Multidimensional approach to quantitative reasoning course

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Plan

- Introduction and description of QR course in the UG programme
- Design principles
- Examples of topics, projects and assessment

List of courses

Creative computing (SCRATCH)

QR through Python

Game theory, counting and symmetry

Logic, Chance and Order

Disease, Game theory

Practical mathematics

Precalculus

Calculus

Quantitative methods in biology

Introduction to quantitative methods in economics

Big picture

Pedagogy	Assessment	Tools
Active learning using technology, games ,activities	Assignment	Python
Examples and situations chosen from real life	Quiz	GeoGebra
Tutorials every week	Projects	SCRATCH
Link concepts and activities with disciplinary major		Art
Activities designed to recall elementary concepts from school		

Games, counting and symmetry

Explore frieze patterns (border patterns), platonic solids and tessellations

Permutations, combinations, Pascals triangle

Rational thinking using simultaneous and sequential games

Games, counting and symmetry

1. Lectures, tutorials and quizzes to revisit basics concepts as well as introduce new concepts using active learning strategies.
2. Projects in every unit.

- Class divided into groups of three
- Guidance given for choice of topics
- Rubric given for writing report and presentation
- Pop quiz at the end of every presentation to check engagement of class

Projects

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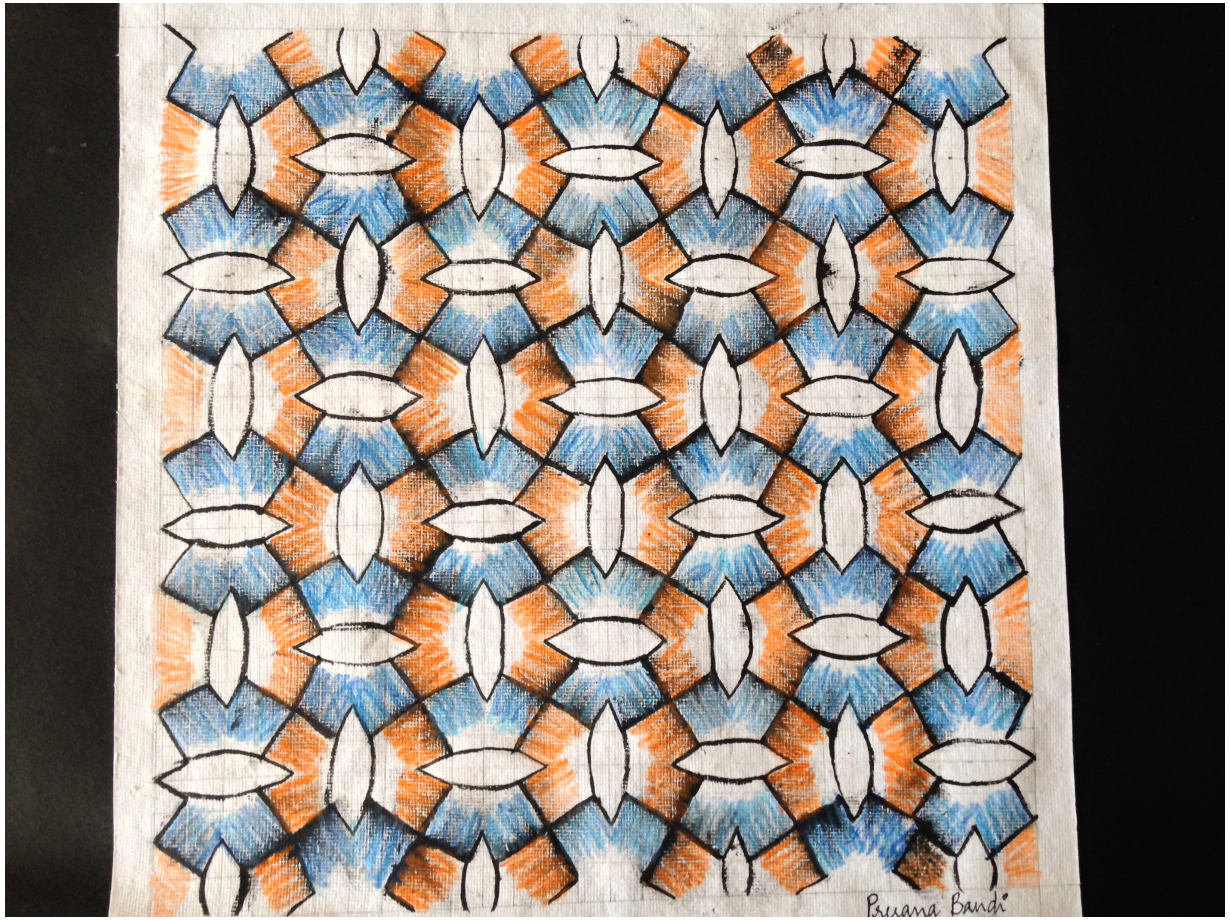
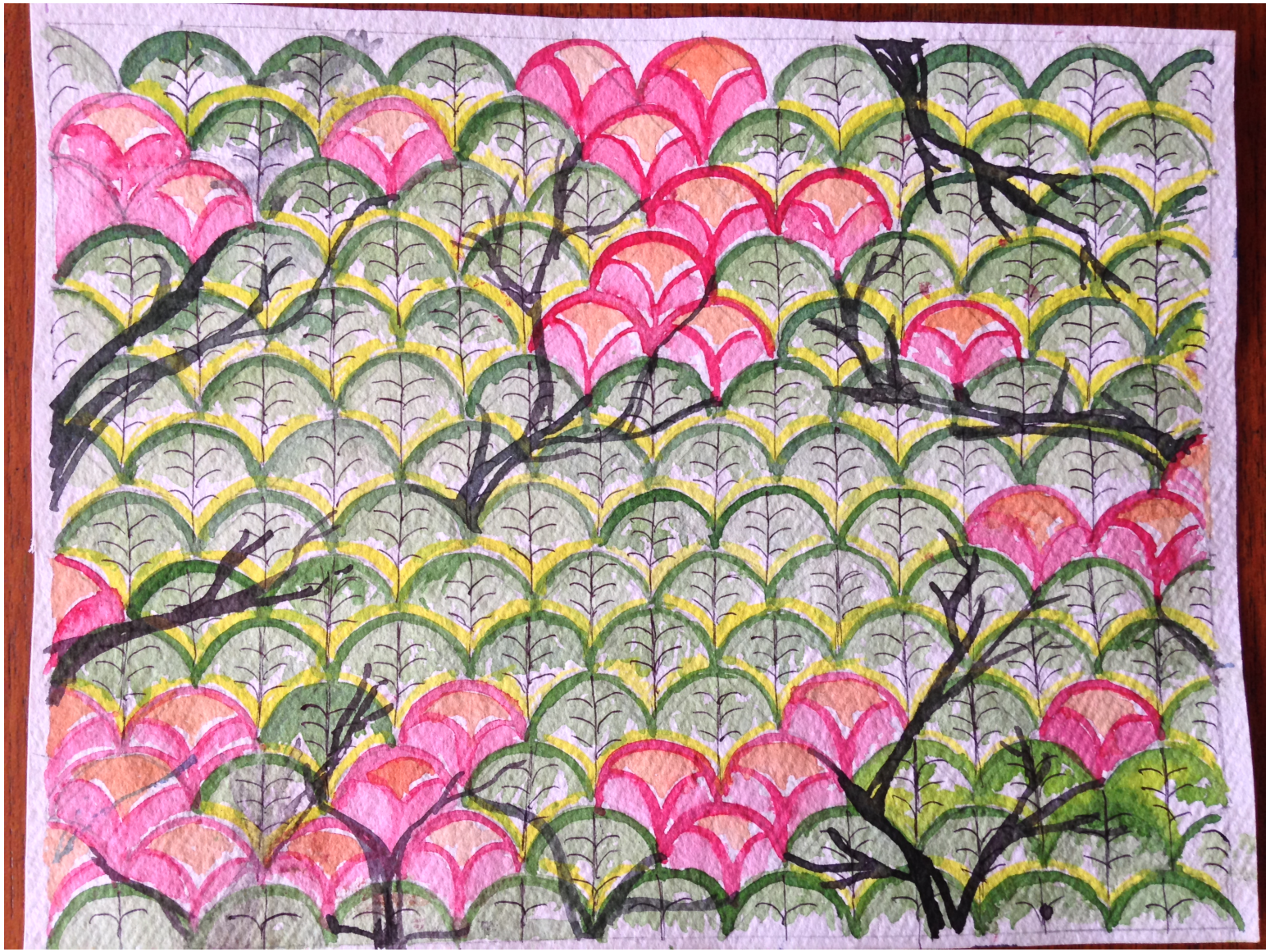
Grou	Topic	Reference	Task	Report	Presentation
1	To understand how ideas of permutations and combinations relate to music/poetry.	https://www.berklee.edu/bt/211/lesson.html	Identify some of the ways in which permutation combination are used in music/poetry. Some indicative resources are given. You could use other resources	Explain the context in music/poetry where permutations or combinations are used . Do these methods add any beauty element or do they only provide systematic way of doing things?	Demonstrate through three examples how permutations/combinations feature in poetry or music.
