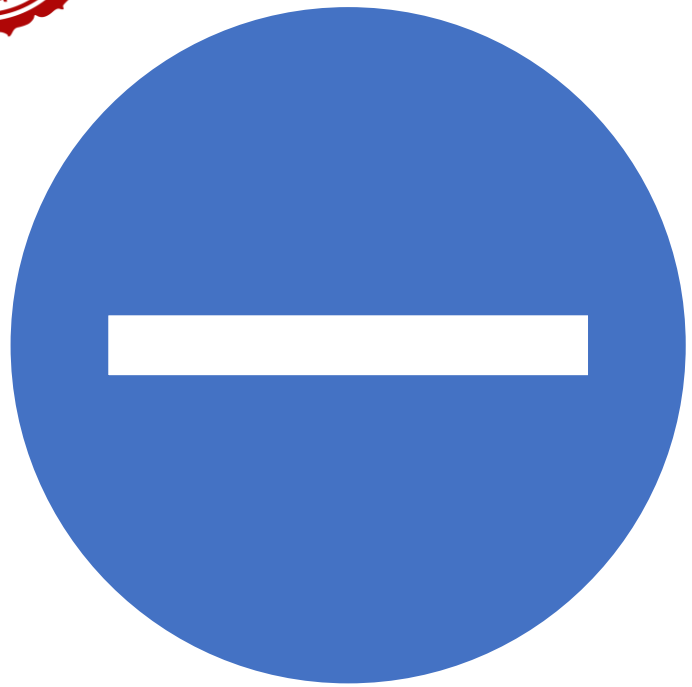


Mathematics – The key to the GATE?

