Teaching Computational Physics in Jadavpur University

Jadavpur University is located on the south fringe of Calcutta

Students come from the city (30 – 60 %)
as well as from suburban and rural areas (40 – 70 %)

Physics teaching :

Undergraduate honours level : 40 – 45

Undergraduate subsidiary courses : ~140

Undergraduate Engineering : ~1200

Postgraduate (day) : ~35

Postgraduate (evening, school teachers etc) : ~35

Undergraduate teaching includes :

2 semester course in computer applications → 2nd Year B.Sc.

Till 1999 – Introduction to **Fortran**

From 2000 – Introduction to **C**

Undergraduate teaching includes :

2 semester course in computer applications → 2nd Year B.Sc.

Till 1999 – Introduction to **Fortran**

From 2000 – Introduction to **C**

Advantage : Basic course, compulsory to all science students, interdepartmental initiative

Undergraduate teaching includes :

2 semester course in computer applications → 2nd Year B.Sc.

Till 1999 – Introduction to **Fortran**

From 2000 – Introduction to **C**

Advantage : Basic course, compulsory to all science students, interdepartmental initiative

Disadvantage : No Major-subject specific tailoring, Not enough application in the major (honours) subject

Postgraduate teaching includes :

2 semester course in Fortran Programming and
Numerical Methods → 1st Year (since 1988)

Errors in numerical computation

Solutions of equations : Bisection, Secant, Newton-Raphson Method.

Finite Differences

Newton and Lagrange interpolation

Euler method, Runge-Kutta method

Method of least squares

Matrix eigenvalues

Numerical integration : Trapezoidal and Simpson's method

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

1. Review of Fortran
2. Introduction to Mathematica

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

1. Review of Fortran
2. Introduction to Mathematica
3. Classical Mechanics

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

1 Review of Fortran

2 Introduction to Mathematica

3 Classical Mechanics – Motion of point particle, Orbits in central force field, solution of Hamilton's equation, non-linear dynamics, Bifurcations, Duffing oscillator, van-der Pol oscillator, Lorenz equation, Chaos.

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

1 Review of Fortran

2 Introduction to Mathematica

3 Classical Mechanics – Motion of point particle, Orbits in central force field, solution of Hamilton's equation, non-linear dynamics, Bifurcations, Duffing oscillator, van-der Pol oscillator, Lorenz equation, Chaos.

4 Quantum Mechanics

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

1 Review of Fortran

2 Introduction to Mathematica

3 Classical Mechanics – Motion of point particle, Orbits in central force field, solution of Hamilton's equation, non-linear dynamics, Bifurcations, Duffing oscillator, van-der Pol oscillator, Lorenz equation, Chaos.

4 Quantum Mechanics – Time evolution of wave packet, Bound state energies and wave function, scattering of wave packet at potential step.

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

5 Statistical Physics

Postgraduate teaching includes :

2 semester course : **Computer Applications in Physics** (since 1995, UGC special assistance) → 2nd Year M.Sc.

5 Statistical Physics – Random numbers and variables, Monte Carlo simulation, random walks, approach to equilibrium, Metropolis algorithm, Ising model

Impact of the course on students – some instances

Impact of the course on students – some instances

Deepak Kar – B.Sc. and M.Sc. (JU) – 2003

Feels the "Comput'l Phys" course as one of the best he had at JU

Ph. D. Univ of Florida at Gainesville, 2008.

Present : post doc at T.U., Dresden

Impact of the course on students – some instances

Deepak Kar – B.Sc. and M.Sc. (JU) – 2003

Feels the "Comput'l Phys" course as one of the best he had at JU

Ph. D. Univ of Florida at Gainesville, 2008.

Present : post doc at T.U., Dresden

Rupsi Chandra – B.Sc. (other univ) and M.Sc. (JU) – 2003

Comput'l Phys Proj: Chaos in Dynamical Systems

Ph.D. Univ of Delaware, 2008.

Present : post doc at Naval Research Lab

Impact of the course on students – some instances

Deepak Kar – B.Sc. and M.Sc. (JU) – 2003

Feels the "Comput'l Phys" course as one of the best he had at JU

Ph. D. Univ of Florida at Gainesville, 2008.

