# Guru Kalyan Jayasingh

*Curriculum Vitae*

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## Education

2017–Present **Indian Institute Of Technology Bombay, India**, Senior Undergraduate.
Major in Engineering Physics (with honors), Minor in Mathematics
GPA : 9.25/10

## Research Experience and Key Projects

August - November 2019 **Introduction to Quantum Field Theory**, *Supervised Learning Project.*
Supervisor: Prof. P. Ramadevi, Dept. of Physics, IIT Bombay.

- Studied Canonical Quantization for bosons and fermions, interacting field theory and quantum electrodynamics .
- Explored S-matrix and Wick's contraction as a perturbation technique to calculate scattering amplitude, particularly for scalar Yukawa theory as an example.
- Gave a presentation on the study by highlighting the approach of Feynman diagrams to compute 2nd order amplitudes. Submitted a report summarising the work done. [Presentation][Report]

June - July 2019 **Asymmetric Gravity and Cosmology**.
Supervisor: Prof. T.P. Singh, Tata Institute of Fundamental Research, Mumbai.

- Investigated the *extension of Non-symmetric metric theories* with the inclusion of Einstein-Cartan theory as a limit.
- Reviewed the works of Einstein, Moffat and Hammond on asymmetric metric and analyzed the coupling with EM field and a torsion analogue to classical GR.
- Proved the *inability of the existing approach to settle at Einstein Cartan theory in classical limit.* This was helpful to provide an extension of Einstein's original ansatz to include torsional connections while working with a real metric.

May - June 2019 **On a possible correspondence between Non-Commutative Geometry and Trace Dynamics**.
Supervisor: Prof. T.P. Singh, Tata Institute of Fundamental Research, Mumbai.

- Involved in finding a *possible relation between Adler's trace dynamics and Connes's non-commutative geometry* as a candidate for a theory of quantum gravity.
- Performed literature review on Non-commutative geometry and Spectral action. Also explored elements of Trace dynamics.

May - June 2018 **Banach Spaces and their Applications**.
Supervisor: Dr. Sutanu Roy, School of Mathematics, National Insitute of Science Education and Research.

- Studied about Banach Spaces, Continuous and Contraction Mappings, Banach Fixed Point theorem, Operators on Hilbert Space, Orthonormal Systems and Fourier Series.
- Explored a more practical application of the theorem in the *world of art and photography.* (Mise en Abyme).
- Presented my study in a talk towards the end of the project.[Report]

December 2018 **Differential Geometry via Differential forms**.
Supervisor: Prof. Urjit Yajnik, Dept. of Physics, IIT Bombay.

- Studied Differential Forms, integration of forms, exterior derivatives and pullbacks.
- Explored a more General proof of Stokes theorem for Diff. Forms and it's applications in Electrodynamics. Also motivated basic notion of DeRham Cohomology.

# Achievements

## Academic awards

2019 Received **Institute Academic Prize** for the highest SPI (Semester Performance Index) in physics department for the year 2018-2019.

2019 Ranked *3rd* in a batch 42 students in Physics Department.

2019 Secured *AP* grade in the course *MA -214 Introduction to Numerical Analysis* for excellent performance. Awarded to top 1% students in a course.

2017 Secured *99.62* percentile in JEE-ADVANCED 2017 among 200,000 applicants.

2017 Secured *All India Rank 17* in NEST 2017, an exam conducted for admission to prestigious institutes of basic sciences such as CBS,Mumbai and NISER, Bhubaneswar.

## Olympiads

2017 Was among the *top 400* among a total of 40,000 students, selected to appear *INCHO* (Indian National Chemistry Olympiad).

2015 Qualified *KVS-RMO(Regional Mathematics Olympiad)* and was among the top 50 students from all over the country to attend a 10 day long INMO (Indian National Mathematics Olympiad) preparatory camp.

## Scholarships

2017 Awarded *KVPY (Kishore Vaigyanik Protsahan Yojana) scholarship by* Department of Science and Technology, INDIA for identifying exceptional talent and promoting careers in basic sciences among high school students. Secured All India Rank 342 among 50,000 applicants.

# Course Projects

April 2019 **Optical Tweezers - What, How and Why?**, *Course: EP226*, Waves and Oscillations.
Supervisor: Prof. Tapanendu Kundu, Dept. of Physics, IIT Bombay.

- Explored the principle behind working of optical tweezers, considering both effects of Rayleigh scattering and gradient forces with applications to entrapment of micro spheres.
- Suggested a possible use in differential separation of certain cells on account of their distinct refractive indices. Gave a presentation on other novel uses in cell biology, cold atom entrapment and gene manipulation. [Slides]

August 2018 **Small World Networks**, *PH542*, Non-Linear Dynamics.
Supervisor: Prof. Punit Parmananda, Dept. of Physics, IIT Bombay.

- Studied about the world wide phenomenon of *Six Degrees of Separation*, it's origin and analogous notion of collaboration distance in research papers.
- Presented the *Watts-Strogatz Model*, effective at explaining low geodesic distance in a directed graph and it's modification to the *Inverse square network* to model decentralized search.
- Gave a presentation on the same which also included other applications of Non-Linear Dynamics such as Fractals, Chaos Games etc.[Slides]

## Presentations

August 2018 **Fractals**.
Course: PH542 Non Linear Dynamics
- We gave a presentation covering the basics of fractals, fractional dimension, various methods to calculate dimension of a fractals and a general idea of Hausdroff Dimension.

September 2018 **A Microscope for the Fixed Point**.
Maths and Physics Club, IIT Bombay
- I discussed about *Fixed Point theorems*, some simple proofs and known applications in ODE's and numerical computation, particularly in *Google's Page Rank Algorithm.*

## Organisation and Leadership

May - June 2019 **Teaching Assistant**, *Course: PH108 Basics of Electricity and Magnetism.*
Instructor: Prof. B.K. Nandi, Dept. Of Physics, IIT Bombay.
- Responsible for conducting *Tutorial Sessions* for a batch of over 35 students throughout the course and helped them clear conceptual doubts through personal interaction.
- Assisted in correction of answer sheets and selecting relevant practice problems.

April 2019 - Present **Manager, Maths and Physics Club, IIT Bombay**.
- Leading a Team of 5 conveners to foster enthusiasm in mathematics and physics, tending to a community of 400 - 500 in campus with an online presence of over 8000.
- Supervised the Conduction of Summer Of Science 2019, a novel initiative through which over 400 students got an opportunity to purse reading project in a topic of their interest, under the guidance of over 120 student senior mentors .
- Conducted frequent visits to public lectures by TIFR, Mumbai and currently involved in organising several institute-wide competitions, lab visits, talks and group discussions to promote interest in Sciences.

## Key Courses Taken

**Mathematics** - Real Analysis, Basic Algebra, Complex Analysis, Multivariate calculus, Linear Algebra, Partial Differential Equations, Numerical Analysis.

**Physics** - Quantum Mechanics - I,II and III(Relativistic), Nonlinear Dynamics, Special theory of Relativity, Classical Mechanics, Electrodynamics, Waves and Oscillations, Thermal Physics, Photonics.

**Others** - Psychology, Digital Systems, Data Analysis and Interpretation, Electronics Lab - Microprocessors, Analog and Digital, Computer Programming and Utilization, Biology.

*to be completed by end of Autumn 2019 term.

## Technical skills

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| Languages | C++, Python, VHDL |
| Softwares | Autocad, LaTeX, Solidworks, Git, Jekyll, Arduino |
| Scientific Packages | Numpy, Scipy, Matplotlib, Pandas, Mathematica |