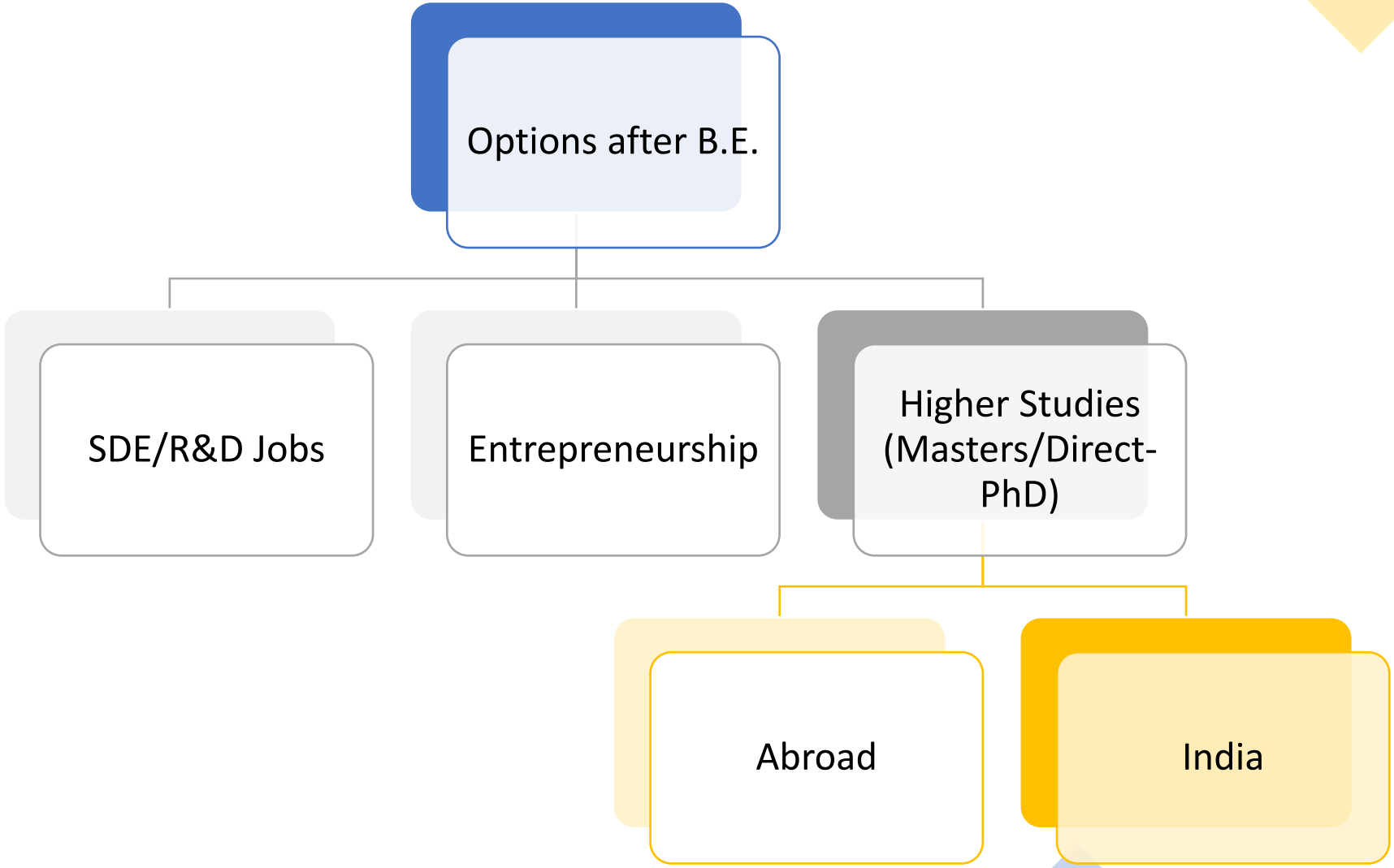
2023, IT - SIP

Mainak Biswas

2021 B.E. IT (JU; GATE 2021 CS – 111)

IISc, 3rd year PhD (PMRF), BAI

Options to choose after graduation



Reasons to pursue Higher studies?

Why?

- Benefits are many folds

Academia

- Interested in Academia and Research
- Career in research
- Love Teaching?

Industry

- Getting scientist roles in industry
- You mostly get SDE roles after a Bachelors degree! (may be monotonous)

Above All

- Interested in the Big Picture Question!

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)

Examinations

- IELTs/TOEL – Slowly these scores are being waivered
- GRE General Aptitude Test (and/or Math/Physics tests depending on you interest)

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)

