Course Paper Program

in Research-Oriented Instruction

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Nanjing University
2015.08.11
Outline

1. Background
   - My course: University Physics
   - Textbook: published by Springer Verlag Germany CBS India HEP China
   - Students: Physics major + non-physics major

2. Statistics and samples
   - Number of papers
   - Some titles of course paper from NJU & THU
3. Course paper program

Four effects:

- Training for future researchers
- Reference platform for cross-disciplinary development
- Learn to switch between pedestrian/expert
- Change style of study

Two emphases

- DIY mode of topics finding
- Correct and scientific citation

4. Conclusion
1. Background

**Course:** University Physics

*Two semester*

*Calculus-based*

*Introductory physics course*

*Teach in Nanjing University (NJU) and 2003, 2005, 2007 in Tsinghua University (THU)*

Coursepaper program is arranged through two semesters: one for proposal and another for paper.
Textbook

University Physics
Second Edition
Dexin Lu

Springer-Verlag
Germany

CBS India

HEP China

HEP China

University Physics
New edition

- knowledge + training
- Optics

Method of teaching/learning
Physics
System: knowledge + training
Nanjing University

Kuang Yaming Honors School
(School of Fundamental Sciences)

Division 1
- Astronomy
- Physics

Division 2
- Atmosphere
- Geography
- Geology

Division 3
- Life Sciences
- Chemistry

Dept II
- Sciences
- LL, His, Phi

Students

background
Tsinghua University 2003

Students:
- Hydraulic: 1
- Environment: 2
- Chemistry: 18
- Life science: 33
- Physics: 51
- Mathematics: 36
- Electronic: 1
- Software: 1
Course paper of *University Physics* in NJU and THU

<table>
<thead>
<tr>
<th>Academic year</th>
<th>NJU</th>
<th>THU</th>
</tr>
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<tbody>
<tr>
<td>1989-2005</td>
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<tr>
<td>2005-2006</td>
<td>563</td>
<td>257</td>
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<td>2006-2007</td>
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<td>2007-2008</td>
<td>341</td>
<td>60</td>
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<td>2008-2009</td>
<td>390</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>6627</strong></td>
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</table>

2009 We won a national prize, since then we do not make data open again.
<table>
<thead>
<tr>
<th>Class 91</th>
<th>SHI Leiming</th>
<th>On effect of <strong>gravitational retardation</strong> on motion of stars</th>
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<tbody>
<tr>
<td>Class 92</td>
<td>WANG Jun</td>
<td><strong>Visual appearance of moving objects with high speed</strong></td>
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<tr>
<td>Class 93</td>
<td>CHENG Xuemei</td>
<td>Explanation of the relation between static <strong>friction</strong> and normal, contact area by <strong>fractal theory</strong></td>
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<td>Class 93</td>
<td>YANG Chengyong</td>
<td><strong>Comet collides Jupiter</strong></td>
</tr>
<tr>
<td>Class 97</td>
<td>YU Hao (Geology)</td>
<td>Design of <strong>measurement of ( g )</strong> by laser confinement of atoms and its geophysical significance</td>
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*Steven Zhu 1997*
<table>
<thead>
<tr>
<th>Class</th>
<th>Name</th>
<th>Subject</th>
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<tr>
<td>Class 97</td>
<td>WANG Junfeng</td>
<td>Astronomy</td>
<td>Reverse Compton Scattering and ICS Model of Radiative Pulsar</td>
</tr>
<tr>
<td>Class 97</td>
<td>Kong Dong</td>
<td>Biochemistry</td>
<td>Changeable Demons—Computer Imitation of Fractals in Biology</td>
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<td>Class 98</td>
<td>CHEN Ming</td>
<td>Geography</td>
<td>7-Fold Symmetry</td>
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<tr>
<td>Physics 31</td>
<td>ZHANG Chi</td>
<td>Assumption of spacetime quantization and difference Schrödinger equation</td>
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<td>Science 31</td>
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<td>Visual Feature and Color of High Speed Moving Objects</td>
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<td>Science 32</td>
<td>YAN Wenbin</td>
<td>Semi-modern description of gravitation wave</td>
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<tr>
<td>Science 33</td>
<td>HU Jue</td>
<td>Proportion Between Tree Height, Trunk Diameter and Growth Ring and its Spreading</td>
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<tr>
<td>Physics 31</td>
<td>FAN Bo</td>
<td>On nozzle emendation in ancient Chinese temperament</td>
<td></td>
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<tr>
<td>Subject</td>
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<td>Title</td>
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<tr>
<td>Biology</td>
<td>LIANG Jun</td>
<td>On dissonances</td>
<td></td>
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<tr>
<td>Biology</td>
<td>XIE Xie</td>
<td>Comparison between timbre of piano and Chinese zither</td>
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<tr>
<td>Physics</td>
<td>WANG Ziyan</td>
<td>Backhand sleight for pen-hold grip player in table tennis</td>
<td></td>
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<tr>
<td>Math</td>
<td>BENG Zixiong</td>
<td>Canyon effect</td>
<td></td>
</tr>
<tr>
<td>Science</td>
<td>LEI Peng</td>
<td>The Dust Trail and the Entropy</td>
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</table>
Dalitz plot

