
}


void Phase::displayCards() {
    Display::PrintCards(cards);
    Display::BeginColor("Black");
    Display::NewLine();
}
```

Player.h

```
/*
 * File:   Player.h
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 3:06 PM
 */

#ifndef PLAYER_H
#define PLAYER_H

#include <list>
#include "Card.h"

class Player {
public:
    Player();
    virtual ~Player();

    void sortHand();
    void addCardToHand(Card);
    void displayHand();
    Card removeCard(int);
    void endRound();
    bool getLayDown() { return layDown; }
    void setLayDown() { layDown = true; };
    int getCurrentPhase() { return phase; }
    void increasePhase() { phase++; }
    int getScore() { return score; }
    bool handEmpty() { return hand.empty(); }
private:
    int score;
    int phase;
    std::list<Card> hand;
    bool layDown;
};

#endif /* PLAYER_H */
```

Player.cpp

```cpp
/*
 * File:   Player.cpp
 * Author: Thomas Kleist
 *
 * Created on November 2, 2024, 3:06 PM
 */

#include "Player.h"
#include "Display.h"
#include <list>
#include <algorithm>    // std::random_shuffle
#include <random>
#include <iostream>

Player::Player() {
    score = 0;
    phase = 0;
    layDown = false;
}

Player::~Player() {
}

bool cardCompare(Card &card1, Card &card2) {
    if (card1.getFaceValue() < card2.getFaceValue()) return t
    if (card1.getFaceValue() == card2.getFaceValue() && card1
    return false;
}

bool colorCompare(Card &card1, Card &card2) {
    if (card1.getColorNum() < card2.getColorNum()) return tru
    if (card1.getColorNum() == card2.getColorNum() && card1.g
    return false;
}

// Function to merge two sorted lists
std::list<Card> merge(std::list<Card>& left, std::list<Card>&
    std::list<Card> result;
    auto itLeft = left.begin();
    auto itRight = right.begin();

    // Merge the two lists into the result list
    while (itLeft != left.end() && itRight != right.end()) {
        if (*itLeft < *itRight) {
            result.push_back(*itLeft);
            ++itLeft;
        } else {
            result.push_back(*itRight);
            ++itRight;
        }
    }

    // Append any remaining elements from left or right
    result.insert(result.end(), itLeft, left.end());
    result.insert(result.end(), itRight, right.end());

    return result;
}

// Function to split a list into two halves
void split(std::list<Card>& original, std::list<Card>& left,
    auto it = original.begin();
    std::advance(it, original.size() / 2);
    left.splice(left.end(), original, original.begin(), it);
    right.splice(right.end(), original, it, original.end());
}

// Function to perform merge sort on a list
std::list<Card> mergeSort(std::list<Card> lst) {
    if (lst.size() <= 1) {
        return lst;  // Base case: if the list has 1 or 0 ele
    }

    std::list<Card> left, right;
    split(lst, left, right);  // Split the list into two halv

    // Recursively sort the two halves and merge them
    left = mergeSort(left);
    right = mergeSort(right);

    // Merge the two sorted halves
    return merge(left, right);
}

struct Node {
    Card* data;
    Node* left;
    Node* right;

    Node(Card *value) {
        data = value;
        left = right = nullptr;
    }
};

Node* insertTree(Node *root, Card *data) {
    if (root == nullptr) {
        root = new Node(data);
        return root;
    }

    if (colorCompare(*data, *(root->data))) {
        root->left = insertTree(root->left, data);
    } else {
        root->right = insertTree(root->right, data);
    }

    return root;
}

std::list<Card> readTree(Node *root, std::list<Card> lst) {
    if (root == nullptr) {
        return lst;
    }

    lst = readTree(root->left, lst);
    lst.push_back(*(root->data));
    lst = readTree(root->right, lst);
    return lst;
}

std::list<Card> treeSort(std::list<Card> lst) {
    Node *root = nullptr;

    for (std::list<Card>::iterator it = lst.begin(); it != ls
        root = insertTree(root, &(*it));
    }
    std::cout << std::endl;

    std::list<Card> newList;
    lst = readTree(root, newList);

    return lst;
}



void Player::sortHand() {
    if (phase == 7) {
        hand = treeSort(hand);
    } else {
        hand = mergeSort(hand);
    }
}

void Player::addCardToHand(Card card) {
    hand.push_back(card);
    sortHand();
}

void Player::displayHand() {
    Display::PrintCards(hand);
    Display::BeginColor("Black");
    for (int i = 0; i < hand.size(); i++) std::cout << "   " <
    Display::NewLine();
}

Card Player::removeCard(int pos) {
    if (pos < 0 || pos >= hand.size()) throw "Out of Range";
    std::list<Card>::iterator it = hand.begin();
    std:advance(it, pos);
    Card toReturn = *it;
    hand.erase(it);
    return toReturn;
}

void Player::endRound() {
    while (!hand.empty()) {
        score += hand.front().getPointValue();
        hand.pop_front();
    }
    layDown = false;
}
```

Run.h

```
/*
 * File:   Run.h
 * Author: Thomas Kleist
 *
 * Created on November 3, 2024, 1:43 PM
 */

#ifndef RUN_H
#define RUN_H

#include "Phase.h"

class Run : public Phase {
public:
    explicit Run(int x) : Phase(x) { }
    virtual ~Run();
    bool addCard(Card);
    void printType();
    void addAvailableCards (std::set<std::string>& setOfCards
private:

};

#endif /* RUN_H */
```

Run.cpp

```
/*
 * File:   Run.cpp
 * Author: Thomas
 *
 * Created on November 3, 2024, 1:43 PM
 */

#include "Run.h"
#include "Display.h"
#include <iostream>
#include <string>

bool Run::addCard(Card card) {
    // Do not add skip cards
    if (card.getFaceValue() == 14) return false;

    if (cards.empty()) {
        // If adding a wild card, ask for which value to use
        if (card.getFaceValue() == 13) {
            int numSelected = 0;
            Display::Print("Select which number you want the
            Display::NewLine();
            while (!(numSelected >= 1 && numSelected <= 12))
                std::cin >> numSelected;
            card.setPhaseValue(numSelected);
        }
        cards.push_back(card);
        return true;
    }

    if (card.getFaceValue() == 13) {
        Display::Print("Would you like to add this wild to th
        Display::PrintUnderlined("Front");
        Display::Print(" or ");
        Display::PrintUnderlined("Back");
        Display::Print("?");
        Display::NewLine();

        bool success = false;
        while (success == false) {
            std::string choice;
            std::cin >> choice;
            if (choice == "Front") {
                if (cards.front().getPhaseValue() > 1) {
                    card.setPhaseValue(cards.front().getPhase
                    cards.push_front(card);
                    return true;
                }
                return false;
            }
            if (choice == "Back") {
                if (cards.back().getPhaseValue() < 12) {
                    card.setPhaseValue(cards.back().getPhaseV
                    cards.push_back(card);
                    return true;
                }
                return false;
            }
        }
    }

    if (card.getPhaseValue() == cards.front().getPhaseValue()
        cards.push_front(card);
        return true;
    }

    if (card.getPhaseValue() == cards.back().getPhaseValue()+
        cards.push_back(card);
        return true;
    }

    return false;
}

void Run::addAvailableCards (std::set<std::string>& setOfCard
    if (!empty()) {
        if (cards.front().getPhaseValue() > 1) setOfCards.ins
        if (cards.back().getPhaseValue() < 12) setOfCards.ins
    }
}

void Run::printType() {
    Display::Print("Run of ");
    Display::Print(requiredSize);
}

Run::~Run() {
}
```