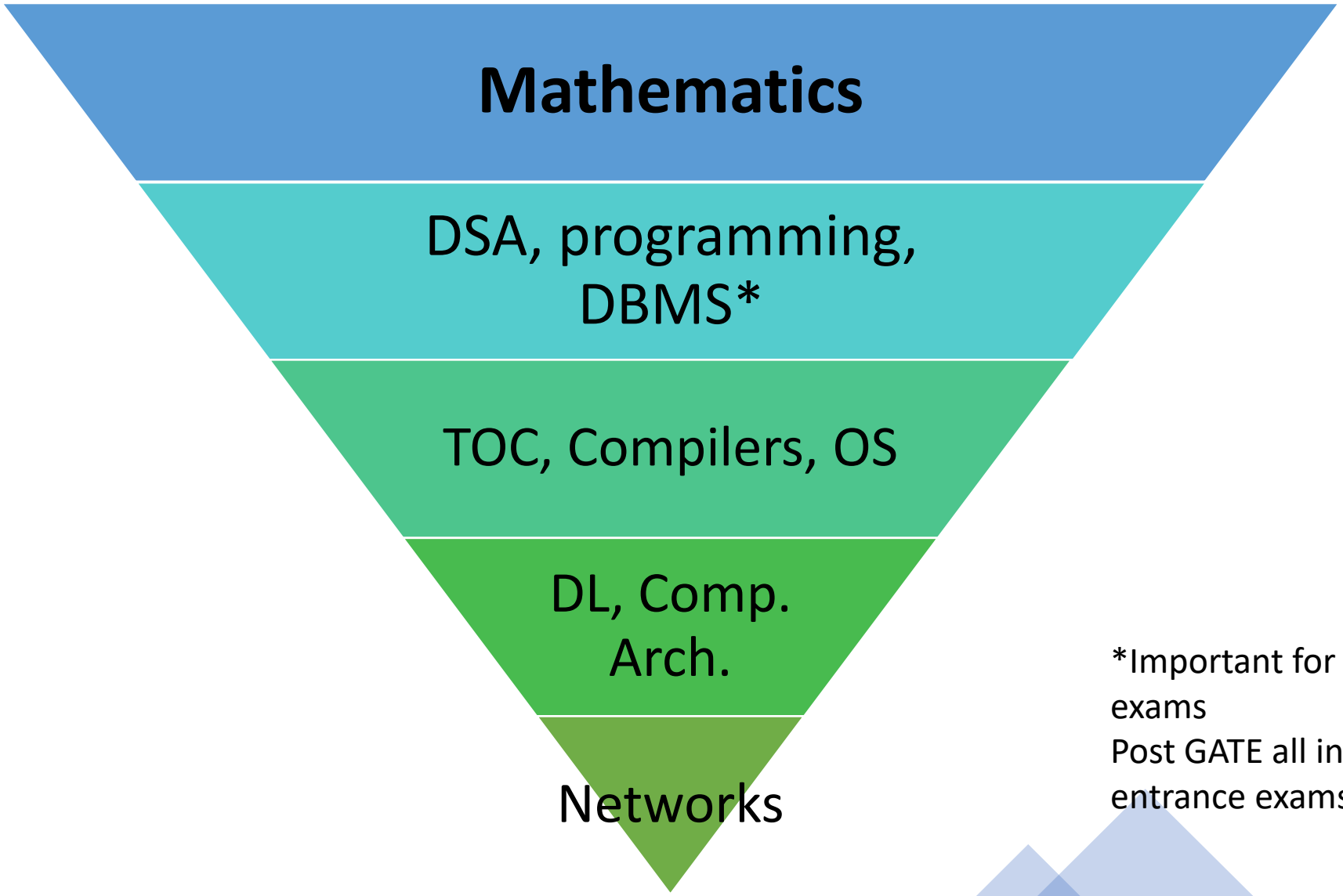
Examination Details

- 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?