2	To understand Pigeon hole principle and applications	The Pigeonhole P Click to open t	nition of sets, onto functions. When a function is you say about the cardinality of the domain. e pigeonhole principle. Provide applications: erson has a large number of socks of colour blue pink . How many socks must he pull out to he has a pair. a set of n+1 integers . Show that there exist distinct integers a and b such that their difference is a multiple of n. c. Theorem: For any natural number n, there exists a multiple whose digits are all zeros.	Explain the pigeonhole principle. Illustrate by giving simple examples and also the theorem c.	Use three slides to explain pigeonhole principle and one application.
3	Understand Johnson Trotter algorithm	http://mathlesstraveled.co	Read the following resources to understand the trotter algorithm. Use this algorithm to work out permutation of six elements,	Explain the Johnson Trotter algorithm in your own words. Illustrate with a few examples.	Use two slides to explain the algorithm and one example
4	To understand application of the concept of modulo in calculating days of the week of a given year.	http://www.tondering.dk/claus/cal/week.php http://www.tondering.dk/claus/cal/chrweek.php	Read the following material in the links provided. Using this method calculate the day you were born – all three in the group	In your own words, please explain how to use the formula for calculating the day of the week.	Using three slides of ppt , outline the method and one example.
5	Use of permutations in DNA sequencing	http://www.le	Verify that this method works by using sample sequence of varying length . You could use three or four small sequences.	Show the working of the task.	Make a ppt with four slides to explain the method.
6	To understand recurrence relations	http://users.su	Work out the solution to the following problem: 1. Every time I come home I have to climb a flight of stairs. When I'm feeling energetic I sometimes take two steps at a time. This gives me a number of ways to climb the stairs. For example, if there are ten steps, I could climb them taking five leaps of two, giving the pattern 2, 2, 2, 2, 2. Or I could only use a leap of two at the beginning and the end, giving the pattern 2, 1, 1, 1, 1, 1, 1, 2. How many ways are there all together of climbing the ten steps? Being a mathematician, I don't have ten steps of course, but I have n steps. Can you find a formula to express the number of ways there are of climbing steps using leaps of one and two? 2. If T(n)=T(n/2)+n and T(1)=1. What is T(32). What is the pattern that you observe? 