Programming Improvements

Milestone 1: Turning Algorithm

Precise Short Bursts:

- Replaced one single sweep with multiple small bursts.
- Every burst has a high PWM value to overcome grooves in the tiles.
- Color sensor reading between each burst allows precise recognition.

```
void correctLeftBoundary() {
    float r, g, b, lux;
    for (int i = 0; i < 10; i++) {          // a few quick nudges
        delay(50);
        pivotRight(150, 150);                 // slightly stronger turn
        delay(200);                          // short movement
        motorsBrake();
        delay(10);

        String c = readColorOnce(r, g, b, lux);

        // Still on BOUNDARY? Keep nudging.
        if (c == LEFT_BOUNDARY_COLOR) continue;

        // We've left WHITE: could now be BLACK/BLUE/YELLOW or something else.
        // Mark that we just came off a boundary so the next forward step is gentle.
        justRecoveredFromBoundary = true;
        return;
    }
    motorsBrake();
}
```

Turning algorithm

Milestone 2: Lux Readings

Computing lux values:

- Problem: Black tape and the Floor had similar RGB readings.
- Solution: Added code to color sensing section to calculate lux values.
- Enabled differentiation between the floor and the black tape, allowing backtracks when the rover crosses margin tapes.

```
inline String readColorOnce(float &r, float &g, float &b, float &lux) {
    ...
    ...
    // Optional: also compute lux from raw data
    uint16_t c, ri, gi, bi;
    tcs.getRawData(&ri, &gi, &bi, &c);
    lux = tcs.calculateLux(ri, gi, bi);
    return detectColor(r, g, b, lux);
}
```

Lux computation

```
// ---------- FLOOR FALL PROTECTION ----------
if (color == "FLOOR") {
    motorsBrake(); delay(100);
    motorsBackward(50, 50); delay(10);
    return true;
}
```

"FLOOR" color reaction

Milestone 3: Recovery Sequence

Sensing ALL colors during recovery:

- Problem: Recovery sequence only checked for Follow_colors.
- Caused it to ignore boundary colors
- Solution: Moved color reaction code in one function to allow detection of all colors in one sweep.
- Significantly improved recovery, allowed reaction to all colors.

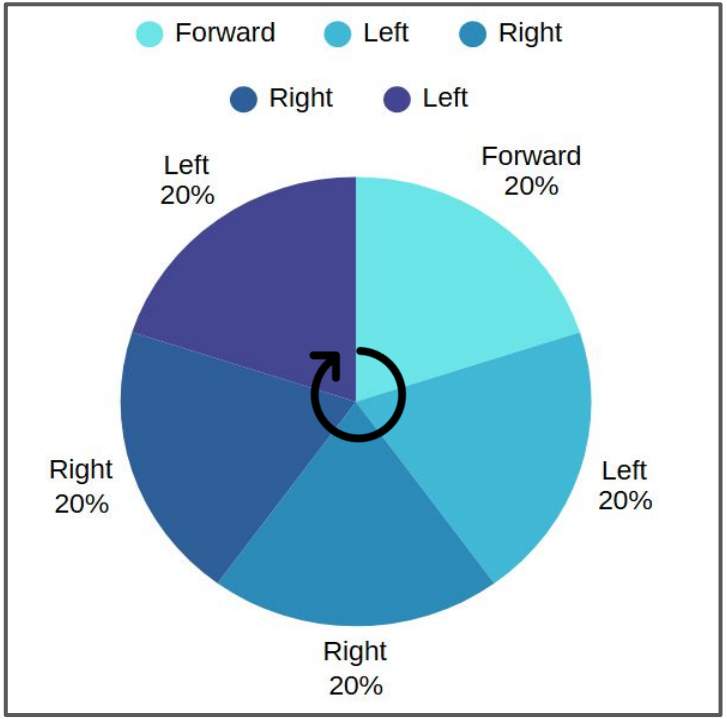
```
bool handleColorReaction(String color, float r, float g, float b, float lux) {
    // ---------- TURN MARKERS ----------
    if (color == LEFT_TURN_MARKER) {···
    }
    if (color == RIGHT_TURN_MARKER) {···
    }
    // ---------- FLOOR FALL PROTECTION ----------
    if (color == "FLOOR") {···
    }
    // ---------- FOLLOW-COLORS ----------
    bool isFollowColor = false;
    for (int i = 0; i < NUM_FOLLOW_COLORS; i++)···
    if (isFollowColor) {···
    }
    // ---------- BOUNDARIES ----------
    if (color == LEFT_BOUNDARY_COLOR) {···
    }
    if (color == RIGHT_BOUNDARY_COLOR) {···
    }
    return false;   // No reaction → normal recovery sequence should continue
}
```

Color handler function

Milestone 3: Recovery Sequence

New sequence:

- Forward -> Left -> Right -> Right -> Left
- Inspired from the simple pendulum motion.
- Rover ended the sequence facing front.
- Recovery sequence almost always triggered near the boundary of the tapes.
- Enabled immediate recovery from “Unknown” reading on color sensor.



New Recovery Cycle