



Mathematics – The key to the GATE?

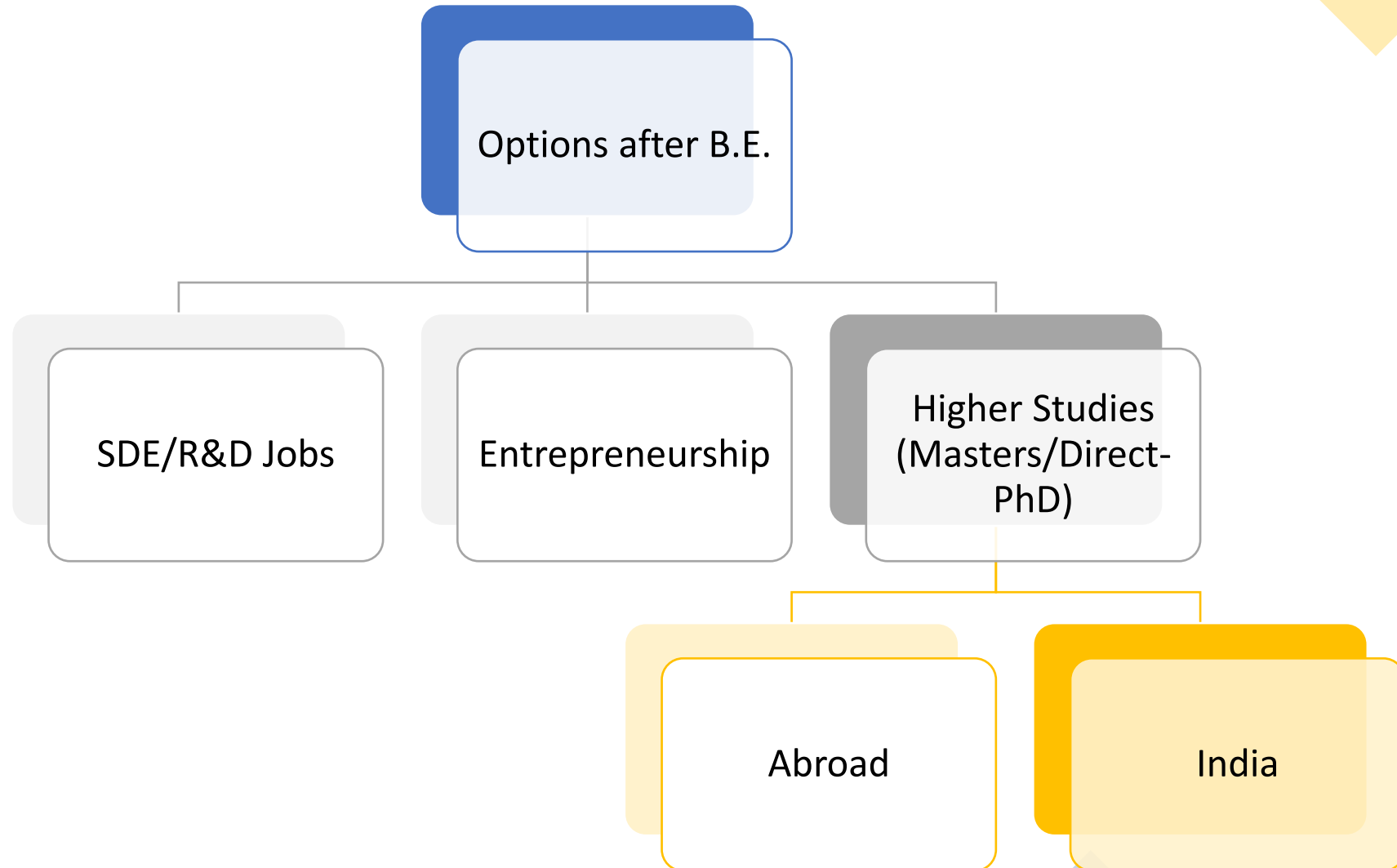
2023, IT - SIP

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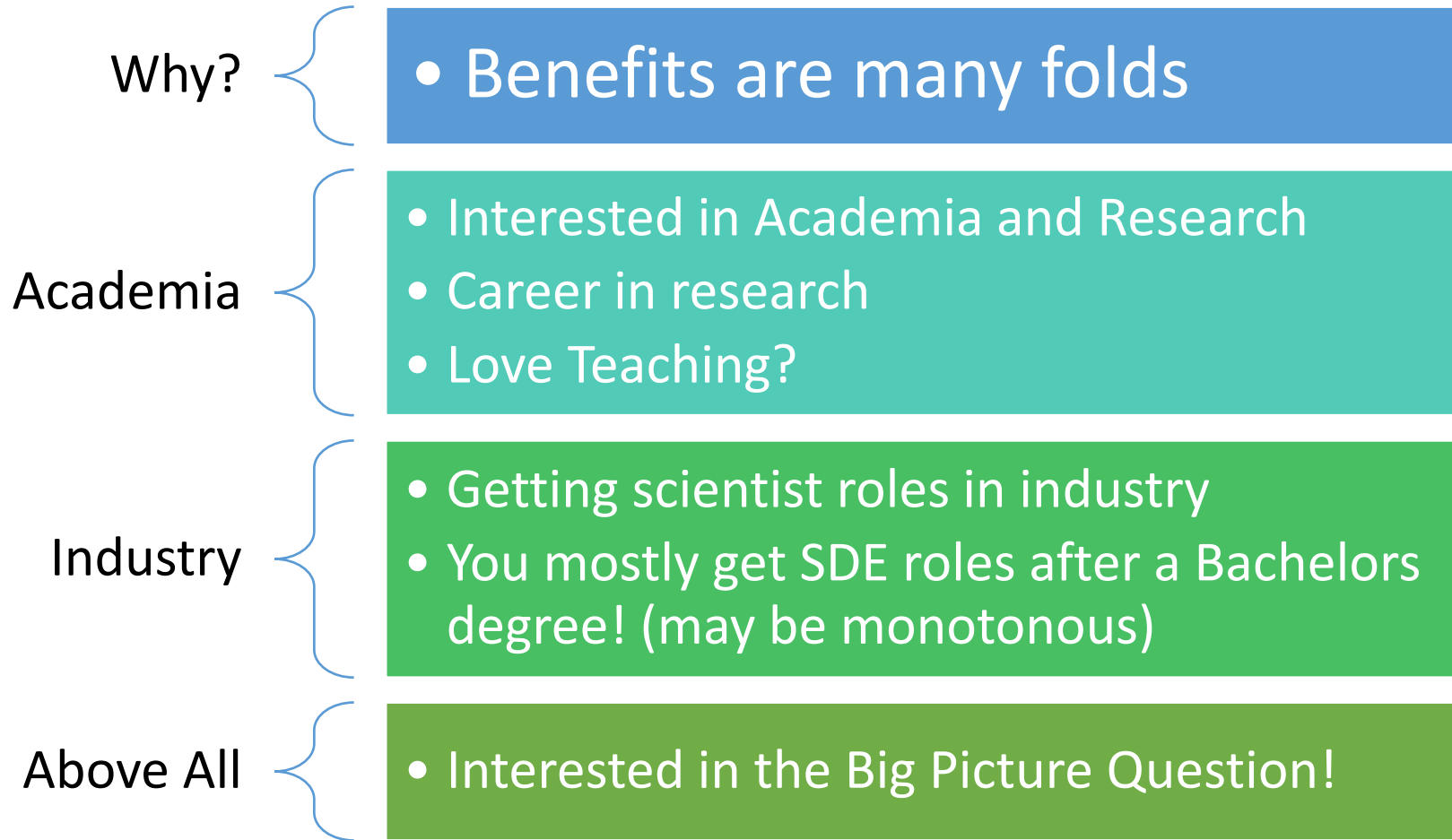
2021 B.E. IT (JU)

IISc, 3rd year PhD (PMRF), BAI

Options to choose from after graduation



Reasons to pursue Higher studies?



Path for admission to tier-1 foreign Universities

Before you apply

- What steps do one follow?

The Fundamentals

- Identify your interests
- Ask the question: Why?
- Take the extra yard: Plenty of Information available today

Research

- Identify your research interests.
- How? Try out a wide variety of stuff in the 1st and 2nd year
- Start working on some basic research question: A lot of great researchers are around you!

Experience

- Get some industry experience (internships): JU provides a lot of opportunity
- Some academic summer research internships in IITs/ IISERs/ MITACs (Canada) / DAAD (Germany)

Tier 1 universities in India?

