Appendix L: Completion of Interrupted Degree

Students whose registration at the University of Maryland, College Park, has lapsed for more than 10 years shall be required to complete a minimum of 15 credit hours at College Park after their return to campus in order to earn a baccalaureate degree.

Recommendations about courses needed to satisfy the remaining degree requirements will be made at the department level, with approval of the Dean's Office required. The reason for requiring these credits is that many fields change sufficiently in 10 years to require that students take current courses if they are to be awarded a current degree. Exceptions to the requirement for a minimum of 15 credits earned at College Park upon return to the campus can be recommended by the Deans for approval in the Office of the Vice President for Academic Affairs.

College Park Senate
October 1995

Dear Professor Boyle:

I am a faculty member in the Mathematics Department at Georgetown University (and a former chair of the Department). For many years I have been a participant and cosponsor of a weekly seminar held in the Mathematics Department at CUA (in the distant past GWU was part of the seminar). This school year an individual named Brent Baccala started attending the seminar and gave several talks during the seminar. This summer he is attending weekly evening meetings of the Georgetown Math Club. Some months ago he asked me to write him a letter of recommendation for graduate school in mathematics at the University of Alaska. As I began to write the letter, Brent informed me that he had been told that he would not be admitted for lack of an undergraduate degree. The school had initially indicated that such an omission was acceptable and apparently this, along with a sense of adventure, is what had lead him to apply

Preparing to write the letter and in the last six months or more, I have become familiar with Brent. He is an extremely talented person, perhaps a genius, and he belongs in a graduate program in mathematics somewhere.

Brent is in his thirties. He was an undergraduate physics major at Maryland years ago, and apparently is within one semester or so of graduation. His grades were poor as an undergraduate, and he apparently quarreled with some members of the Physics Department (although he seems to me to be a rather polite and even−tempered person). He lives near Annapolis at home with his mother. He has a website that I urge you to visit to get some sense of him. The address is: http://www.freesoft.org/.

Brent has an extensive background in computer science and is very interested in and knowledgeable about algebraic geometry and differential algebra. He attended a conference on the subject, met a member of our seminar there, and that’s how he came to join our seminar.

My wife years ago went back to complete her undergraduate degree out West (and has since gotten a Master of Fine Arts from the University of Maryland), and I remember that when we were looking into schools, we found that it was much easier (many fewer semesters of study) to get one’s undergraduate degree at the school where one started rather than by transferring to a new school. Brent still has some contacts at Maryland and offered a non−credit course in 2006 described on his Website (but canceled when no one enrolled).

What can be done for him? If I had the authority to do so, I would immediately admit him to Maryland to complete his undergraduate degree, would give him advice on what courses to take, and would help him to seek appropriate financial aid.

Lacking that authority, I am writing to you. I urge you to act at once, if it is in your power, to interview him or arrange for someone to, and help him get on track. He seems to be the kind of person for whom school, graduate school, and academic research are made. Although there is no certainty, I think he would be an excellent investment by the University of Maryland and would add luster to the school.

Brent’s website has a biography of him and some contact information. I told him a week or two ago that I would contact someone at Maryland. I would be glad to act as a go−between, or you are welcome to contact him directly. My fear, of course, is that bureaucratic red tape will be used wittingly or unwittingly to discourage him, to his detriment

and Maryland’s.

Regards,

Andrew Vogt
vogta@georgetown.edu
202/687-6254 (w)
202/244-8665 (h)

From purtilo@cs.umd.edu Fri Sep 26 09:50:11 2008
Date: Thu, 24 Jul 2008 08:57:37 −0400
From: Jim Purtilo <purtilo@cs.umd.edu>
To: Brent Baccala <cosine@freesoft.org>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

Hi, Brent − Actually I can probably save you a trip by giving in email a synopsis of what we have in the records here. After your friend Andrew contacted Mike Boyle in math, Mike CC'd me on his response, since I am the Associate Dean for Undergraduate Education in this college. I pulled the records and requested a full audit from the physics advisor who would normally do graduation clearances, i.e. the person responsible for checking requirements in place. My report to you is based on this information, though I could not (for privacy reasons) relay it via other parties, only to you directly. So ... here is where we are:

Since your GPA is above a 2.00, it should be relatively simple to be readmitted. You can talk to Ms. Loretta Thomas in the Reenrollment/Reinstatement Office (UG Admissions) −at (301) 314−8389, or lthomas@umd.edu about what you would need to submit, how and by when. You have probably already missed the deadline to apply for reenrollment for Fall 2008 (which was July 1, 2008), but could do so for Spring in plenty of time. Loretta can give more detail.

In terms of progress, you have the right total number of credits (greater than 120) but the University's policy states that when a student wants to complete an interrupted degree, he will need to complete at least 15 credits. It's in Appendix L of the undergraduate catalog − which isn't coming up in the online version, but is on page 348 of the 2007−08 printed catalog.

In addition, you'll come in under what are the new rules for your major. To complete the major requirements in Physics, you would need: _PHYS401 (4 cr), PHYS402 (4 cr) _− updated versions of PHYS421 and PHYS 422 which the student took, _PHYS374 (4 cr_) − a math methods course for PHYS majors, _PHYS174 (1 cr)_ a lab methods course that didn't exist when the student was here in the past, and _PHYS405 (3 cr)_ − a required course then and now that you didn't pass. It was formerly given as PHYS395. This is 16 credits.

So bottom line, 16 credits stand between you and finishing here. Probably as scheduling works out, this is two modest semesters of a modest load.

I hope this helps!

−− JMP

From cosine@freesoft.org Mon Sep 22 12:10:17 2008
Date: Mon, 22 Sep 2008 12:10:13 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Thomas Gleason <tgleason@umd.edu>
Subject: completing my B.S.