Falling cat
3. Course paper program

Four effects of Course Paper Program:

- *Future researchers receive comprehensive training, their CNS publications.*
- *Mixed (major) class students get a reference platform of cross-disciplinary development.*
- *Students learn to switch their perspective between pedestrian/expert, appreciate more colorful life and beautiful physics.*
- *Students change their style of study*
1. *Future researchers receive comprehensive training, their CNS publications.*

Course paper program provides strong background for future researchers: knowledge, consciousness of innovation, skill training etc. Most of our students can easily join research items in their junior and senior years. Many of them affirm that their research consciousness or research career started since then. After entering graduate period they can work well and publish papers. Some of them have CNS publications.
Junjun Wu et al.

Control of Energy Transfer in Oriented Conjugated Polymer-Mesoporous Silica Composites

Three papers in single issue *Science*

Xiaoshan Xu$^{1997}$, Shuangye Yin$^{1997}$ et al.  
*Ferroelectricity in Free Niobium Clusters.*  
*Science* 300(2003)1265

Xuemei Cheng$^{1997}$ et al.  
*Deformation Twinning in Nanocrystalline Aluminum.*  
*Science* 300(2003)1275

Congjun Wang$^{1999}$ et al.  
*n-Type Conducting CdSe Nanocrystal Solids*  
*Science* 300(2003)1277
Fei Sun Class 2001

Crystal Structure of Mitochondrial Respiratory Membrane Protein Complex II

_Cell_, 121-7 (2005), 1043-1057

Fei Sun¹,², Xia Huo², Yujia Zhai¹, Aojin Wang², Jianxing Xu², Dan Su¹, Mark Bartlam¹,² and Zihe Rao¹,²

¹Tsinghua-IBP Joint Research Group for Structural Biology, Tsinghua University, Beijing 100084, China
²National Laboratory of Biomacromolecules, Institute of Biophysics (IBP), Chinese Academy of Sciences, Beijing 100101, China
Both the Establishment and the Maintenance of Neuronal Polarity Require Active Mechanisms: Critical Roles of GSK-3β and Its Upstream Effectors

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Beijing 102206
China
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Northwestern University Feinberg School of Medicine
303 E. Chicago Avenue, Ward 10-185
Chicago, Illinois 60611

Summary

Axon-dendrite polarity is a cardinal feature of neuronal morphology essential for information flow. Here we report a differential distribution of GSK-3β activity in the axon versus the dendrites. A constitutively active GSK-3β mutant inhibited axon formation, whereas multiple axons formed from a single neuron when expressed in the dendrites. The cell-autonomous requirement for GSK-3β in axon formation is mediated by the forkhead transcription factor FOXA1. In contrast, activation of the axon requires the upstream regulators cAMP and protein kinase A (PKA). The cAMP-PKA signaling pathway regulates cytoskeletal dynamics and promotes axon differentiation, whereas the GSK-3β signaling pathway antagonizes these processes. These findings reveal that opposing regulatory mechanisms control axon and dendrite formation.
Interaction with Vesicle Luminal Protachy Regulates Surface Expression of δ-Opioid Receptors and Opioid Analgesia