Repeat

- Follow the previous steps

Added Challenge

- Write the GATE examination
- Apply to universities of your interest
- Appear for entrance Exams
- Appear for Interviews

Other option

- Appear for GATE
- Use the score for PSU jobs

GATE: Graduate Aptitude Test in Engineering

Number of Papers

- 30, you can apply in 2! 2024 will be conducted by IISc
- Most Relevant exams to take –
- CS (Computer Science and IT)
- DA (Data Sciences and AI)

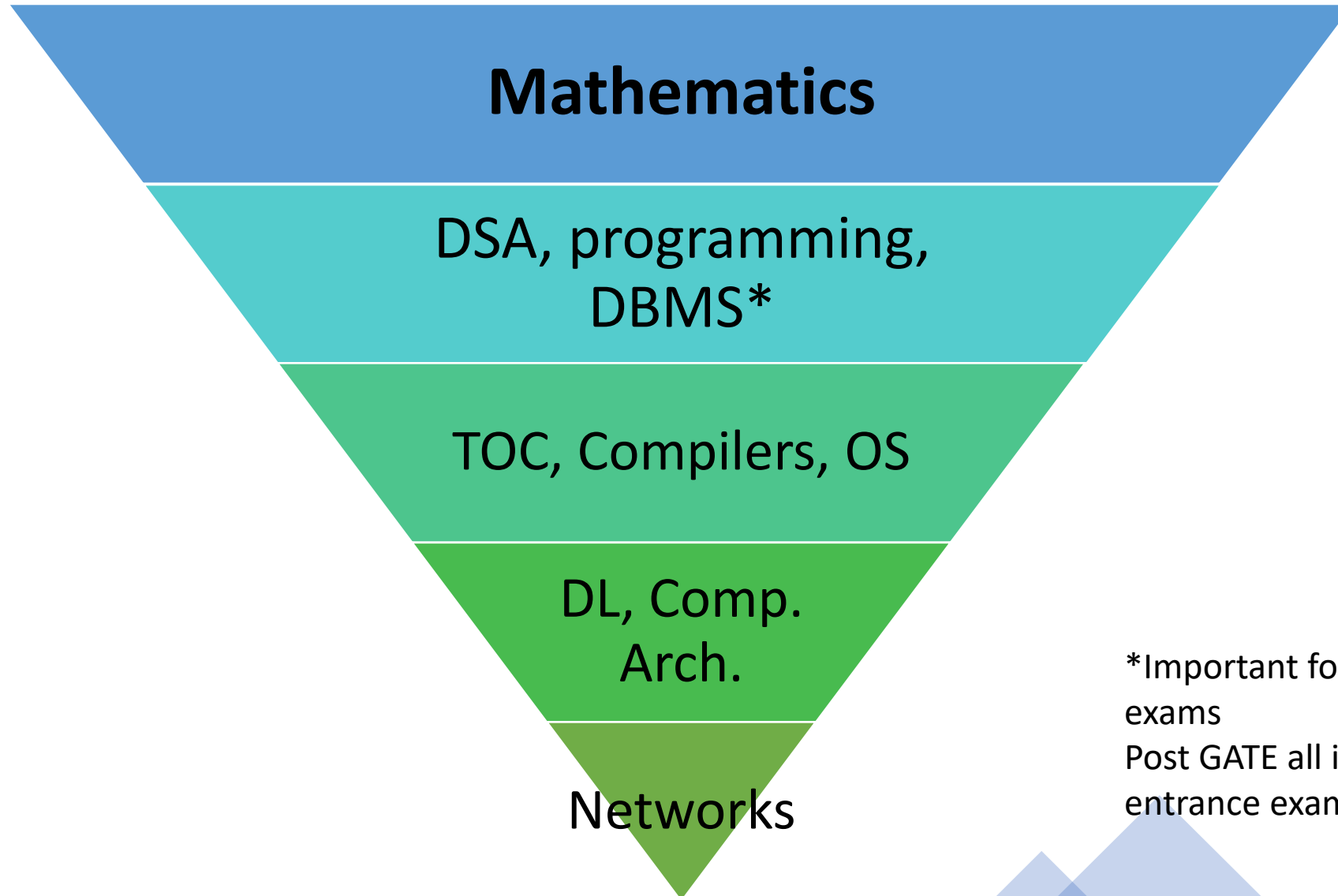
Examination Details

- 100 Marks, 3 hours
- 65 Questions (35x2 + 30x1)
- 10 General Aptitude (15 marks), 55 on the paper chose
- MCQs (33% Negative marking)
- MSQ / Numerical types

Where is the score accepted?

- You get a normalized score (out of 1000)
- National Universities (for Mtech/MS/Direct-PhD)
- PSUs

Subjects in CS-IT Paper



*Important for gate but not for further exams

Post GATE all institutes will take entrance exams/interviews

Subjects in DA Paper

**Mathematics – Prob, Linear
Algebra, Calculus and Optimization**

DSA, programming

**Machine
Learning and AI**

DBMS*

*Not sure of its relative importance yet. But logically, this should be the sequence

Keys to self-preparation?