3. Have you come across recurrence relation in any other context?	Explain the idea of recurrence relation, example of tilings . Explain the answer to the problem	In three slides of ppt, explain idea of recurrence relation, one example of recurrence relations and answer to the problem
7	Cryptography	Encryption and modulo http://www.math.cornell.edu/~mec/20	Application of concept of modulo in encryption, understand the Diffiehellman method and transposition cipher	Explain the Diffiehellman method and transposition cipher in your own words.	Make a ppt with four slides to explain transposition cipher and Diffiehellman method
8	Understand sorting algorithms	http://www.sorting-algorithms.com/ https://www.youtube.com/watch?v=lyZQPjUT5B4	How do the various sorting methods work? Bucket sort, bubble sort, insertion sort, heap sort. Work out how many steps each of these methods take for small cases. The videos illustrating these algorithms using dance are illustrative.	Explain the four sorting algorithms with examples worked out for a set (1,2,3,4,5,6). Are there any uses for sorting.	Demonstrate three sorting algorithms, you may use three slides of ppt presentation.
9	Counting the cardinality of a set by setting up a bijection with a set whose cardinality is known.	Use the first three pages of the reference material given below: http://yufeizhao.com/olympiad/bijections.pdf	Recall definition of function, one-one and onto functions, bijective functions. How are cardinality of domain and codomain related in each of these functions. . Understand the bijection and the formula for counting number of partitions of an integer.	Explain the formula for calculating number of partitions of integer n into k parts. For n=10 , write out actual partitions into k parts.	Use three slides to illustrate bijection, the idea of bijective proof and the forumula for counting number of partition of n into k parts.