Ji-Song Guan1,3,7 Zhen-Zhong Xu,1,3,7 Hua Gao,2 Shao-Ou He,1 Guo-Qiang Ma,2 Tao Sun,1 Li-Hua Wang,1 Zhen-Ning Zhang,2 Isabelle Lena,6 Ian Kitchen,6 Robert Elde,5 Andreas Zimmer,4 Cheng He,1 Gang Pel,2 Lan Bao,2 and Xu Zhang1,*,

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School of Biomedical and Molecular Sciences
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Guildford
Surrey GU2 7XH
United Kingdom

Introduction

The opioid system serves to modulate pain transmission. δ- and μ-opioid receptors are members of the superfamily of G protein-coupled receptors (Noble et al., 1992; Thompson et al., 1998b). δ-opioid receptors are found in the rodent small dorsal root ganglion neurons, where they might modulate the effects of endogenous opioids. Interestingly, while μ-opioid receptors (MORs) are transported along the constitutive pathway (Zhang et al., 1998a), δ-opioid receptors (DORs) are sorted into the regulated pathway and are often found to be associated with large dense-core vesicles (LDCVs; Cheng et al., 1995; Zhang et al., 1998b), secretory granules with electron-opaque content. Furthermore, plasmamembrane insertion of DORs can be triggered by DOR-agonist-induced or nociceptive stimulus-induced Ca²⁺ influx that causes exocytosis of LDCVs (Bao et al., 2003), consistent with the presence of DORs in the regulatory pathway. Since newly synthesized cell-surface receptors are in general sorted into microvesicles of the constitutive pathway and inserted into the plasma membrane by spontaneous exocytosis, some cellular mechanisms must be present to sort DORs into LDCVs for regulated surface insertion.

Sorting signals have been identified for some membrane proteins of secretory granules, such as that found in the cytoplasmic domain of P-selectin (Disdier
Jun Lu Class 1997

*MicroRNA expression profiles classify human cancers*


doi: 10.1038/nature03702
Jun Wang and Wei Wang,
A computational approach to simplifying the protein folding alphabet
Nature Structural Biology, 6(1999), 1033-1038,
A computational approach to simplifying the protein folding alphabet

Jun Wang and Wei Wang

National Laboratory of Solid-State Microstructure and Department of Physics, Nanjing University, Nanjing 210093, People’s Republic of China.

What is the minimal number of residue types required to form a structured protein? This question is important for understanding protein modeling and design. Recently, an experimental finding by Baker and coworkers suggested a five-residue solution to this problem. We were motivated by their results and by the arguments of Wolynes to study reductions of protein representation based on the concept of mismatch between a reduced interaction matrix and the Miyazawa and Jernigan (MJ) matrix. We find several possible simplified schemes from the relationship of minimized mismatch versus the number of residue types (N = 2–20).

As a specific case, an optimal reduction with five types of residues has the same form as the simplified palette of Baker and coworkers. Statistical and kinetic features of a number of sequences are tested. Comparison of results from sequences with 20 residue types and their reduced representations indicates that the reduction by mismatch minimization is successful. For example, sequences with five types of residues have good folding ability and kinetic accessibility in model studies.

The heterogeneity of 20 types of amino acid residues and the diversity of different protein structures introduce complexity into protein folding. Much effort has been made by considering “minimalists” models with a small number of residue types to simplify this complexity. To allow interpretation of some features of protein folding, the hypothetical interactions in these minimalist models are much simpler than the real ones. Physically, this means that 20 types of residues (the natural set of residues) are grouped, approximately according to similarities in their physical and chemical properties. Each group can be regarded as a type of monomer, and can be represented by a letter. Consequently, the matrix of interaction between residues can be reduced to one with a small dimension (Fig. 1a). The simplest reduction scheme is the HP model (where H stands for hydrophobic and P for polar), which consists of only two letters and considers hydrophobicity as the only driving force.