- Here are some very important courses you might consider (not only for gate) for understanding the basics. The topics that are not mentioned can be studied from books, and university notes, OCW, Harvard/Stanford online and NPTEL. For each the courses corresponding problem sheets are available in the respective websites.

Mathematics

- Linear Algebra: [Gilbert Strang 2005, ocw](#)
- Prob-Stats: [Joe Blitzstein, stats 110](#)
- Calculus*: Differential Equns ([ocw](#)) Multivariate ([ocw](#))
- For ML there are many NPTEL/ocw courses available

[JU 2023, Math for ML](#)

CS fundamentals

- DSA: Naveen Garg, [IITD, NPTEL](#)
- DBMS: P.P. Chakrabarti, [IITkgp, NPTEL](#)
- OS, DL, TOC, Compilers, Computer Org: JU classes (slides, books) + NPTEL courses + youtube tutorials
- Networks: Ravindrababu Ravula

Gate Specific

- Gate-overflow Book ([website](#), [book](#))
- Buy the Arihant Gate CSE book and solve (Errors)
- Atleast appear for 50 mock tests (CBTs): like madeeasy test series (around 1k rupees only)

*Not directly required, but important.

Fields of Study, Subjects to Focus on!

AI

- Maths (1st need foundations in prob, stats, linear algebra, calculus)
- Introduction to ML, DL, pattern recognition (Coursera, ocw, nptel)

Quantum
Computing/ Physics
related

- Mathematics
- Quantum Mechanics ([ocw](#))
- If time permits, consider Special Relativity too. ([nptel](#)) (not necessary fo QT)

Cryptography,
TOC, etc.

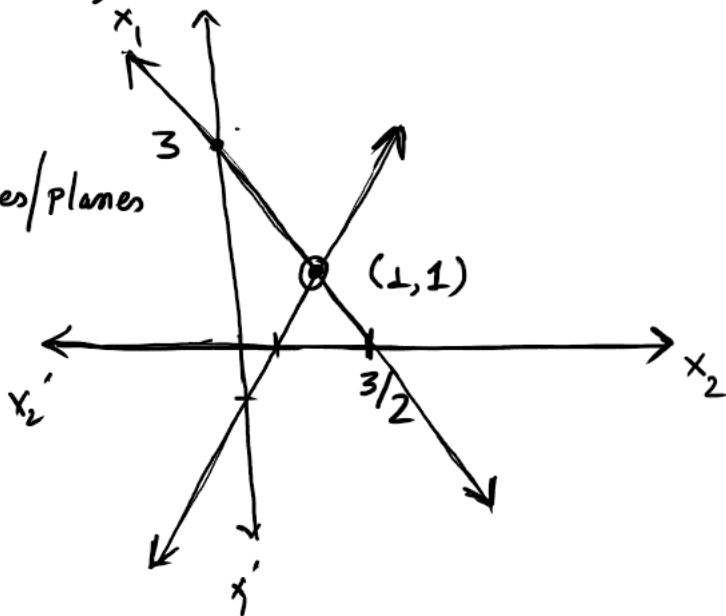
- Number theory (for TOC related research the course material extremely important)

Let's look at an example – Linear Algebra!

$$\begin{cases} x_1 + 2x_2 = 3 \\ x_1 - 2x_2 = -1 \end{cases}$$

$$x_1 = x_2 = 1$$

- Intersection of lines/planes
view -



or: - Comes in the foundation of linear Algebra.

$$\begin{bmatrix} 1 \\ 1 \end{bmatrix} x_1 + \begin{bmatrix} 2 \\ -2 \end{bmatrix} x_2 = \begin{bmatrix} 3 \\ -1 \end{bmatrix}$$

$a_1 \quad a_2 \quad r$

$$\Rightarrow v_1 x_1 + v_2 x_2 = r$$

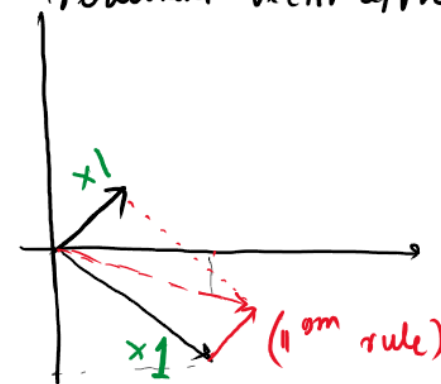
(make the resultant vector with the given vectors)

(thus, the resultant vector approach)

$Ax \Rightarrow$ can be thus thought of as

$$\begin{bmatrix} a_1 & a_2 & \dots & a_n \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ \vdots \\ x_n \end{bmatrix}$$

$$= \sum_{i=1}^n x_i a_i \quad [\text{linear combination of columns}]$$



Example 2 - Calculus!