Present : post doc at T.U., Dresden

Rupsi Chandra – B.Sc. (other univ) and M.Sc. (JU) – 2003

Comput'l Phys Proj: Chaos in Dynamical Systems

Ph.D. Univ of Delaware, 2008.

Present : post doc at Naval Research Lab

Baisakhi Mal – B.Sc. and M.Sc. (JU) – 2006

Comput'l Phys Proj : Surface Growth – Ballistic-Random Deposition Process

Present : Research fellow at Jadavpur University

Impact of the course on students – social relevance

Impact of the course on students – social relevance

Maitreyi Banerjee – B.Sc. (CU) – 1987

discontinued study for raising family,

M.Sc. (JU, evening) – 2004

Presently with Lucent Technologies.

Impact of the course on students – social relevance

Maitreyi Banerjee – B.Sc. (CU) – 1987
discontinued study for raising family,
M.Sc. (JU, evening) – 2004
Presently with Lucent Technologies.

- *While studying central force orbits could not find any orbit agreeing with some shown in Goldstein.*

Impact of the course on students – social relevance

Maitreyi Banerjee – B.Sc. (CU) – 1987
discontinued study for raising family,
M.Sc. (JU, evening) – 2004
Presently with Lucent Technologies.

- While studying central force orbits could not find any orbit agreeing with some shown in Goldstein.

- *This computation inspired us to show analytically that some of the orbits presented in Goldstein are impossible.*

Impact of the course on students – social relevance

Maitreyi Banerjee – B.Sc. (CU) – 1987
discontinued study for raising family,
M.Sc. (JU, evening) – 2004
Presently with Lucent Technologies.

- While studying central force orbits could not find any orbit agreeing with some shown in Goldstein.
- This computation inspired us to show analytically that some of the orbits presented in Goldstein are impossible.
- *Some analytical results were also found for general power law forces.*

"Orbits in a central force field : Bounded orbits" - arvix.org/abs/physics/0410149v1 cited by J. T. Wheeler in Einstein Centennial Review in Canadian Journal of Physics 83(2) 2005, p91. Also in http://arXiv.org:physics/0511054

Impact of the course on students – social relevance

Anindya Chatterjee – B.Sc. Presidency College (CU) 1988.
Taught in a school
M.Sc. (JU, evening), 2004
Presently Headmaster in a Calcutta school.

Impact of the course on students – social relevance

Anindya Chatterjee – B.Sc. Presidency College (CU) 1988.
Taught in a school
M.Sc. (JU, evening), 2004
Presently Headmaster in a Calcutta school.

- Introduced to computer use in M.Sc.

Impact of the course on students – social relevance

Anindya Chatterjee – B.Sc. Presidency College (CU) 1988.
Taught in a school
M.Sc. (JU, evening), 2004
Presently Headmaster in a Calcutta school.

- Introduced to computer use in M.Sc.
- Implemented computer laboratory (12 computers) in school with assistance from alumni and NGO.

Impact of the course on students – social relevance

Anindya Chatterjee – B.Sc. Presidency College (CU) 1988.
Taught in a school
M.Sc. (JU, evening), 2004
Presently Headmaster in a Calcutta school.

- Introduced to computer use in M.Sc.
- Implemented computer laboratory (12 computers) in school with assistance from alumni and NGO.
- Introduced a Computer Applications course for school students. It is an optional course at secondary level in WB .
- Students can also play with applets as an aid to their school books.

Limitations :

Our courses teach standard methods without handling some of the tricky (critical) questions from students.

Limitations :

Our courses teach standard methods without handling some of the tricky (critical) questions from students.

1. Why does the same program give different results when run on different machines ?

Limitations :

Our courses teach standard methods without handling some of the tricky (critical) questions from students.

1. Why does the same program give different results when run on different machines ?
2. How much time will my program take ?

Limitations :

Our courses teach standard methods without handling some of the tricky (critical) questions from students.

1. Why does the same program give different results when run on different machines ?
2. How much time will my program take ?
3. How do I calculate the factorial of a large number ?

Limitations :

Our courses teach standard methods without handling some of the tricky (critical) questions from students.