Experimentally, some specific patterns of amino acid composition have been discovered in the reconstruction of secondary structures, such as binary patterns in α-helices and β-sheet bundles. Recently, Baker and colleagues successfully built the well-ordered S13 domain with five types of amino acids. These results indicate that it is possible to depict structural characteristics of proteins with a reduced set of amino acids. Furthermore, combinatorial studies by Baker et al. suggest that five or more types of residues seem necessary for a foldable protein. Indeed, even in previous experimental studies of HP patterns, more than two types of residues were required for successful building of protein structure. Therefore, more detailed patterns than the simple two-letter HP forms should be explored for better description of proteins.

Different simplified schemes, such as the HP and multi-component models, in which each monomer has multiple choices of type, have been considered in theoretical studies. As argued by Wolynes, the theoretical energy landscape for the two-letter cases has many local traps and does not have a steep funnel, features that could slow the folding process. The fact that many proteins have fast folding characteristics implies that some complexity of natural proteins is not embodied in the HP model. To encode a wide range of structures and properties of proteins, multi-component schemes are recommended. However, a number of questions remain unanswered. First, how should one reduce the 20 types of residues in order to simplify the description? Second, how many types are necessary in the minimalist models? Third, what is the physical origin of the reduction in these minimalist models?

Reduced representation by grouping of residues

Let us introduce a general method for reducing the representation of proteins by the grouping of residues. A reduction algorithm, which connects different representations of a protein generally rests on the idea that residues (or monomers) can be distributed into several groups, each of which has different physical and chemical properties, and thus, different interactions. For a successful reduction, the interactions between monomers of the two groups, say group A and B, should have similar characteristics.

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>AA</td>
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<td>EE</td>
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</table>

Fig. 1 A general view of reduction. Residues are put into A groups, such as A, B, C, D, and E, and they are marked at A11 (T, L, S, G, and so forth). The matrix of interactions between residues with 20 = 20 elements is reduced to one with 5 × 5 blocks, which reflects the interaction between groups. Because of its symmetry, only the grey area is considered.
2. Mixed (major) class students get a reference platform of cross-disciplinary development.

Our physics course paper program provide a platform, different major students can exchange their ideas there, helping students construct their cross-disciplinary structure of knowledge.
For example, Fei SUN (class 2001 physics) is now one of head scientists in Institute of Biophysics, CAS. While Hao YU, (class 1997 geology) simply moves to physics for his graduate study. His course paper of g-measurement ranked the best one in class.

I suppose my colleagues here would like to see how physics attracts non-physics major students and how physics percolates to other fields.
3. Students learn to switch their perspective between pedestrian/expert, appreciate more colorful life and beautiful physics.
For example you may appreciate Snooker Games, and meanwhile consider the mechanics problem in it.

e.g. collision between rotating cue ball and snooker ball seems not to be a solved problem yet.
You can attend concert and appreciate piano play, you can also study **chords** in Chopin’s music, standard or non-standard.
You can attend concert and appreciate piano play, you can also study **chords** in Chopin’s music, standard or non-standard.
If physics can let people feel life is more colorful and physics is beautiful, what do you think? Is it great?
4. More or less, students change their style of study

In class you may tell students:

- who discovered the law,
- what is the original paper,
- other references,
- what problem left and so on.

They can more easily accept if they have the experience of course paper and they will take initiative. If students can actively query, inquiry, an instructor may judge that they are better learners.
3. Course paper program

