Combinatorial Computing Assignment 1

Combinatorial Computing

Lucas Famous

Supervisor(s): Prof. Radziszowski

2026-2-3

Rochester Institute of Technology

CSCI-761

Rochester, NY

Table of Contents

1 Part 1 - connecting to nauty

1.1 Environment

Install nauty on your computer, or get other access to nauty package, and learn its basic command-line usage. Try first the functions geng, countg and pickg. In each case '-help' lists available options. Describe briefly your environment.

My environment is on a windows laptop. I had to download and use a program called "cygwin" to get a linux environment on windows so that I can interact with nauty in a command line terminal.

1.2 Nauty functions

There are exactly 2 nonisomorphic graphs on 10 vertices which have 16 or 17 edges, without cycles of length 4, and with maximum degree 4. Find these graphs using nauty functions.

a. Which nauty functions and with what options did you use?

I used the command "./geng 10 16:17 -f -D4 -l".

./geng runs the "generate graphs" function, 10 sets the graph to 10 vertices, 16:17 sets the edges to minimum 16 and maximum 17, -f removes cycles of length 4, -D4 sets an upper bound on the max degree to 4, and -l does a cononical labeling.

b. Print g6-format of the nauty canonical labeling of these two graphs.

The two returned graphs are IpD?GUbV? and IqKaK?X@w

c. Show 0-1 matrices of these graphs when labeled canonically according to nauty.

To do this, I concatenated the first command with "./showg -A" (giving the full command "./geng 10 16:17 -f -D4 -l | ./showg -A" to write the binary adjacency matrix. The output is as follows:

Graph 1, order 10.

0 1 1 0 0 0 0 0 1 0

1 0 0 0 0 1 0 0 0 1

1 0 0 1 0 0 0 0 1 0

0 0 1 0 1 0 0 0 0 1

0 0 0 1 0 0 0 1 0 1

0 1 0 0 0 0 1 0 0 1

0 0 0 0 0 1 0 1 1 0

0 0 0 0 1 0 1 0 1 0

1 0 1 0 0 0 1 1 0 0

0 1 0 1 1 1 0 0 0 0

Graph 2, order 10.

0 1 1 0 0 0 0 1 0 0

1 0 0 1 0 0 1 0 0 0

1 0 0 0 1 1 0 0 0 0

0 1 0 0 1 0 0 0 1 0

0 0 1 1 0 0 0 0 1 0

0 0 1 0 0 0 1 0 0 1

0 1 0 0 0 1 0 0 0 1

1 0 0 0 0 0 0 0 1 1

0 0 0 1 1 0 0 1 0 1

0 0 0 0 0 1 1 1 1 0

2 Part 2 - Some small graphs

2.1 Nonisomorphic graphs

Draw all nonisomorphic graphs on up to 4 vertices.

