Krea - RAM Maths Circle - Session 10

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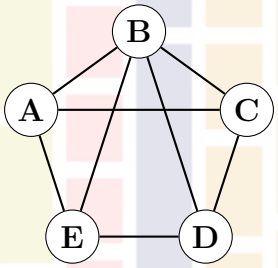
11/10/2026

1 Overview

In this session, we found out ways to count the number of paths for larger path lengths, without manually counting them. The faculty nudged the students towards Matrix Multiplication through degrees.

2 Listing and Counting Paths

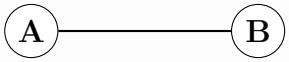
1. Five Points: Pentagon



Length	Paths from A to C
0	0
1	1
2	1
3	8
4	$8(1) + 8(1) = 16$
5	$8(1) + 8(8) = 72$
6	$8(8) + 8(16) = 192$
7	$8(16) + 8(72) = 704$
8	2112
9	7168

Can you spot any pattern?

2. Two Points, One path between the two points



Length	Paths from A to B
0	0
1	1
2	0
3	1
4	0
5	1

3. Two Points, Three paths between the two points

Length	Paths from A to A	Paths from A to B
0	1	0
1	0	3
2	9	0
3	0	27
4	81	0
5	0	243

This was found by elimination using the Branching Tree Method done in the previous class and also by manual counting.

3 Matrices

We store the information about the graph in the form of a table. Each cell shows the number of edges between the column vertex and the row vertex. For example, in the case of two points, A and B, with a single edge between them,

- Path length = 0

$$\begin{array}{c} \\ A \\ B \end{array} \begin{array}{c} \begin{array}{cc} A & B \end{array} \\ \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \end{array}$$

- Path length = 1

$$\begin{array}{c} \\ A \\ B \end{array} \begin{array}{c} \begin{array}{cc} A & B \end{array} \\ \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \end{array}$$

- Matrix Multiplication:
  1. Make a new matrix of the same size.
  2. Pick a row from the left matrix and a column from the right matrix.
  3. Check which cell is common across these 2 selections.
  4. For the corresponding cell in the new matrix, add the products of the corresponding cells from the row and column that has been selected. In other words, multiply the first cell from the selected row with the first cell of the column + multiply the second cell from the selected row with the second cell of the column. Put this value after addition in the common cell in the new matrix.
  5. Our output is the new matrix.
- Observation: If we multiply the matrix where path length is 1, with itself, then we get the matrix for path length 2.

$$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \times \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$$

- Observation: If we multiply the matrix where path length is 1, with the matrix where path length is 2, then we get the matrix for path length 3.

$$\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix} \times \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

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