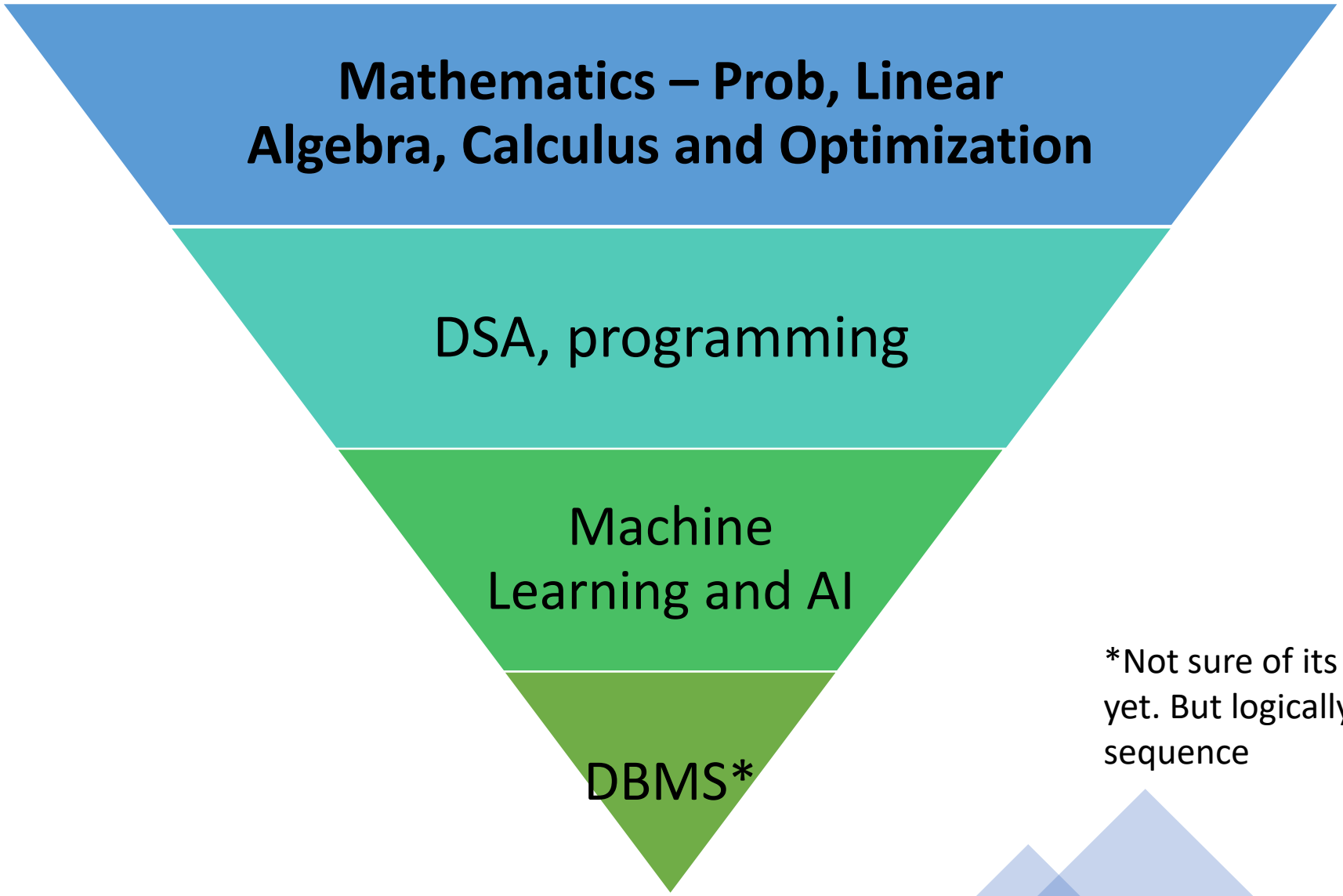
- You get a normalized score (out of 1000)
- National Universities (for Mtech/MS/Direct-PhD)
- PSUs

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



*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)

Above all have an inquisitive mind.

Enough Intro – Time for Maths!

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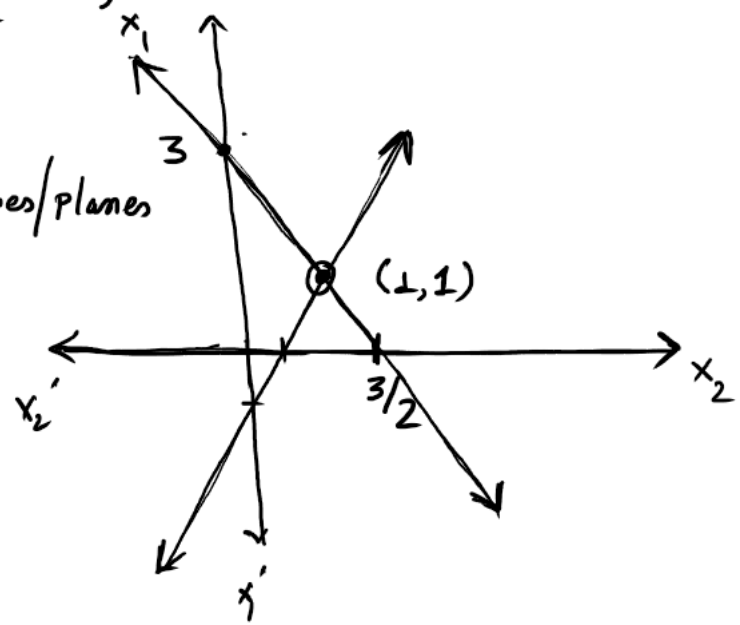
Let's look at an example – Linear Algebra!