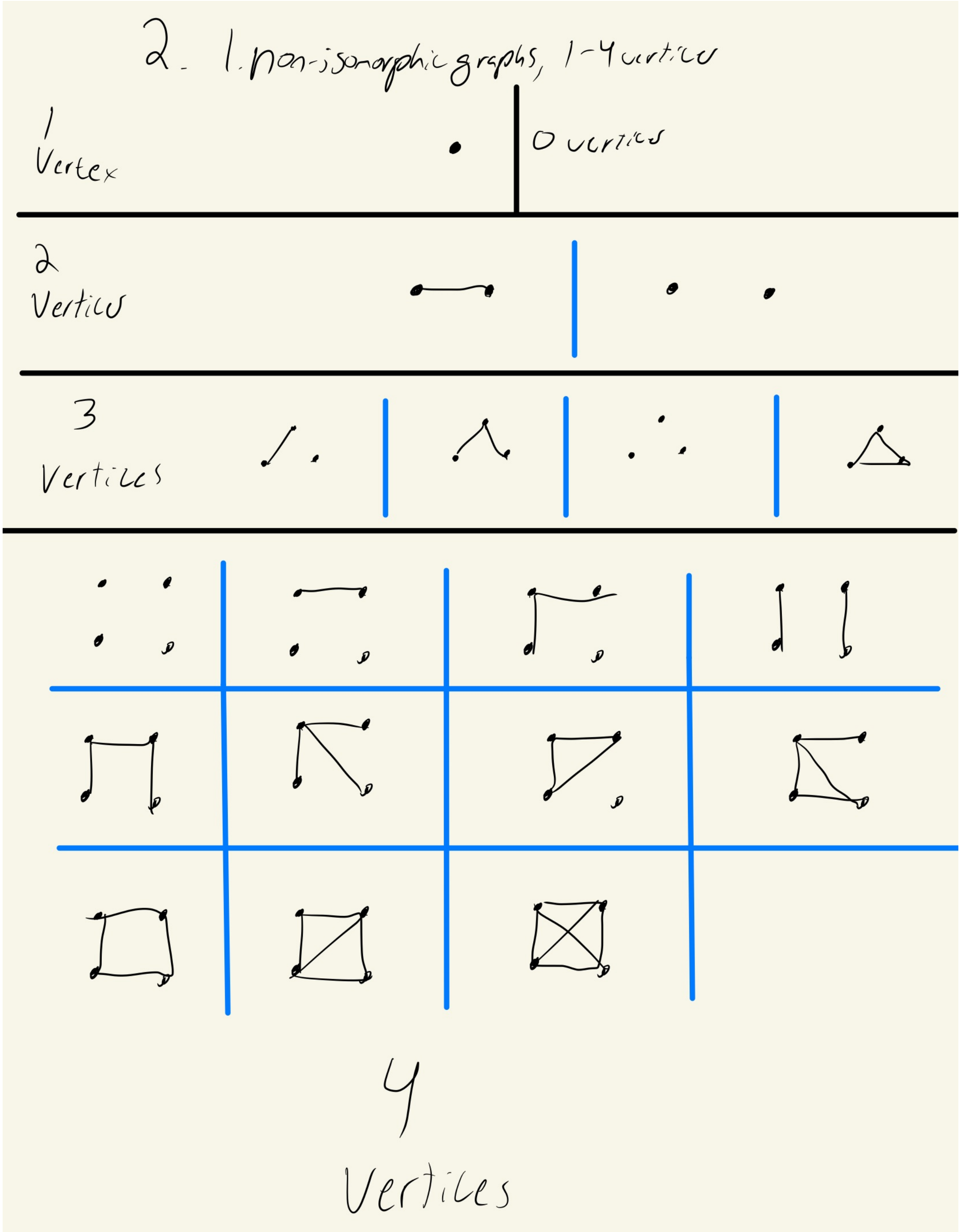

Figure 1: Part 2. 1

2.2 Pentagon matrices

How many distinct (5 x 5) 0-1 matrices are there representing a pentagon? Prove it in just a few lines of common sense reasoning (say by counting the same things in different ways).

Argument 1:

1. A pentagon is equivalent to C5.

2. C5 has 5 edges.

3. The first vertex can be adjacent to 2 of the other 4 vertices. $\binom{4}{2} = 6$.

4. Once those are chosen, the last 2 vertices can be in 2 spots. This gives $6 * 2 = 12$ possibilities.

Argument 2:

1. There are $5! = 120$ ways to number the 5 vertices in the pentagon.

2. Divide 120 by $10 = 12$ to account for the 5 isomorphic rotations and by 2 for the isomorphic reversal in the graph.

2.3 Drawing

Draw the two graphs from the second part of Part 1 as nicely as you can.

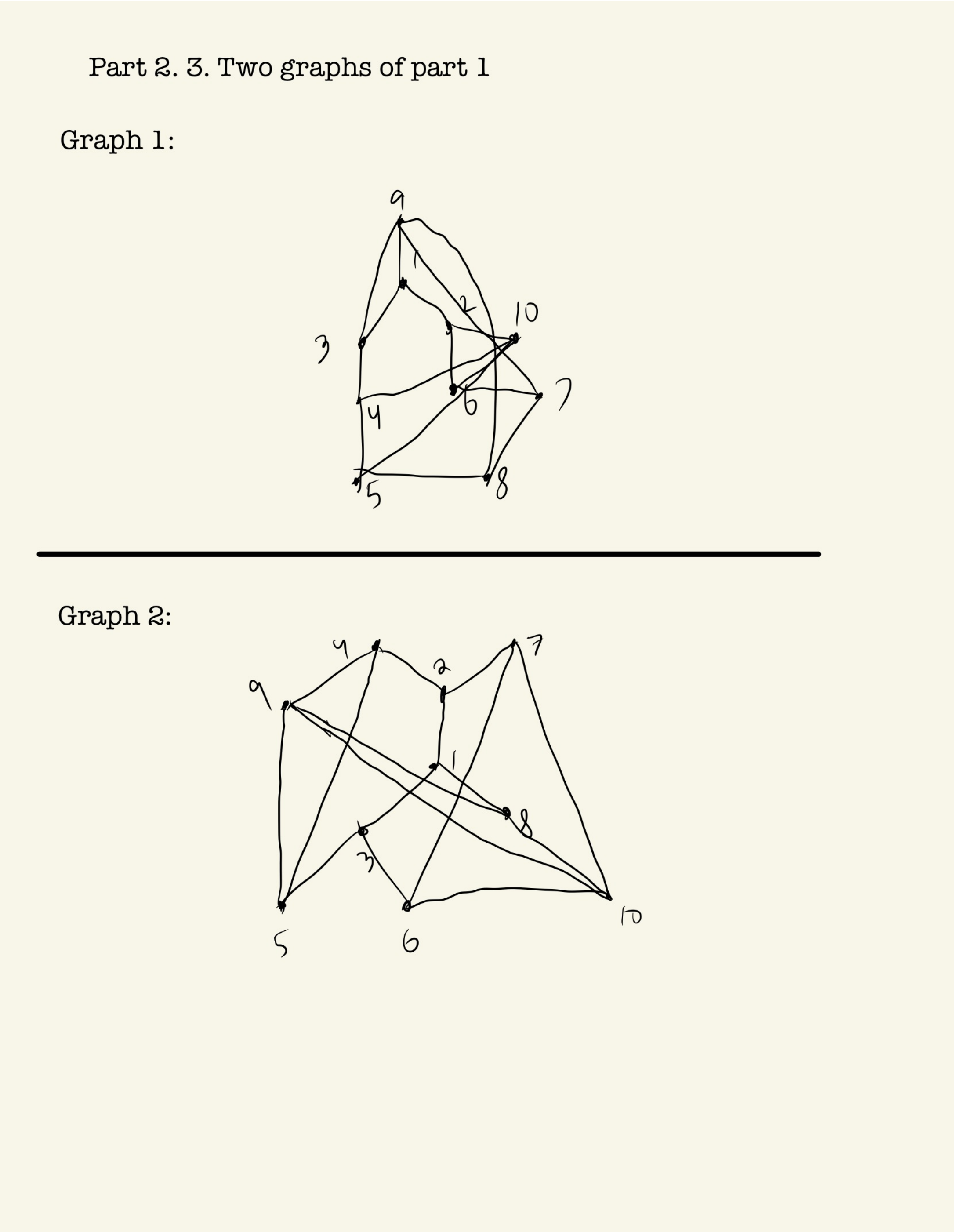

Figure 2: Part 2. 3