Pruana Bandi

Tessellations



Experiments

- Buffon needle experiment to estimate pi
- Coin tossing to show root n rule of random walks
- Kids RSA
- Triangulation to identify point-GPS
- Optimisation to find locations

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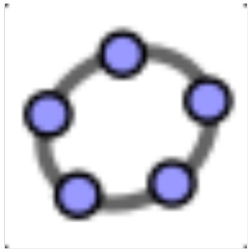
Arch. Dept. India Office, London.

Sample worksheet

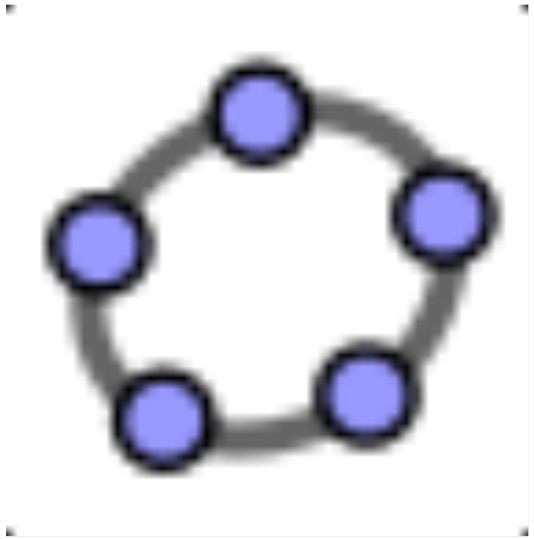
- Decompose 1001, 10001, into prime factors using GeoGebra Mod function and testing with prime divisors from the sieve of problem 2.. Once you get one divisor carry out the division and then test the quotient similarly.
- One more result due to Euclid (or at least he compiled it in his books) is the following. If a prime divides (is a factor of) XY, then it either divides X, or divides Y, or both. The case where it divides XY but not X or Y is impossible. Find examples where this is true with 7 as the prime Find an example where it is not true using 6 as the divisor. Translate this result into modular arithmetic. Connect it to a properties of the multiplication table modulo 6 and modulo 7 which we saw earlier.
- Take two numbers a=2701125 and b=496125. Find the HCF using Euclids algorithm. Write down the Euclid algorithm for the HCF of two numbers A and B (with A>B) as a set of equations in modular arithmetic.(These are also called ‘congruences”). No pictures allowed! . Justify why the last remainder (before zero) is a common factor. Why is it the highest common factor? Find the LCM using the known result form high school maths, a*b=HCF(a,b)*LCM(a,b). Now break a and b into prime factors. Can you use this decomposition to find their HCF and LCM ? 5 Imagine that we have

GeoGebra



pappus.ggb

Fermat’s principle



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Logarithms

A very practical logarithmic scale is inflation – rising prices. Assuming the rate of inflation to be

uniform, look at the following data. A loaf of bread which cost 60 paise in 1967 (when I first came to Bengaluru) now costs 30 rupees in 2017, 50 years later. This is a factor of 50 in 50 years. That means

the logarithm to the base 10 has increased by 1.7 in 50 years, so for each year it was 0.034. What is the percentage of inflation? The antilogarithm is 100.034=1.0814 . We would call this 8.14 per cent

inflation. Actually, in more recent times it has been more like 10 per cent.

Learnings

Work required on basic numeracy

Streaming along majors

Need two QR courses

Academic support needed