INDEPENDENT STUDY PROGRAM PETITION

ISP PROPOSAL

Student: _____ MSC: _____
(Please print)

Cell Phone #: _____ YOS: _____

Pertinent Background: (Attached)

Goals of proposal; reasons for applying: (Attached)

Faculty Advisers: (Indicate Chairman) Chairman: John Preskill
Alexei Kitaev
Amnon Yariv

Agreement with ISP Study Proposal:

Student: _____ Date: 12-2-08

Faculty Adviser: _____ Date: 12-2-08
(Chairman)

_____ Date: 12-2-08

_____ Date: 12-8-08

Dean of Students: _____ Date: 1/6/09

Chair, Curriculum Committee: _____ Date: _____

Pertinent Background

I have conducted theoretical and experimental research in physics and computer science for several years; Axline Scholar.

Goals of Proposal, Reason for Applying

In the words of Rolf Landauer, information is physical. Properties of information, whether encoded in strands of DNA, subatomic particles, or silicon transistors, are governed by certain physical laws. In recent years, this simple idea has become an exciting new way to think about the world we live in.

The innovative field of quantum information science was born out of this idea. Today, quantum information science continues to produce new insights into quantum mechanics, computational complexity, and information theory, as well as hold exciting physical applications for computation, communication, lithography, and metrology. However, the highly multidisciplinary nature of quantum information science is often a challenge for researchers in the field.

The goal of my option is to study a broad cross-section of computer science and physics related to quantum information science. I feel that I will obtain a stronger foundation and greater appreciation for this recent shift in thinking than I can obtain by studying either of these fields individually.

A note on course revisions:

I have replaced CS 184 (Computer Architecture) with Ph 106 (Topics in Classical Physics).

I have tried to eliminate scheduling errors, but course secretaries and option representatives have told me that it is not possible to know when every course will be offered in the future. However, I note in my proposal that my advisors approve of me making minor scheduling rearrangements in the event of course conflicts, offerings, etc.

In addition, I have added Ph 172 (Research in Experimental Physics) to third term of second year, as I have talked to Professor Kimble about working in his quantum optics lab.

A note on motivations:

I have a genuine interest in quantum information science, unconventional computation, and the physical nature of computation. It is becoming increasingly obvious to me that my future career goals will fall somewhere in these broad categories.

As a freshman in high school, I was astonished by the ideas of quantum mechanics. Soon after, I was utterly captivated by the concept of quantum computation. I remember being absorbed by Gerald Milburn's *The Feynman Processor* long into the night, taking notes. I proceeded to voraciously read preprints on the arXiv and began conducting my own theoretical research on quantum algorithms.

At the start of college, I took some time to explore other academic fields, such as biology, chemistry, and mathematics. While I found many of these topics interesting, it soon became apparent that my real interest lay in computer science and physics. I faced a dilemma, however, when I realized that I would have to choose between the two.

For a while, I juggled the ideas of a computer science degree and physics degree. Should I do one or the other? Should I try CS with physics classes, or physics with CS classes? Either way, I felt like I would be missing important and interesting material. I briefly thought about a double major, but unfortunately, my ability to learn material decreases substantially when I am overwhelmed by too many classes.

Unsure of what to choose, I then did some background research. I learned that in biology, new ideas about information have recently led to the blossoming of such fields as neural computation, biological computation, computational biology, bioinformatics, and bioengineering. This new way of thinking has given birth to options such as CNS and biological engineering at Caltech. I thought about the emergence of quantum information, and how it has evolved in a similar way into a whole new way of thinking about physics and computation. I thought that it might even lead to a sort of physics/computer science option at Caltech in the far future.

At this point, I realized that the solution to my dilemma is an independent study option.

A note on some issues:

I spoke with my advisors at length about the implications of my independent study proposal. They all thought that it was an excellent idea for me. However, a few main issues about my proposed schedule arose:

-lack of physics labs and programming classes
-spreading myself too thin among the different disciplines
-graduate schools

These are our conclusions, and why this independent study option is right for me.

-Lack of physics labs and programming classes

Inevitably, my independent study proposal does not include some of the standard courses required for physics and computer science majors. This is similar to how a CNS option does not contain all the courses required for biology and computer science options. In particular, my schedule lacks labs (physics) and programming (computer science).

My advisers and I decided that my SURF experience in a quantum photonics lab last summer, as well as future experimental research experiences, are sufficient to learn the necessary laboratory techniques and methods of analysis common in the physical sciences.

I note that I have some college-level experience in these areas (Ph 3 and CS 2), and considerable pre-college experience.

-spreading myself too thin among the different disciplines

Since I will not be taking as many physics labs and programming courses, I am actually not missing much of the core curriculum in either physics or computer science. Therefore, if I decide to abandon quantum information science completely, my independent study option will still have provided me with a strong foundation and the flexibility to pursue either physics or computer science. In fact, the new ideas that I learn from quantum information science may provide some interesting perspective in whatever I decide to pursue.