Tom −

We had emailed two or three years ago about what it would require for me to finish my B.S. at Maryland. I left in 1993, one class (PHYS 395) short of a physics degree. The discussion several years ago ended when I started looking at the financials, but the department's answer seemed to be along the lines of wanting some additional requirements to complete a 2006 (or 2009) degree as opposed to a 1993 one.

A few things have changed for me in the ensuing years, most specifically that I may now have a bit of money at my disposal. So I'd like to know specifically what the department will require.

I'd prefer to satisfy any additional requirements by passing some kind of test or oral examination. I specifically don't want to be taking classes where I already know most of the material, and if there is additional material that I need to study, then I'd rather be given a syllabus and a reading list, since I tend to learn mainly by reading.

There is also the practical fact that I currently live an hour away from the university, by car.

My SSN is XXX−XX−XXXX, if you need that to pull my records. If you would please investigate this and let me know, I'd appreciate it.

−bwb

Brent Baccala
cosine@freesoft.org

Dr Purtillo –

After reviewing the course descriptions for the curriculum you outlined, I've concluded that four of the five classes on the list would probably be inappropriate for me. Here are my reasons:

PHYS 174 – "this course will lay a foundation for higher–level labs" I've passed every higher–level lab required by the major except 395/405. How challenging will a one hundred–level lab be?

PHYS 374 – "Introduces or reviews areas of mathematics that are regularly used in upper level and graduate courses in physics". Andy Vogt wrote of me, "he is an extremely talented person, perhaps a genius, and he belongs in a graduate program in mathematics somewhere". I'm currently sitting in on John Benedetto's Wavelets class (MATH 648) and am holding my own. So how challenging could 374 be to me?

PHYS 401/402 – I passed 421 and 422. The catalog description of 401 states "Credit will be granted for only one of the following: PHYS401 or PHYS421. Formerly PHYS421". Ditto for 402.

PHYS 405 – this one I can accept, as I never passed 395.

As for the 15 credits requirement, they'll have to come from courses like MATH 648 – classes that I find interesting and challenging. Some possibilities include graduate classes in technical departments like math or computer science, or perhaps some undergraduate Spanish classes. I'm sure that we could work something out.

Overriding these considerations, though, are the financial issues. I don't have to go to the bursar's office to figure out that 15 credits are going to add up to thousands of dollars in tuition. Furthermore, I currently live an hour away from campus by car, and wouldn't consider taking on any kind of course load like this unless I could move to College Park for a while, which I can't afford at this time. I'm not willing to go into debt. Dr. Benedetto has indicated that he has some programming work that the Norman Wiener Center would pay me to do, but I doubt that that can be counted on to fund all of this, and I would want to see a comprehensive resolution of the financial issues before proceeding.

From purtilo@cs.umd.edu Mon Oct 6 19:27:19 2008
Date: Mon, 06 Oct 2008 19:34:15 −0400
From: Jim Purtilo <purtilo@cs.umd.edu>
To: Brent Baccala <cosine@freesoft.org>
Cc: Nick Hadley <hadley@umd.edu>, Tom Gleason <tgleason@umd.edu>, Amy Alexander <aga@umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

Hi, Brent − I've now had a chance to get physics' detailed input on your specific request, and here is where I think we are.

Your points about similarity of some topics between what we've asked and what you have passed are well taken, but physics (correctly, it seems to me) observes in response that course titles aside, the content is very different in many of these cases, and they want to underscore the importance of some of these materials in any BS granted here. Since you were here before, the department has significantly revised the lab curriculum for majors in order to ensure a mastery of fundamental principles of experimental techniques and data analysis. I trust and respect their insights on this. The list of suggested courses I relayed to you before was crafted based on input from the physics department and based on their best assessment of how you should proceed.

Based on exchanges here since your inquiry to me, Physics will offer the following for getting past the departmental requirements: They will allow you to take the final exam (i.e. credit−by−exam) for PHYS374 (Intermediate Theoretical Methods.) However, credit by exam will not be available for the other courses; you would need to complete the rest of the program per my previous email to you.

There is one alternative. They will allow you exactly one attempt at the graduate qualifier exam. If you take and achieve a passing score on both parts their graduate qualifier exam, Physics would allow you to finish the BS in physics by completing PHYS174 and PHYS405 −− a total of 4 credits. If you take the exam and do not pass, then this option is off the table, and we default back to the above plan.

That text addresses physics−specific requirements. There is the matter of the 15 credit policy, which for the present I will support. The smallest number of credits you would need from physics (depending on how things go) would be 4 credits. Whatever is the balance of credits needed to make it to 15, we presume you would take them from classes you find interesting and challenging.

Please let us know how you'd like to proceed, thanks.

Jim

From cosine@freesoft.org Tue Oct 7 11:31:07 2008
Date: Tue, 7 Oct 2008 11:31:04 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Jim Purtilo <purtilo@cs.umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

On Mon, 6 Oct 2008, Jim Purtilo wrote:

> There is one alternative. They will allow you exactly one attempt at the
> graduate qualifier exam. If you take and achieve a passing score on both
> parts their graduate qualifier exam, Physics would allow you to finish the
> BS in physics by completing PHYS174 and PHYS405 −− a total of 4 credits.
> If you take the exam and do not pass, then this option is off the table,
> and we default back to the above plan.

Is this their entrance exam for incoming grad students or their
Ph.D. candidacy qualifier?

−bwb

Brent Baccala
cosine@freesoft.org

From purtilo@cs.umd.edu Tue Oct 7 11:32:11 2008
Date: Tue, 07 Oct 2008 11:36:07 −0400
From: Jim Purtilo <purtilo@cs.umd.edu>
To: Brent Baccala <cosine@freesoft.org>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

It is not a placement exam for incoming graduate students − it is an exam
given to graduate students after 1 or 2 years of study here.