1. Why does the same program give different results when run on different machines ?
2. How much time will my program take ?
3. How do I calculate the factorial of a large number ?
4. After a curve fitting / interpolation, how do I estimate the error inherent (error bars) ?

Limitations :

Our courses teach standard methods without handling some of the tricky (critical) questions from students.

1. Why does the same program give different results when run on different machines ?
2. How much time will my program take ?
3. How do I calculate the factorial of a large number ?
4. After a curve fitting / interpolation, how do I estimate the error inherent (error bars) ?
5. How good are my random numbers ? (Chi sq. test etc.)

These limitations - **not unique** to computer applications :

These limitations - not unique to computer applications :

1. Quantum Mech –
   i) Do we really need ***Hilbert spaces***? Is linear space enough?

These limitations - not unique to computer applications :

1. Quantum Mech –
   i) Do we really need Hilbert spaces? Is linear space enough?
   ii) Do we need ***Hermitian operators*** just to ensure real eigenvalues, or are there deeper reasons ?

These limitations - not unique to computer applications :

1. Quantum Mech –
   i) Do we really need Hilbert spaces? Is linear space enough?
   ii) Do we need Hermitian operators just to ensure real eigenvalues, or are there deeper reasons ?
   iii) Is bra vector just an adjoint (transpose conjugate) of ket ?

2. Statistical Mechanics –
   i) ***Product of an increasing and a decreasing function*** has a maximum. Is that always true ?

These limitations - not unique to computer applications :

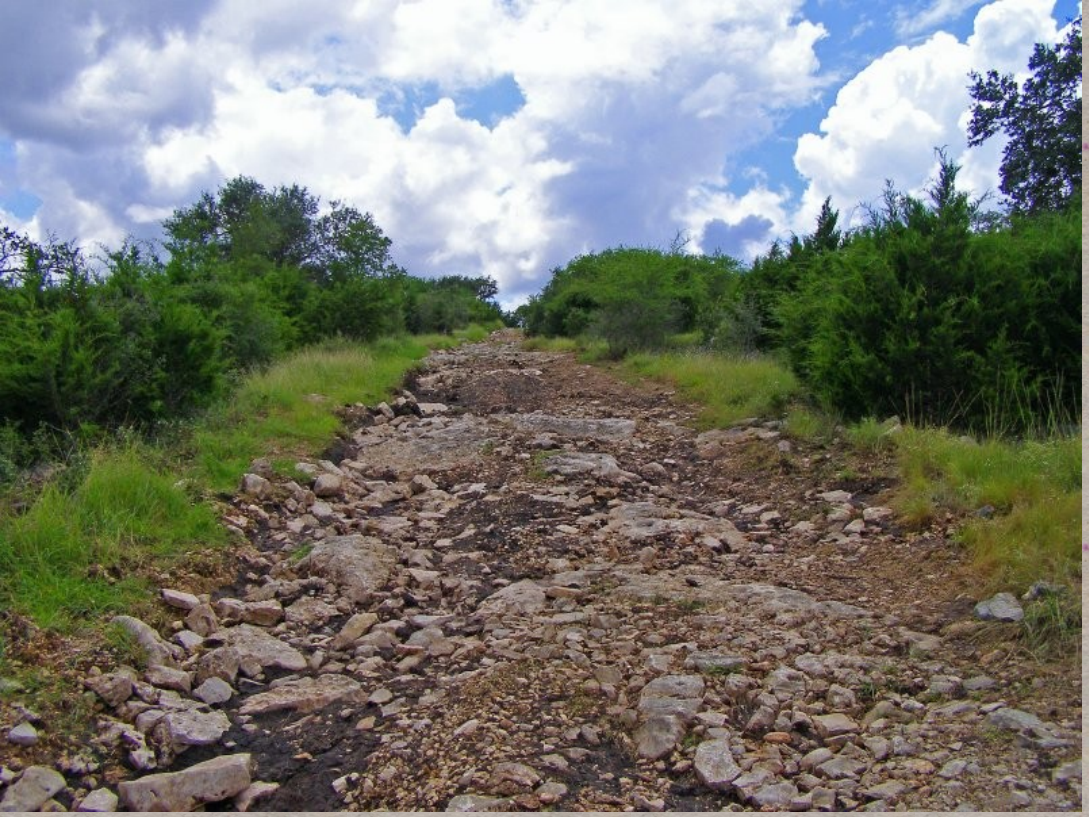
1. Quantum Mech –
   i) Do we really need Hilbert spaces? Is linear space enough?
   ii) Do we need Hermitian operators just to ensure real eigenvalues, or are there deeper reasons ?
   iii) Is bra vector just an adjoint (transpose conjugate) of ket ?