As noted above, however, it is becoming increasingly obvious to me that my future career goals will fall somewhere in the broad categories of quantum information science, unconventional computation, and the physical nature of computation. If I do pursue this route, then my course selection will certainly provide me with an ideal foundation.

-graduate schools

After some consideration, we decided that my independent study major will not have a significant effect on my admission into graduate schools, and, in fact, may have a slight positive effect if I decide to pursue my current interests.

In conclusion, my advisers and I decided that the pros far outweigh the cons of this independent study option.

California Institute of Technology

INDEPENDENT STUDY PROGRAM PETITION

ISP CONTRACT

Course #: _____

Student: _____

Responsible Faculty Adviser: John Preskill

Subject Area: Physics / Computer Science

Time Period: 2008 to 2011 Units of ISP Credit: ≥ 486

Course Description: Independent study in physics and computer science.

Student Commitments: Student is responsible for passing all classes. Student may make minor scheduling changes in the event of time conflicts, course offerings, etc.

Adviser Commitments: Advisors may provide guidance when necessary.

Method of Grading: Grades and P/F, when appropriate.

Agreement with above contract:

Student: _____ Date: 12-2-08

Chairman, Student's Advisory Committee: John Preskill

Evaluation by Chairman: _____

California Institute of Technology

ISP PROGRAM APPROVAL FORM

Student Name: _____

Course of Study (Attached)

Sophomore Year

Term	Course #	Units	Title of Description	Instructor

Junior Year

Term	Course#	Units	Title of Description	Instructor

Senior Year

Term	Course#	Units	Title of Description	Instructor

Approved: Committee of Three J. A. Preskill

Kip Thorne

Thomas Tombrello

Date: 12-8-08

2nd Year

1st Term
Ma 2a- Differential Equations – 9 units
Ph 12a-Waves – 9 units
CS/EE/Ma 129 a- Information And Complexity – 9 units
Ph/CS 219 - Quantum Computation – 9 units
EE 243 a- Quantum Electronics – 6 units
HUM/Social Science/Other – 9 units

2nd Term
Math 2b-Statistics – 9 units
Ph 12b- Quantum Mechanics – 9 units
Ph/CS 219 - Quantum Computation – 9 units
EE 243 b- Quantum Electronics – 6 units
HUM/Social Science/Other – 9 units

3rd Term
Ph12c- Statistical Mechanics – 9 units
CS 38 - Introduction to Algorithms – 9 units
Ph/CS 219- Quantum Computation – 9 units
EE 243 c- Quantum Electronics – 6 units
HUM/Social Science/Other – 9 units
Ph 172 - Research in Experimental Physics – 3-6 units

3rd Year

1st Term
Ph 125a - Quantum Mechanics – 9 units
Ma 5a- Abstract Algebra – 9 units
CS 138a - Computer Algorithms – 9 units
Ph 106 – Topics in Classical Physics – 9 units
HUM/Social Science/Other – 9 units

2nd Term
Ph 125b - Quantum Mechanics – 9 units
CS 138b - Computer Algorithms – 9 units
Ph 106 – Topics in Classical Physics – 9 units
CS 150- Probability and Algorithms – 9 units
HUM/Social Science/Other – 9 units

3rd Term
Ph 125c - Quantum Mechanics – 9 units
CS 138c - Computer Algorithms – 9 units
Ph 106 – Topics in Classical Physics – 9 units
CS 151 - Complexity Theory – 9 units
HUM/Social Science/Other – 9 units

4th Year

1st Term

CNS/Bi/Ph/Cs 187- Neural Computation – 9 units
Ph 225a - Advanced Quantum Mechanics – 9 units
Ph 135a - Applications of Quantum Mechanics or Ph 205 - Relativistic Quantum Mechanics – 9 units
Ma/CS 117a - Computability Theory or CS/Ma 6a- Introduction To Discrete Mathematics or EE/Ma 126a - Information Theory – 9 units
HUM/Social Science/Other – 9 units

2nd Term

CS/CNS/Bi 91a - Biomolecular Computation – 9 units
Ph 225b - Advanced Quantum Mechanics – 9 units
Ph 135b - Applications of Quantum Mechanics or Ph 205- Relativistic Quantum Mechanics – 9 units
EE/Ma 127a - Error Correcting Codes or EE/Ma 126b - Information Theory – 9 units
HUM/Social Science/Other – 9 units

3rd Term

CS/CNS/Bi 91b - Biomolecular Computation – 9 units
Ph 225c - Advanced Quantum Mechanics – 9 units
Ph 135c - Applications of Quantum Mechanics or Ph 205 - Relativistic Quantum Mechanics – 9 units
EE/Ma 127b - Error Correcting Codes
Ph 210 - Theoretical Quantum Chromodynamics – 9 units
HUM/Social Science/Other – 9 units