Brent Baccala wrote:
> On Mon, 6 Oct 2008, Jim Purtilo wrote:
>
> > There is one alternative. They will allow you exactly one attempt at the
> > graduate qualifier exam. If you take and achieve a passing score on both
> > parts their graduate qualifier exam, Physics would allow you to finish
> > the BS in physics by completing PHYS174 and PHYS405 −− a total of 4
> > credits. If you take the exam and do not pass, then this option is off
> > the table, and we default back to the above plan.
>
> Is this their entrance exam for incoming grad students or their
> Ph.D. candidacy qualifier?
>
>
>   −bwb
>
>   Brent Baccala
>   cosine@freesoft.org

From cosine@freesoft.org Tue Oct 7 23:00:10 2008
Date: Tue, 7 Oct 2008 23:00:06 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Jim Purtilo <purtilo@cs.umd.edu>
Cc: Nick Hadley <hadley@umd.edu>, Tom Gleason <tgleason@umd.edu>, Amy Alexander <aga@umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

On Mon, 6 Oct 2008, Jim Purtilo wrote:

> Hi, Brent − I've now had a chance to get physics' detailed input on your
> specific request, and here is where I think we are.
>
> ...
>
> There is one alternative. They will allow you exactly one attempt at
> the graduate qualifier exam. If you take and achieve a passing score
> on both parts their graduate qualifier exam, Physics would allow you
> to finish the BS in physics by completing PHYS174 and PHYS405 −− a
> total of 4 credits. If you take the exam and do not pass, then this
> option is off the table, and we default back to the above plan.

From the department's web site on "Master's Degree without Thesis":

> > > Pass a final comprehensive examination testing the depth and breadth
> > > of his or her knowledge. This is a written examination and for this
> > > purpose the student may select whichever section of the
> > > Ph.D. Qualifying Examination he or she prefers. The chosen section
> > > must be passed at the master's level. A student who has passed the
> > > entire Ph.D. Qualifying Examination is considered to have met this
> > > requirement.

> > >   http://www.physics.umd.edu/academics/grad/Current/BlueBook.htm

I think the M.S. option should be satisfactory to complete a B.S,
don't you? One section, passed at master's level.

Here's what I'd suggest for PHYS 174. Several years ago I constructed
a small hydraulic ram for SEMERNAP (the Mexican equivalent of the
national park service). It's a water pump that doesn't use
electricity − it uses two valves and operates on purely hydraulic
principles. It's still sitting in my basement. I had meant to do
some experimental measurements on it − energy conversion efficiency,
flow rates at different input levels, that kind of thing, but I never
got around to it. I'll consult with whoever's teaching 174, finish my
work on the ram, write it up in a paper, and come down one day to
present it to the 174 class. It's a good show−and−tell presentation,
hydraulics should be different from what they're used to, and I'll
make sure to skew my talk in the direction of practical elements of
experimental design and analysis. OK?

And I'll take 405 "straight up", of course.

> That text addresses physics−specific requirements. There is the
> matter of the 15 credit policy, which for the present I will
> support. The smallest number of credits you would need from physics
> (depending on how things go) would be 4 credits. Whatever is the
> balance of credits needed to make it to 15, we presume you would
> take them from classes you find interesting and challenging.

The main problem that I see here is the added expense, but I talked to
John Benedetto about this earlier this evening. He's optimistic that
the Norbert Wiener Center can pay me enough to cover the expense of 15

credits. We'd both like to know if my current work in his MATH 648 class can be counted as 3 credits towards this requirement. That would leave 12 credits, including the lab classes and plus the qualifying exam, to be done this spring.

-bwb

Brent Baccala
cosine@freesoft.org

From cosine@freesoft.org Wed Oct 8 15:43:43 2008
Date: Wed, 8 Oct 2008 15:43:42 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Jim Purtilo <purtilo@cs.umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

You know, at this point, we've discussed a lot of different options by email, and it might be best to just sit down face−to−face and discuss this (assuming my last proposal isn't completely acceptable). I think that this would make the most sense if we could have one of the professors teaching 174 and one of the professors teaching 401/402 along with you and me and whoever in the department is making this decision.

−bwb

Brent Baccala
cosine@freesoft.org

From purtilo@cs.umd.edu Wed Oct 8 16:12:33 2008
Date: Wed, 08 Oct 2008 16:20:01 −0400
From: Jim Purtilo <purtilo@cs.umd.edu>
To: Brent Baccala <cosine@freesoft.org>
Cc: Nick Hadley <hadley@umd.edu>, Tom Gleason <tgleason@umd.edu>, Amy Alexander <aga@umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

Hi, Brent − Sorry that iterating with you on this is not quite in real time, but since some of the players I must sync with on each iteration are out of town, it takes some time to confirm where we are.

First in response to your previous message: If I correctly understand your counter−proposal, then
1. You propose satisfying 174 by means of some demonstration of a system you developed. This would not be acceptable to us.
2. You inquire about the offer to demonstrate proficiency by taking the grad exam here. The offer is that you would have a one time chance to take and pass both parts of the exam, not just one.
3. You propose using your involvement in MATH 648 as somehow counting towards credit here. This is not relevant to the physics requirement, and, absent your actually taking the course to get credit and a grade, would not be useful towards fulfilling the 15 credit obligation.

As a point of information, the credit−by−exam option (which physics said it would allow for PHYS374) entails a $30 fee.

Now in response to your most recent message: I am certainly willing to meet with you to discuss this. I am uncertain what I could tell you that we have not communicated by email, however, and I would not schedule with professors teaching 174 or 401/402, as this is not a negotiation about content of those courses. Physics has made an offer, and I have outlined how we are willing to proceed. Let us know your decision.