2. Statistical Mechanics –
   i) Product of an increasing and a decreasing function has a maximum. Is that always true ?

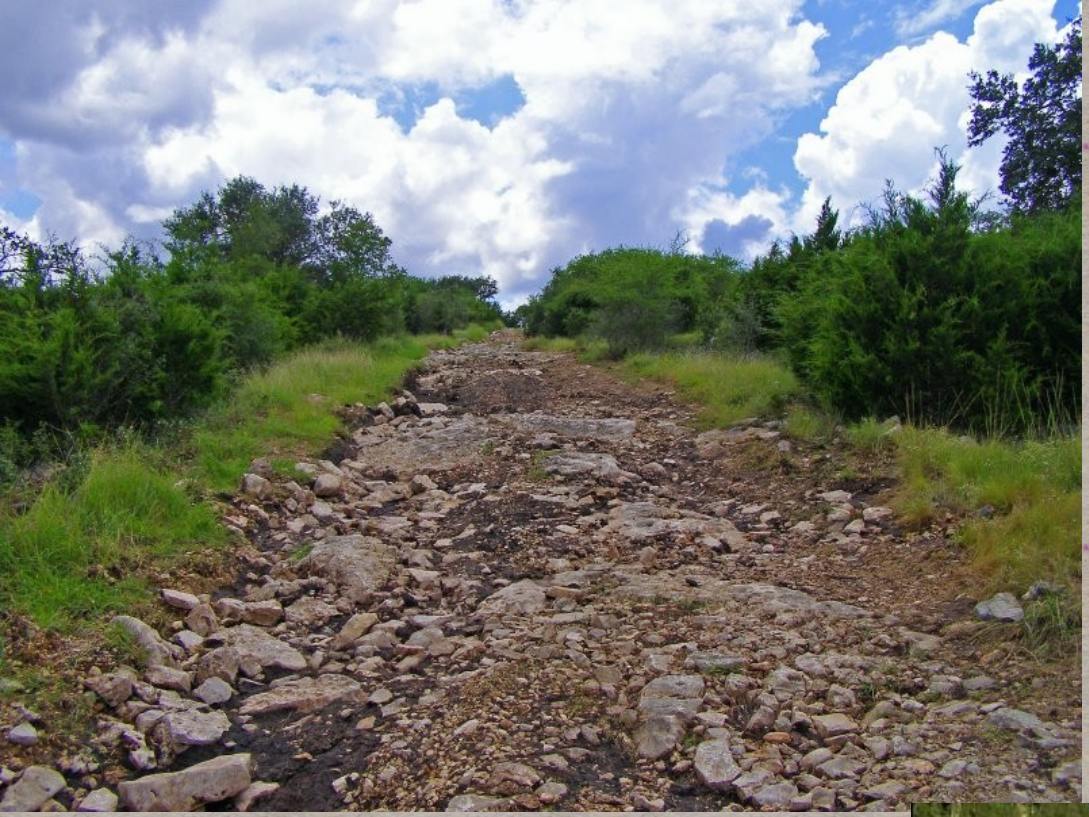
3. Classical mechanics –
   i) How do we define virtual displacement ?
   Is principle of zero virtual work a definition (it is not), or an additional condition on the system of virtual displacements ?

What do I expect from a meeting like the present one :

- Exchange experience and ideas (may continue through email)
- Discuss common core curricula
- Evolve realistic and effective method of feedback from students
- Hold discussion sessions for continuous improvement in future



Learning physics is sometimes like traversing a rough road through beautiful places.



Learning physics is sometimes like traversing a rough road through beautiful places.

There will always be twists and turns, but a paved road can lead to more exotic beauty of nature.