Four effects of Course Paper Program:
Two emphases

- **DIY mode of topics finding**
- Correct and scientific citation

We put the topics finding as a part of training. It is the fundamental requirement of our program. It is necessary for the situation in China. We know China has a great population, but did you know how large a class here could be? I show you a class of mine.
It is indeed the scene of course paper seminar, class 2006. Let’s see the podium and the moderator.
1. 陆明(物): 太阳振动时月球绕地公转的影响
2. 丁晓辉(理): 关于潮汐力的进一步研究
3. 王展(生): Basic Hydromechanics Equation in Special Relativity
4. 李晓(理): 电吉他演奏的物理研究
5. 王力(生): 关于弹簧振子系统的一些研究
6. 沈成(理): 二维简谐振动与有关力场运动
7. 奥(程): 乒乓球器材中的力学原理
8. 谢基伟(理): 另一个角度看红移
3. 孙庆(程): The Rotation of the Moon and problems on the Venus
We put the program in Research-Oriented Instruction (ROI) environment. My colleagues and I tell stories of discovery. We show students about critical thinking, our inquiry and impact to traditional contents, master’s blunder, and so on. All these might help students to challenge existing results and authority too.

We never offer students topics directly. Instead we provide them methodology:

a) Normal procedures
b) Other often used ways
c) Special maneuver
a) Normal procedures:

- find phenomena you feel *interesting*,
- extract its *kernel physics* and the *keywords*
- search & browse and construct the primary topic
- lookup references to *confirm* the topic is reasonable
b) Other often used ways:

- reverse (e.g. inverse Compton effect)
- change dimensionality (scale)
- combination
- transplant (e.g. fractal-friction)
- from experiments
- from hobbies
- from topics done
c) *Special maneuver*

We know in our textbooks there are many examples, models. They are all simplified. If we remove some condition(s) of simplifying, we can obtain a real object.

For example, from *simple pendulum* we can obtain thousands of *physical pendulums*.

What is a simple pendulum?
inextensible

small

light

soft

no damping

in inertial system

$m$ fixed

$r \ll \ell$
Remove or change any one or some condition(s) we get a real problem. For example, we can have elastic pendulum, sandglass pendulum, many physical pendulum, rope pendulum....

Totally we have:

\[ C_8^1 + C_8^2 + C_8^3 + C_8^4 + C_8^5 + C_8^6 + C_8^7 + C_8^8 = ? \]

\[ 2^8 - C_8^0 = 255 \]
Besides we can have more subjects, but trivial:

different initial conditions
motion in two perpendicular planes
\textit{charged bob}

\ldots

One of my students (GE Xiao) found a meaningful topics from those trivial ones. \textit{He put charged bob in magnetic field and found that Lorentz force and Coriolis force are of same math structure. Then he wrote a paper of electromagnetic Foucault pendulum.}

We emphasize that any topic proposal should be confirmed through reference.
Correct and scientific citation

Correct citation and online citation of reference are necessary for paper and confirm of the proposal. It is scientific regulation and related to ethics. Lack of correct citation the author could be considered academic misconduct, e.g., plagiarism.

We choose a Nature paper of stone-skipping as an example to show students the real way of citation.
4. Conclusion

Course paper program in introductory physics course is feasible and works well. It is very effective to engage students in physics.

Our program is not carried out alone. It is a part of ROI, and exhibits the effect of ROI best. In our ROI strategy many session can be a kind of training. For example, problem-exercise could be very good training occasion.

I’ll show you some example in poster session. I expect you come to discuss with me and good handout prepared for you.
Thanks

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Solutions Beyond the Normal

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Abstract: We find solutions of some problems in general physics far beyond the normal answer. Indeed many problems are not so simple as they look. So assignment can be a kind training of thinking or research.

Problem 3.4 Rotating funnel
A very small cube of mass $m$ is placed on the inside of a funnel rotating about a vertical axis at a constant rate of $\nu$. The wall of the funnel makes an angle $\theta$ with the horizontal. If the coefficient of static friction between surfaces is $\mu$, what are the largest and the smallest values of $\nu$ for which the cube will not move with respect to the funnel?


<table>
<thead>
<tr>
<th>Normal solution</th>
<th>New solution: Phase diagram</th>
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</table>

Problem 6.3 Unwinding of a tape
A length $l$ of flexible tape is tightly wound. It is then allowed to unwind as it rolls down a steep incline that makes an angle $\theta$ with the horizontal, the upper end of the tape being tacked down. Show that the tape unwinds completely in a time $t = \sqrt{\frac{Mg\sin\theta}{\kappa}}$.