Cordially,

Jim

From cosine@freesoft.org Thu Oct 9 01:02:02 2008
Date: Thu, 9 Oct 2008 01:01:59 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Jim Purtilo <purtilo@cs.umd.edu>
Cc: Nick Hadley <hadley@umd.edu>, Tom Gleason <tgleason@umd.edu>, Amy Alexander <aga@umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

On Wed, 8 Oct 2008, Jim Purtilo wrote:

> Now in response to your most recent message: I am certainly willing
> to meet with you to discuss this. I am uncertain what I could tell
> you that we have not communicated by email, however, and I would not
> schedule with professors teaching 174 or 401/402, as this is not a
> negotiation about content of those courses. Physics has made an
> offer, and I have outlined how we are willing to proceed. Let us
> know your decision.

This isn’t about negotiating the content of the courses. This is about a classic "student teacher conference" to reach agreement on an acceptable study plan.

I don’t see any point in a meeting unless someone like Nick Hadley is there − a tenured professor, in the physics department, for whom 174 and 401 aren’t just numbers in the course catalog. I’m not trying to be rude, Jim, but you’re a comp sci professor in the dean’s office and and I think that there’s just a practical limit to how deeply you can discuss this.

If this is OK, then just propose a meeting time at least a day in advance. I would prefer the afternoon, but almost anything will be acceptable. Tomorrow (Friday), in particular, I am completely free, but next week is fine, too.

For those of you on the cc line that I omitted from my last email to Jim, it was simply this:

> You know, at this point, we’ve discussed a lot of different options by
> email, and it might be best to just sit down face−to−face and discuss
> this (assuming my last proposal isn’t completely acceptable). I think
> that this would make the most sense if we could have one of the
> professors teaching 174 and one of the professors teaching 401/402
> along with you and me and whoever in the department is making this
> decision.

−bwb

Brent Baccala
cosine@freesoft.org

From purtilo@cs.umd.edu Thu Oct 9 06:46:20 2008
Date: Thu, 09 Oct 2008 06:57:38 −0400
From: Jim Purtilo <purtilo@cs.umd.edu>
To: Brent Baccala <cosine@freesoft.org>
Cc: Nick Hadley <hadley@umd.edu>, Tom Gleason <tgleason@umd.edu>, Amy Alexander <aga@umd.edu>, "Ozga, Kim" <ozga@umd.edu>
Subject: Re: [Fwd: Brent Baccala]Contacts at Maryland

No.

We have worked out the plan of study at great hit to people's time on this end. Happy to have done so. That time investment is at an end. If you choose not to exercise some of the special considerations afforded to you by Physics in order to get from me an approval for exception to college policy then of course you may complete, by the numbers, the rest of your physics degree according to our published rules, as we have outlined to you. An offer is on the table. Let me know how you would like to proceed.

Jim

Brent Baccala wrote:
> On Wed, 8 Oct 2008, Jim Purtilo wrote:
>
> > Now in response to your most recent message: I am certainly willing
> > to meet with you to discuss this. I am uncertain what I could tell
> > you that we have not communicated by email, however, and I would not
> > schedule with professors teaching 174 or 401/402, as this is not a
> > negotiation about content of those courses. Physics has made an
> > offer, and I have outlined how we are willing to proceed. Let us
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>
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> about a classic "student teacher conference" to reach agreement on an
> acceptable study plan.
>
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> there − a tenured professor, in the physics department, for whom 174
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> be rude, Jim, but you're a comp sci professor in the dean's office and
> and I think that there's just a practical limit to how deeply you can
> discuss this.
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> acceptable. Tomorrow (Friday), in particular, I am completely free,
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>
>
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> Jim, it was simply this:
>
> > You know, at this point, we've discussed a lot of different options by
> > email, and it might be best to just sit down face−to−face and discuss
> > this (assuming my last proposal isn't completely acceptable). I think
> > that this would make the most sense if we could have one of the
> > professors teaching 174 and one of the professors teaching 401/402
> > along with you and me and whoever in the department is making this
> > decision.
>
>
>   −bwb
>

618 Laurel Drive
Pasadena, MD 21122

October 10, 2008

Dr. Nariman Farvardin
Senior Vice President for Academic Affairs and Provost
1119 Main Administration
University of Maryland
College Park, MD 20742

Dr. Farvardin,

I am a 38-year-old former UMCP student interested in completing my interrupted B.S. degree in Physics from 15 years ago.

I am writing to call your attention to the university administration's handling of this matter, and have attached the relevant correspondence. I see no need to comment on it, as you can read it and draw your own conclusions, though I would ask you to read it *carefully*, particularly regarding their graduate exam offer.

This is somewhat important to me, as it basically comes down to whether or not I am going to complete a college degree. I would appreciate it if you would ask this department and this college to sit down with me and discuss this face-to-face.

Thank you.

Sincerely,

Brent Baccala

cc:
Stephen Halperin, Dean, CMPS
Drew Baden, Chair, Physics
Jim Purtilo, Associate Dean for Undergraduate Education, CMPS
Nick Hadley, Associate Chair of Undergraduate Education, Physics
Tom Gleason, Associate Director of Student Services, Physics
Amy Alexander, Director for Student Services, CMPS
Kim Ozga, Assistant Director for Recruitment and Co-Curricular Programs, CMPS

From cosine@freesoft.org Fri Oct 17 00:29:14 2008
Date: Fri, 17 Oct 2008 00:29:01 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Nariman Farvardin <farvar@umd.edu>
Cc: Steve Halperin <shalper@umd.edu>, Drew Baden <drew@umd.edu>, Jim Purtilo <purtilo@cs.umd.edu>, Nick Hadley <hadley@umd.edu>, Tom Gleason <tgleason@umd.edu>, Amy Alexander <aga@umd.edu>, "Ozga, Kim" <ozga@umd.edu>
Subject: Brent Baccala's appeal request

Dr. Favardin,

Dr. Benedetto has helpfully suggested that since you are very busy, I need to summarize the content of those emails that I sent you. I have also learned a few more things since last week. In a nutshell:

1. A Georgetown professor (Andy Vogt) writes to Michael Boyle (the Maryland math chair) to ask him to help me finish my Bachelor's degree at Maryland, which I left 15 years ago with a single class (PHYS 375) remaining to be completed.