$x_1 + 2x_2 = 3$
$x_1 - 2x_2 = -1$
$\Rightarrow x_1 = x_2 = 1$

- Intersection of lines/planes view –



or: - Comes in the foundation of linear Algebra.

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

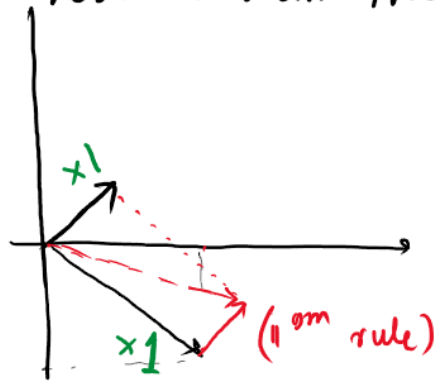
v_1 v_2 r

(make the resultant vector with the given vectors)

$\Rightarrow v_1 x_1 + v_2 x_2 = r$

(Thus, the resultant vector approach)

$Ax \Rightarrow$ can be thus thought of as



$$\begin{bmatrix} a_1 & a_2 & \cdots & a_n \\ | & | & & | \end{bmatrix} \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}$$

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

Example 2 - Calculus!

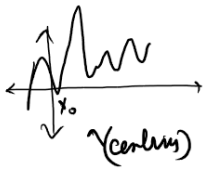
Taylor's Expansion

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

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

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

Taylor/Maclaurin Series



[(n) pts → max (n-1) degree polynomial]

Any analytic function can be written:

$$f(x+h) = f(h+x) = f(x) + f'(x)h + \frac{f''(x)}{2}h^2$$

[Pt Expansion]

$$\lim_{h \to 0} \Rightarrow f(x+h) \approx f(x) + f'(x)h$$

Rel^{n} with Linear Algebra : $f(x)$

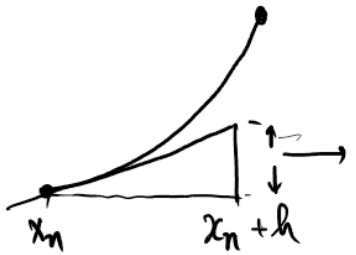
$$\left(\lim_{n \to \infty}\right) \begin{bmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{bmatrix} = \begin{bmatrix} 1 & x_1^2 & \cdots & x_1^{n-1} \\ 1 & x_2^2 & \cdots & x_n^{n-1} \\ \vdots & & & \\ 1 & & \cdots & x_n^{n-1} \end{bmatrix}_{n \times n} \begin{bmatrix} a_0 \\ a_1 \\ \vdots \\ c_{n-1} \end{bmatrix}$$

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



$g(x_n, y_n)\, h$

Algebraic

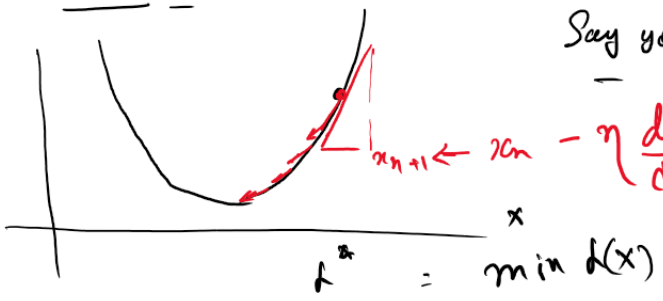
$$f(x+h) \approx f(x) + \frac{dy}{dx} h$$

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

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

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

Gradient Descent



Say you want to find ; (0 at min)

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

Taylor

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

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

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

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