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Phys. 427, 429, and 527
Senior Laboratory and Graduate Laboratory
Spring 2011

1. Instructor

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Curriculum Vita of the instructor (M.S.)

Education: Ph.D. (March 1977) Physics, University of Tokyo, Japan

Positions held

Professor, Department of Physics, State University of New York at Binghamton, Binghamton, New York 13902-6000 (9/86 – present)
Visiting Professor, Institute for Molecular Science, Myodaiji, Okazaki 444, Japan (8/92 - 12/92)
Visiting Scientist, Schlumberger-Doll Research, Ridgefield, Connecticut 06877 (11/85 - 8/86)
Visiting Research Assistant Professor, Department of Physics, University of Illinois at Urbana-Champaign, Urbana, Illinois 61801 (7/84 - 8/86)
Research Associate, Department of Physics, Ochanomizu University, Tokyo, Japan (4/77 - 8/86)

2. Text book

R.A. Dunlap, "Experimental Physics Modern Methods," Oxford University Press 1988 (as reference)

(This book is relatively old. However, many universities in the U.S. like to use this as a standard textbook.)

Mathematica 8.0	(free)
Kaleidagraph	(free) You can make a copy of KG3.5 program in your computer.

3. Classes

Monday:	1:10 PM –	2:10 PM	(lecture and oral talk)
	SII G-48		
Wednesday	12:00 PM –	3:30 PM	(experiments)
	SII 5-th floor		
Friday	12:00 PM –	3:30 PM	(experiments)
	SII 5-th floor		

4. Topics of experiments

The Course includes the following experiments.

Cavendish experiment (determination of the gravitational constant *G*)
x-ray diffraction (Cotts' Lab)
Lock-in amplifier (understanding the principle of lock-in amplifier)
Hall effect by van der Pau method (not working)
Quantum analog (new experiment)
Resistivity and Hall effect of bismuth Bi
Resistivity of high temperature superconductor $YBa_2Cu_3O_7$
Nuclear magnetic resonance
Differential scanning calorimetry (Cott's Lab).
Superconducting transition of Sn (required)
Superconducting tunneling (not working)
Optical pumping of Rb
Stern Gerlach experiment (not working)
Optical fiber
Fourier optics
Zeeman effect (newly improved)
Matrix optics
Modern interferometry (new experiment)
Holography
Faraday rotation
Mr. SQUID: Josephson effect
Young's double slit experiment
Photon correlation spectrometer
SQUID (superconducting quantum interference) (not working)
Mutual inductance using digital lock-in amplifier
Muon decay measurement (time dilation in special relativity)
Critical behavior of dielectric constant in TGS

((**Note**))

I have been taught this class since 1995. There are many topics ranging from classical mechanics to quantum mechanics, special relativity. Some topics are relatively simple for you to get good data, while some topics related to the quantum mechanics (in particular NMR and optical pumping of Rb) are hard for you to figure out the underlying physics.

I hope that you pick up the challenging topics such as NMR and optical pumping as your choice of topics.

To be fair, I will give you some credit (bonus point), if you choose such challenging experiments. For example, I will give you enough time to do the experiments (one month). One challenging experiment is equivalent to the two experiments on easier topics. You will also have some credit (bonus point) for the Report.

Some experiments such as TGS and resistivity of high temperature superconductor are developed by Mark and me. If you choose such experiments, I will also give you some credits (bonus). I think that you will have the same experience as researchers who do the research in the Laboratory. Your idea and inspiration are significant in doing such experiments. Even if you do not obtain good result, you will receive some credit for your effort during the experiments.

5. Requirement

Students (graduate Lab **Phys 527**) usually choose 4 topics from 21 topics and one extra topic (superconducting tin). No collaboration work is suggested. They need to submit 5 reports for five experiments. 4 credits.

Students (Senior Lab **Phys 429**) usually choose 4 topics from 21 topics. No collaboration work is suggested. They need to submit 5 reports for five experiments. 4 credits

Students (Senior Lab **Phys 427**) usually choose 2 topics from 21 topics and one extra topic (superconducting tin). No collaboration work is suggested. They need to submit 3 reports for three experiments. 2 credits.

((Requirement))

One topics (superconducting tin, determination of the critical temperature and critical field).

> Each student is required to pick up this experiment. In this experiment, two students work together for the same experiment. It will take only 2 -3 hours (just one day). Mr. Brinkman will transfer the liquid He into the cryostat of the superconducting tin experiments. By pumping the liquid He in the cryostat, the temperature of tin as a sample will be decreased from 4.2 K to 1.5 K. The tin was surrounded by the coil with inductance. The coil and the capacitance (in the measurement box at room temperature) form a tank circuit with some characteristic frequency. This frequency drastically changes when the superconducting state of tin is destroyed by the application of the magnetic field above a critical field (temperature dependent).

Oral talks

They also need to give at least 2 oral talks (15 minutes) on the Monday's classes.

The reports are typed by using computers. Figures should be also prepared by computers. The written reports are assumed to be submitted within two weeks after the

experiments are completed. It is suggested that students use the Power Point for the preparation for the Oral Talks.

6. Report

It is suggested that Reports should be written along the instruction for writing papers in the Physical Review. It consists of

1. **Abstract**
2. **Introduction**
3. **Theoretical Background**
4. **Experimental Procedure**
5. **Result**
6. **Discussion**
7. **Conclusion**
8. **References**
9. **Acknowledgment**

Result and discussion are the main part of the report. Discussion should be carefully made based on the experimental results. Experimental uncertainty should be discussed by methods such as the least squares fitting (Mathematica, Kaleidagraph).