2. CMPS Associate Dean Jim Purtilo takes the lead in the correspondence. In fact, although others are on the cc: lines, he is the only person who ever emails me directly.

3. He develops a list of requirements for me to finish my degree under Appendix L of the Undergraduate Student Catalog, which applies to students who have interrupted their studies for more than 10 years and requires at least 15 credits and a vague requirement for these credits to include "recommendations" that "will be made at the at the department level". Dr. Purtilo's list includes PHYS 174, PHYS 374, PHYS 401, PHYS 402 and PHYS 405.

4. I make several suggestions for alternate evaluation schemes for the classes which I will not find challenging. All are rejected.

5. They develop a credit−by−exam option for the introductory quantum mechanics sequence (401/402). It is essentially this: to obtain a waiver for these two undergraduate classes, I must pass the Ph.D. qualifying exam.

6. My request for a face−to−face meeting between me, Jim Purtilo, and Nick Hadley (the Associate Chair) is refused.

7. I learn that Appendix L is based on a senate resolution from 1995. Since I matriculated in Fall 1987, and my last term of study was Spring 1993, unless senate resolutions are retroactive, Appendix L doesn't apply to me. All I actually need to complete is PHYS 405.

I request an appeal, for the following reasons:

− ACADEMIC INTEGRITY. It's something we talk about a lot with the students, but the administration has responsibilities here too, including the responsibility to ensure that evaluation instruments are appropriate to the material being evaluated. The Ph.D. qualifier is not appropriate to measure competence in undergraduate classes.

− APPENDIX L. If I understand university regulations correctly, this regulation only affects students who matriculated beginning in Spring 1996, and only effectively affects students with less than 15 credits left to complete a bachelor's degree. Assuming that we're not dealing with transfer students, this means that this would affect students with at least 3 1/2 years of study completed. That puts us at Fall 1999. Add ten years and we get Fall 2009. So Appendix L is only just

now coming into effect (it affects former transfer students already). As a human being with an emotion called pride, I can tell you my reaction to being asked to take PHYS 174: you will have quite a few people who will never finish college degrees because of Appendix L.

As a grown man and a former Campus Senator, I know the difference between a department chair, a college dean, and a university provost.

(Dr. Halperin, Dr. Benedetto tells me that you are a stickler for protocol. I am not trying to go around you out off either ignorance of the university's organization structure or any personal contempt.)

Dr. Farvardin, I wish you to hear this appeal personally because the issues it raises – the academic integrity of the administration and the practical effects of Appendix L's implementation – are issues that affect the entire university, not any one department or college.

If you decide to grant this request, I would suggest something like the following:

- A two hour time frame

- An audio recorder running (I intend to bring one)

- At least Jim Purtilo and Nick Hadley present, though anyone on the cc: line would be welcome

- It might be helpful to have a whiteboard or a chalkboard present

Thank you.

–bwb

Brent Baccala
cosine@freesoft.org

From farvardin@umd.edu Fri Oct 17 05:39:28 2008
Date: Fri, 17 Oct 2008 05:49:01 −0400
From: Nariman Farvardin <farvardin@umd.edu>
To: 'Brent Baccala' <cosine@freesoft.org>, 'Robert Waters' <rewaters@umd.edu>
Cc: 'Steve Halperin' <shalper@umd.edu>, 'Drew Baden' <drew@umd.edu>, 'Jim Purtilo' <purtilo@cs.umd.edu>, 'Nick Hadley' <hadley@umd.edu>, 'Tom Gleason' <tgleason@umd.edu>, 'Amy Alexander' <aga@umd.edu>, "'Ozga, Kim'" <ozga@umd.edu>, 'Bev Rodgerson' <brodgers@umd.edu>, 'Mahlon R. Straszheim' <straszhe@umd.edu>, 'Donna Hamilton' <dhamil@umd.edu>
Subject: RE: Brent Baccala's appeal request

Dear Mr. Baccala,

Many thanks for your email. I have reviewed your request and by this email I am asking Dr. Robert Waters in my office to look into your inquiry and the associated circumstances. He will get back to you directly.

Best regards,

Nariman Farvardin

−−−−−Original Message−−−−−
From: Brent Baccala [mailto:cosine@freesoft.org]
Sent: Friday, October 17, 2008 12:29 AM
To: Nariman Farvardin
Cc: Steve Halperin; Drew Baden; Jim Purtilo; Nick Hadley; Tom Gleason; Amy Alexander; Ozga, Kim
Subject: Brent Baccala's appeal request

Dr. Favardin,

Dr. Benedetto has helpfully suggested that since you are very busy, I need to summarize the content of those emails that I sent you. I have also learned a few more things since last week. In a nutshell:

1. A Georgetown professor (Andy Vogt) writes to Michael Boyle (the Maryland math chair) to ask him to help me finish my Bachelor's degree at Maryland, which I left 15 years ago with a single class (PHYS 375) remaining to be completed.

2. CMPS Associate Dean Jim Purtilo takes the lead in the correspondence. In fact, although others are on the cc: lines, he is the only person who ever emails me directly.

