

Part 1

The screenshot shows an IDE with the project 'INFO6206-Spring2022'. The file 'UF_HWQUPC_Test.java' is open, showing a package declaration 'edu.neu.coe.info6205.union_find' and a class 'UF_HWQUPC_Test'. The class contains two test methods: 'testToString()' and 'testIsConnected01()'. The 'testToString()' method creates a 'Connections' object and asserts its string representation. The 'testIsConnected01()' method creates a 'Connections' object and asserts its 'isConnected()' method returns true for a specific pair of nodes. The 'Run' window shows that 13 tests passed in 19 ms. The test results list includes 'testToString()', 'testIsConnected01()', and several 'testFind*' methods.

```
package edu.neu.coe.info6205.union_find;

import java.util.*;

public class UF_HWQUPC_Test {

    @Test
    public void testToString() {
        Connections h = new UF_HWQUPC(10, 2);
        assertEquals("expected: \"UF_HWQUPC:\\n\" +\n" +
            "  count: 2\\n\" +\n" +
            "  path compression? true\\n\" +\n" +
            "  parents: [0, 1]\\n\" +\n" +
            "  heights: [1, 1]\\n\", h.toString());
    }

    @Test
    public void testIsConnected01() {
        Connections h = new UF_HWQUPC(10, 2);
        assertTrue(h.isConnected(0, 1));
    }
}
```

Run: UF_HWQUPC_Test (edu.neu.coe.info6205.union_find) /Library/Java/JavaVirtualMachines/jdk-17.0.1.jdk/Contents/Home/bin/java ...

Tests passed: 13 of 13 tests - 19 ms

Process finished with exit code 0

testToString() 0 ms
testIsConnected01() 0 ms
testFind0 0 ms
testFind1 0 ms
testFind2 1 ms
testFind3 0 ms
testFind4 0 ms
testFind5 1 ms
testToString 0 ms
testConnect01 0 ms
testConnect02 0 ms
testConnect01 1 ms

Part 2

See UF_Client.java under the union-find folder

The screenshot shows an IDE with the project 'INFO6206-Spring2022'. The file 'UF_Client.java' is open, showing a package declaration 'edu.neu.coe.info6205.union_find' and a class 'UF_Client'. The class contains a 'main' method that generates a series of connections and prints the number of connections generated for each run. The 'Run' window shows the output of the program, which prints the number of connections generated for each run, along with the number of nodes (n) and the number of connections (m).

```
package edu.neu.coe.info6205.union_find;

import java.util.*;

public class UF_Client {

    public static void main(String[] args) {
        System.out.println("Run: " + 1);
        for (int n = 10; n < 100000; n *= 5) {
            int connections = count(n);
            System.out.println("Number of connections generated: " + connections + ", n = " + n);
        }
    }
}
```

Run: UF_Client /Library/Java/JavaVirtualMachines/jdk-17.0.1.jdk/Contents/Home/bin/java ...

Run: 1
Number of connections generated: 15, n = 10
Number of connections generated: 86, n = 50
Number of connections generated: 885, n = 250
Number of connections generated: 8896, n = 1250
Number of connections generated: 32852, n = 6250
Number of connections generated: 283531, n = 31250

Run: 2
Number of connections generated: 16, n = 10
Number of connections generated: 143, n = 50
Number of connections generated: 788, n = 250
Number of connections generated: 4615, n = 1250
Number of connections generated: 26703, n = 6250
Number of connections generated: 193636, n = 31250

Run: 3
Number of connections generated: 11, n = 10
Number of connections generated: 64, n = 50
Number of connections generated: 719, n = 250
Number of connections generated: 5486, n = 1250
Number of connections generated: 38371, n = 6250
Number of connections generated: 150123, n = 31250

Run: 4
Number of connections generated: 20, n = 10
Number of connections generated: 149, n = 50
Number of connections generated: 776, n = 250
Number of connections generated: 4288, n = 1250
Number of connections generated: 23966, n = 6250
Number of connections generated: 184882, n = 31250

Run: 5
Number of connections generated: 19, n = 10
Number of connections generated: 126, n = 50
Number of connections generated: 767, n = 250
Number of connections generated: 5721, n = 1250
Number of connections generated: 22576, n = 6250
Number of connections generated: 181401, n = 31250

Process finished with exit code 0

Part 3.

Number of Connections (m)					Average m	lg n	lg m
Run 1	Run 2	Run 3	Run 4	Run 5			
15	16	11	20	19	16.2	3.32192809	4.01792191
86	143	64	140	126	111.8	5.64385619	6.80477638
803	780	719	776	767	769	7.96578428	9.58683979
8096	4615	5486	4288	5771	5651.2	10.2877124	12.4643415
32052	26703	38373	23966	22575	28733.8	12.6096405	14.8104612
203531	193636	150123	184882	181401	182714.6	14.9315686	17.4792324

From the above data we can see that $\lg m$ and $\lg n$ has a linear relationship, while $\lg m \approx 1.2 \lg n$