Taylor's Expansion

$$f(z) = \sum_{i=0}^{\infty} a_i \underbrace{(z - z_0)}^i$$

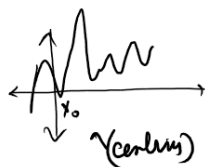
$$f(x) = \sum_{i=0}^{\infty} a_i x^i$$

$$f(x) = \sum_{i=0}^{\infty} \frac{f^{(i)}(0) x^i}{i!}$$

Taylor/Maclaurin Series

Relⁿ with Linear Algebra : $f(x)$

$$\left(\lim_{n \rightarrow \infty} \right) \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_1^2 & \dots & x_1^{n-1} \\ 1 & x_2^2 & \dots & x_2^{n-1} \\ \vdots & \vdots & \ddots & \vdots \\ 1 & x_n^2 & \dots & x_n^{n-1} \end{bmatrix}_{n \times n} \begin{bmatrix} a_0 \\ a_1 \\ \vdots \\ a_{n-1} \end{bmatrix}_{\text{Coeff}}$$



$[n]$ pts \rightarrow min $(n-1)$ degree polynomial

any analytic function can be written :

$$f(x+h) = f(\underbrace{h+x}_{\text{[Pt Expansion]}}) = f(x) + f'(x)h + \frac{f''(x)}{2}h^2 + \dots$$

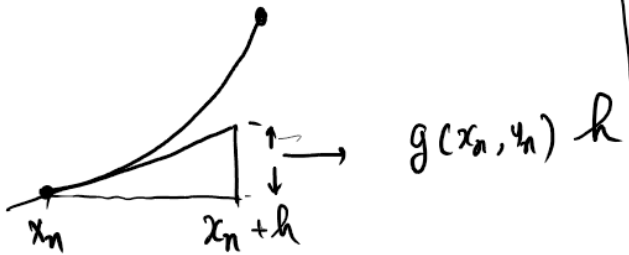
$$\lim_{h \rightarrow 0} \parallel f(x+h) \approx f(x) + f'(x)h =$$

Euler's Method and Gradient Descent

Euler method :

let $\frac{dy}{dx} = g(x, y) = f'(x)$ and given (x_0, y_0) can you trace $y = f(x)$?

Geometric



$$x_{n+1} = x_n + h$$

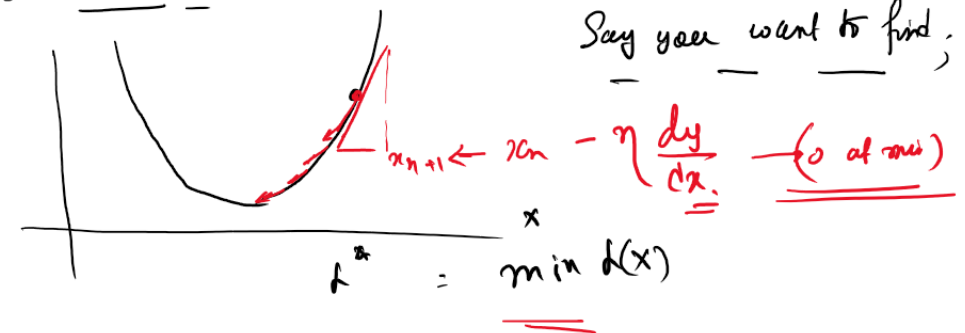
$$y_{n+1} = y_n + \underline{g(x, y)h}$$

Algebraic

$$f(x+h) \approx f(x) + \frac{dy}{dx} h$$

$$y_{n+1} = y_n + g(x, y)h$$

Gradient Descent



$$x_{n+1} \leftarrow x_n - \eta \frac{dy}{dx}$$

Taylor

$$f(x_{n+1}) - f(x_n) < 0$$

$$f(x_{n+1}) = f(\underline{x_n} - \eta g(x_n, y_n))$$

$$\approx f(x_n) - \eta (g(x_n, y_n))^2$$

$$= f(x_{n+1}) - f(x_n) < 0$$



Above all have an inquisitive mind.

Thank you

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