3. He develops a list of requirements for me to finish my degree under Appendix L of the Undergraduate Student Catalog, which applies to students who have interrupted their studies for more than 10 years and requires at least 15 credits and a vague requirement for these credits to include "recommendations" that "will be made at the at the department level". Dr. Purtilo's list includes PHYS 174, PHYS 374, PHYS 401, PHYS 402 and PHYS 405.

4. I make several suggestions for alternate evaluation schemes for the classes which I will not find challenging. All are rejected.

5. They develop a credit−by−exam option for the introductory quantum mechanics sequence (401/402). It is essentially this: to obtain a waiver for these two undergraduate classes, I must pass the Ph.D. qualifying exam.

6. My request for a face−to−face meeting between me, Jim Purtilo, and Nick Hadley (the Associate Chair) is refused.

From rewaters@umd.edu Fri Oct 17 14:19:58 2008
Date: Fri, 17 Oct 2008 14:29:30 −0400
From: Robert Waters <rewaters@umd.edu>
To: 'Brent Baccala' <cosine@freesoft.org>
Cc: Nariman Farvardin <farvardin@umd.edu>, 'Steve Halperin' <shalper@umd.edu>, 'Drew Baden' <drew@umd.edu>, 'Jim Purtilo' <purtilo@cs.umd.edu>, 'Nick Hadley' <hadley@umd.edu>, 'Tom Gleason' <tgleason@umd.edu>, 'Amy Alexander' <aga@umd.edu>, "'Ozga, Kim'" <ozga@umd.edu>, 'Bev Rodgerson' <brodgers@umd.edu>, 'Mahlon R. Straszheim' <straszhe@umd.edu>, 'Donna Hamilton' <dhamil@umd.edu>, "kre >> Diane Krejsa" <dkrejsa@umd.edu>, Dave Robb <drobb@umd.edu>, Beverly C. Rodgerson <brodgers@umd.edu>
Subject: Re: Brent Baccala's appeal request

Dear Mr. Baccala

My name is Robert Waters and I serve as Associate Vice President for Academic Affairs. As you are aware, Provost Farvardin asked me to contact you on his behalf.

I appreciate your desire to complete your degree and am impressed by your professional accomplishments. I am also willing and available to represent the Provost and our office as you seek to resolve this matter. However, the Physics Department and College of Computer, Mathematics and Physical Sciences (in conjunction with guidance provided by the University's Registrar and Legal Offices) are responsible for determining the remaining requirements necessary for you to complete the B.S. in Physics degree. My role on behalf of the Provost is to make sure that these requirements and expectations are in line with University regulations and adequately communicated to you.

I would be happy to work with Dr. Purtillo and other appropriate parties to arrange a meeting on your behalf. Please let me know who you think should be in attendance and times and dates that might work for you.

I can be reached at this e−mail address or at 301−405−5793. I look forward to meeting you.

Rob Waters

Nariman Farvardin wrote:
> Dear Mr. Baccala,
>
> Many thanks for your email. I have reviewed your request and by this email
> I
> am asking Dr. Robert Waters in my office to look into your inquiry and the
> associated circumstances. He will get back to you directly.
>
> Best regards,
>
> Nariman Farvardin
>
> −−−−−Original Message−−−−−
> From: Brent Baccala [mailto:cosine@freesoft.org] Sent: Friday, October 17,
> 2008 12:29 AM
> To: Nariman Farvardin
> Cc: Steve Halperin; Drew Baden; Jim Purtilo; Nick Hadley; Tom Gleason; Amy
> Alexander; Ozga, Kim

From drobb@umd.edu Fri Oct 24 10:05:06 2008
Date: Fri, 24 Oct 2008 10:05:20 −0400
From: Dave Robb <drobb@umd.edu>
To: Robert Waters <rewaters@umd.edu>
Cc: Brent Baccala <cosine@freesoft.org>, Jim Purtilo <purtilo@cs.umd.edu>
Subject: Re: Brent Baccala's appeal request

Rob,

In an earlier email, Mr. Baccala questioned whether the policy on interrupted degrees applied to his case. It is my opinion that the policy, which was adopted by the Senate in 1995, would apply to any student returning to complete their degree after that time. Mr. Baccala has returned subsequent to the adoption of this policy, therefore it applies to him. This policy requires successful completion of a minimum of 15 credits.

Since he will be awarded a current degree, his degree−granting college is authorized to determine all additional needed coursework or otherwise recommend any exception to the 15 credit minimum requirement.

I hope this helps to clarify matters.

Dave Robb
Registrar

Robert Waters wrote:
> Dear Mr. Baccala
>
> Please excuse my delay in replying to your e−mail.
>
> I don't have an opinion on this− I rely on the Office of the Registrar in
> this area. Our Registrar has stated, "please note that in the current
> on−line catalog for 2008−09, "appendix L" has been incorporated in the
> degree requirements section as item number 5."
>
> http://www.umd.edu/catalog/index.cfm/show/content.section/c/27/ss/1585/s/1
> 504
>
> *5. Completion of Interrupted Degree
> *Students whose registration at the University of Maryland, College Park,
> has lapsed for more than 10 years shall be required to complete a minimum
> of 15 credit hours at College Park after their return to campus in order
> to earn a baccalaureate degree.
>
> Recommendations about courses needed to satisfy the remaining degree
> requirements will be made at the department level, with approval of the
> Dean's Office required. The reason for requiring these credits is that
> many fields change sufficiently in 10 years to require that students take
> current courses if they are to be awarded a current degree. Exceptions to
> the requirement for a minimum of 15 credits earned at College Park upon
> return to the campus can be recommended by the Deans for approval in the
> Office of the Vice President for Academic Affairs.
>
> This gives us guidance and a process for gaining a possible exception to
> the rule upon the recommendation of the Dean's Office.
>
> Sincerely,
>
> Rob Waters
>
>