7. Evaluation

The evaluation was made based on the following. The total points are 900 (or 800) points:

Attendance (100 points)
Experimental behavior (100 points)
Five Reports (500 points) or three reports (300 points)
Two oral talks (15 minutes) (200)

For Phys.429/Phy.527, 4 regular experiments + superconducting tin experiment
(total five reports)
For Phys.427. 2 regular experiments + superconducting tin experiment
(total three reports)

You may need more than 90 % of the total points to get a grade A.

8. Use of Blackboard in the Binghamton University

Students of this Course can get an easy access to the Blackboard of the University. They can get any kind of information needed for their experiments. The advantage of the Blackboard is that once the documents are on the Blackboard, we are no longer worried about losing them.

The Blackboard include

1. Instruction manuals of the Binghamton University
2. Instruction manuals of the other Universities as a reference

3. Conversion tables such as magnetic field vs current for magnets
4. Physics constants (NIST)
5. Link to the Web sites
6. Typical examples of reports by students in the past
7. Typical examples of power point for oral talks in the past
8. Instructor's lecture notes on topics and discussion by the Instructor
9. Programs of Mathematica 8.0 made by the Instructor.
10. pdf forms of Feynman Physics (vol. 1, 2, 3), Purcell (electricity and magnetism), and Kittel (Mechanics).
11. Lecture notes (Phys.131 an d 132, Introductory physics, Phys.474 and Phys.514, Mathematical physics, and Phys.468, Computational Physics (Mathematica program).

9. Analysis of experimental data

Students can use two PC computes in the laboratory, which are connected to the Internet network. We have Mathematica 8.0 and Kaleidagraph 4.0. The program of Kaleidagraph can be extensively used by students: to analyze the data and to get least squares fitting of the data to the theoretical prediction.

10 users in the Physics Department will be able to use Kalaidagraph 4.0. If you want to use, contact Mark or Sei.

10. Use of Internet

It is strongly suggested that students study the background of their experiments using the Internet (**Google, Google Scholar**, and so on).

11. Examples of Reports

I put examples of the Reports (by BU students) in the BlackBoard. So you may learn how to write Reports from these examples.

12. Schedule of experiments

Schedule of classes (Spring 2011)

Due date for the report of superconducting tin experiment. two weeks after the experiment is finished.

	Date	Topics
Week-1	24-Jan M	Lecture-1 (guidance, safety by Mark)
	26-Jan W	Exp-1
	28-Jan F	Exp-1
Week-2	31-Feb M	Lecture-2 (x-ray safety by Jim Brownridge)
	2-Feb W	Exp-1
	4-Feb F	Exp-1

Week-3	7-Feb M	Lecture-3
	9-Feb W	Exp-1
	11-Feb F	Exp-1
Week-4	14-Feb M	Lecture -4
	16-Feb W	Exp-1
	18-Feb F	Exp-2
Week-5	21-Feb M	No class (President's Day)
	23-Feb W	Exp-2
	25-Feb F	Exp-2
		Due Date of the Report for Exp-1, 4:00PM
Week-6	28-Mar M	Oral talk-1 (15 minutes, using PPT)
	2-Mar W	Exp-2
	4-Mar F	Exp-2
Week-7	7-Mar M	Oral talk-2
	9-Mar W	Exp-2
	10-Mar F	Exp-2
Week-8	14-Mar M	Oral talk-3
	16-Mar W	Exp-3
	18-Mar F	Exp-3
		Due Date of the Report of Exp-2, 4:00 PM
Week-9	21-Mar M	No class (Spring recess)
	23-Mar W	No class (recess)
	25-Mar F	No class (recess)
Week-10	28-Mar M	Oral talk-4
	30-Apr W	Exp-3
	1-Apr F	Exp-3
Week-11	4-Apr M	Oral talk-5
	6-Apr W	Exp-3
	8-Apr F	Exp-3
		Due Date of the Report of Exp-3, 4:00 PM
Week-12	11-Apr M	Oral talk-6
	13-Apr W	Exp-3
	15-Apr F	Exp-4

Week-13	18-Apr M	No class (Passover, Easter,recess)
	20-Apr W	No class (recess)
	22-Apr F	No class (recess)
Week-14	25-Apr M	No class (recess)
	27-Apr W	Exp-4
	29-Apr F	Exp-4
Week-15	2-May M	Oral talk-7
	4-May W	Exp-4
	6-May F	Exp-4
Week-16	9-May M	Oral talk-8
	11-May W	Exp-4
	13-May F	Exp-4 (last day of the class) 4:00 PM
	19-May T	Due Date of the Report of Exp-4 until Noon

((Note)) Typical examples (Phys.429 and 527)

The case of 5 reports

4 topics (you need to choose and need to do the experiment alone)

1 topics: Superconducting tin experiment (2 people doing the same experiment, only 3 hours experiment)

The case of 4 reports

3 topics (if you choose one of advanced topics such as NMR, optical pumping, resistivity of high T_c superconductor, and so on. You need to do the experiments alone)

1 topics: Superconducting tin experiment (2 people doing the same experiment, only 3 hours experiment)

Schedule for the experiment of superconducting tin (T = 1.5 K - 4.2 K, T_c = 3.6 K)

	Date	Topics
Week-3		
	9-Feb W	(Superconducting tin experiment I)
	11-Feb F	(Superconducting tin experiment II)
Week-4		
	16-Feb W	(Superconducting tin experiment III)
	18-Feb F	(Superconducting tin experiment IV)

Week-5		
	23-Feb W	(Superconducting tin experiment V)
	25-Feb F	(Superconducting tin experiment; extra)