>
> Brent Baccala wrote:
> > On Fri, 17 Oct 2008, Robert Waters wrote:
> >
> > > > Dear Mr. Baccala
> > > >
> > > > My name is Robert Waters and I serve as Associate Vice President for
> > > > Academic Affairs. As you are aware, Provost Farvardin asked me to
> > > > contact you on his behalf.
> > > >
> > > > I appreciate your desire to complete your degree and am impressed by
> > > > your professional accomplishments. I am also willing and available
> > > > to represent the Provost and our office as you seek to resolve this
> > > > matter. However, the Physics Department and College of Computer,
> > > > Mathematics and Physical Sciences (in conjunction with guidance
> > > > provided by the University's Registrar and Legal Offices) are
> > > > responsible for determining the remaining requirements necessary for
> > > > you to complete the B.S. in Physics degree. My role on behalf of the
> > > > Provost is to make sure that these requirements and expectations are
> > > > in line with University regulations and adequately communicated to
> > > > you.
> > >
> > > What is your opinion on the applicability of Appendix L to a student
> > > who matriculated in 1987?
> > >
> > >
> > >
> > >   -bwb
> > >
> > >   Brent Baccala
> > >   cosine@freesoft.org
> >
> > --
> > "Be ashamed to die until you have won some victory for humanity"
> > Horace Mann
> >
> > Robert Waters, Jr.
> > Associate Vice President for Academic Affairs and
> > Special Assistant to the President
> > University of Maryland
> > 1119 Main Administration Building
> > College Park, Maryland 20742
> > 301-405-5793
> > 301-405-8195 (fax)
> >

From cosine@freesoft.org Fri Oct 24 13:38:04 2008
Date: Fri, 24 Oct 2008 13:38:01 −0400 (EDT)
From: Brent Baccala <cosine@freesoft.org>
To: Dave Robb <drobb@umd.edu>
Cc: Robert Waters <rewaters@umd.edu>, Brent Baccala <cosine@freesoft.org>, Jim P
urtilo <purtilo@cs.umd.edu>
Subject: Re: Brent Baccala's appeal request

On Fri, 24 Oct 2008, Dave Robb wrote:

> In an earlier email, Mr. Baccala questioned whether the policy on
> interrupted degrees applied to his case. It is my opinion that the
> policy, which was adopted by the Senate in 1995, would apply to any
> student returning to complete their degree after that time.
> Mr. Baccala has returned subsequent to the adoption of this policy,
> therefore it applies to him. This policy requires successful
> completion of a minimum of 15 credits.

I should point out that I specifically inquired of my department's
advisor, in the Spring of 1993, what would happen if I left at that
point with one class left unfinished. I was told, as best I can
recall, that there was "no time limit on the undergraduate degree,"
which was true in 1993. I made a decision at that time based on that
answer, a decision that I would have much more carefully considered,
if not changed outright, had the new rules been in place.

I hope that an exemption would be warranted under these conditions.

Thank you.

−bwb

Brent Baccala
cosine@freesoft.org

From cosine@freesoft.org Wed Nov 5 10:47:23 2008
Date: Wed, 5 Nov 2008 10:47:20 −0500 (EST)
From: Brent Baccala <cosine@freesoft.org>
To: Robert Waters <rewaters@umd.edu>
Subject: Re: Brent Baccala’s appeal request

On Fri, 17 Oct 2008, Robert Waters wrote:

> I would be happy to work with Dr. Purtillo and other appropriate parties
> to arrange a meeting on your behalf. Please let me know who you think
> should be in attendance and times and dates that might work for you.

Let’s try to do this. I think that this is at least worth sitting down one time in a face−to−face meeting. I’d like at least Jim Purtillo and Nick Hadley to be present. Nick has balked at meeting with me before, but I really see no point whatever to a meeting if the department isn’t going to be represented.

Pretty much any afternoon would be good for me.

Thank you.

−bwb

Brent Baccala
cosine@freesoft.org

From cosine@freesoft.org Thu Dec 11 10:38:12 2008
Date: Thu, 11 Dec 2008 10:38:11 −0500 (EST)
From: Brent Baccala <cosine@freesoft.org>
To: Drew Baden <drew@umd.edu>
Subject: Departmental approval for contract work

Hello −

At the tail end of that debacle in October, Steve Hatcher ignored my last two emails (one pointing out that since I matriculated in 1987, a 1995 regulation should not apply to me, and the last one requesting − again − a face−to−face meeting with Nick and Jim). I thought about following up − again − with the provost, but decided instead that at that point the thing to do was to talk to a lawyer. I seriously considering suing the university (arguing that the 1995 regulation represented a unilateral, ex−post−facto, and thus illegal modification to my original 1987 contract with the university), but finally decided that the B.S. just wasn't important enough to me to bother.

However, if you recall, floating in the background of that entire discussion was the possibility of John Benedetto having some contract work for me to do. That moved forward, and we are very close to finalizing it. There is, however, a catch.

Megan Smith (a Contract Administrator in the Office of Research Administration and Advancement) wrote me:

> Brent, the university will submit proposals or sign agreements for any
> university employee or student provided that the individual is approved by
> their affiliated department. Appointments and approval for work on
> sponsored projects are handled at the department level.

I suppose that the simplest thing would be to transfer to a different department (i.e, math), but I thought that I should at least send you an email and solicit your thoughts first.

As before, I would prefer a face−to−face meeting.

Thank you.

−bwb

Brent Baccala
cosine@freesoft.org

From cosine@freesoft.org Mon Dec 15 00:25:12 2008
Date: Mon, 15 Dec 2008 00:25:11 −0500 (EST)
From: Brent Baccala <cosine@freesoft.org>
To: Jim Purtilo <purtilo@cs.umd.edu>
Subject: Meeting on Fri Dec 19

Jim −

I've thought some more about our exchange, particularly Dean Halperin's observation that you were willing to meet with me. Perhaps it was negligent of me not to explore that possibility.

I have a meeting on campus this Friday at 3 PM to discuss John Benedetto's contract work; it is moving forward.

Can we sit down and talk around 2 PM? Or after the meeting, if that works better for you?

I'm attaching a description of some work that I plan to do this spring; perhaps this will clarify why I will not take PHYS 174.

Thank you.

−bwb

Brent Baccala
cosine@freesoft.org

```
From cosine@freesoft.org Sun Dec 21 20:10:53 2008
Date: Sun, 21 Dec 2008 20:10:51 −0500 (EST)
From: Brent Baccala <cosine@freesoft.org>
To: Drew Baden <drew@umd.edu>, Nick Hadley <hadley@umd.edu>
Subject: Radar experiment

Gentlemen −

Last week, I sent Jim Purillo this attached document (which I wrote
and which describes some work that I plan to do this spring) to
provide a concrete justification as to why I will not take PHYS 174.

I met with Jim and Robert Waters on Thursday; the meeting was cordial
but unproductive.

I wanted to make sure that the two of you saw this also.



                                        −bwb

                                        Brent Baccala
                                        cosine@freesoft.org
    [ Part 2, ""  Application/PDF  372KB. ]
    [ Unable to print this part. ]
```

The meeting was, as I said, “cordial but unproductive.”

The Physics department was completely unrepresented.

Neither Nick Hadley nor Drew Baden answered this email.

In fact, neither one ever answered any of my emails to them.

Up: www.freesoft.org

Guardian Alert: How it works

by Brent Baccala
baccala@freesoft.org
August, 2000

Sense Technologies, Inc. manufactures Guardian Alert, a backup collision warning system (US$379 suggested retail price). The detector is a two inch square, 10.5 GHz radar module fashioned into a plastic license plate frame (Fig. 1). The detector is wired to the white backup lights, powering it when the vehicle is in reverse, as well as to a small speaker and LED module placed near the driver. When backing up, different audio tones warn of objects within one of three radii (Fig. 2). The device is OEMed; Microwave Solutions Ltd designed and manufactures the microwave radar unit that forms the core of the design.

Figure 1. The Guardian Alert backup warning system mounted on a license plate frame, with stylized radar waves.
Photo courtesy Sense Technologies.

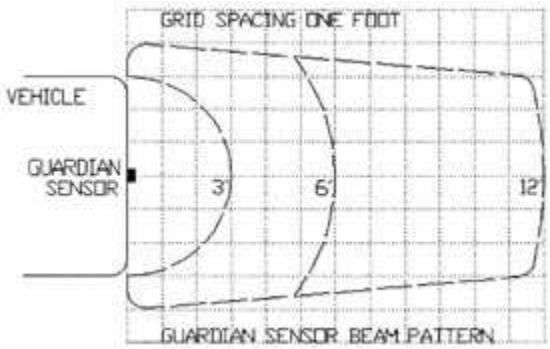


Figure 2. The Guardian Alert's detection pattern.
Diagram courtesy Sense Technologies.

Removing the plastic license plate frame reveals the radar module (Figs. 3 and 4). It measures 5x5x1½ cm, and is a marvel of neat, clean microwave design. Because it's so modular, it's well suited for study and experimentation. Let's explore this clever design in more detail.

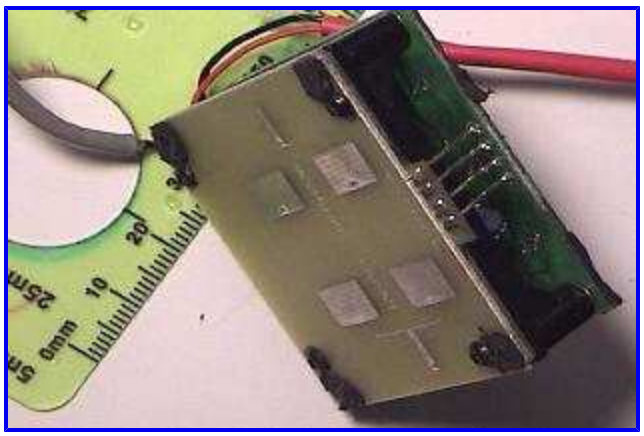


Figure 3. Guardian Alert radar module, front view, showing microstrip patch antennas.

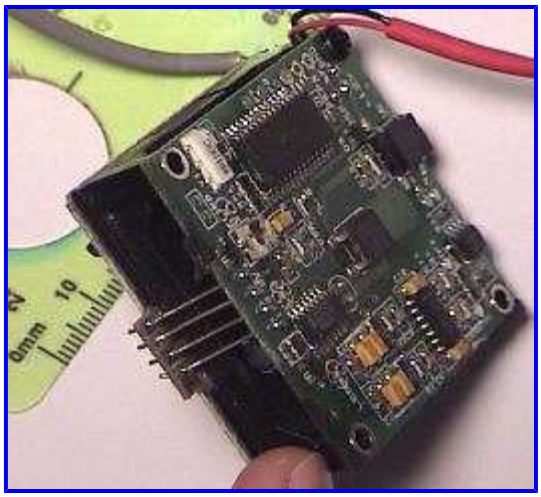


Figure 4. Guardian Alert radar module, rear view, showing low frequency processor board.

Disassembling the radar module (Fig. 5) reveals its four components: the antenna board (1), the high-frequency microwave board (2), an inert plastic frame (3), and the low-frequency processor board (4). Power supply lines and the cable to the driver warning module are seen to the right, soldered to the processor board. The only electrical connections between the boards themselves are the four wires (power, ground, VCO frequency control, and beat signal) between the processor board and the microwave board, visible cut in Fig. 5 and intact in Figs. 3 and 4. The antenna board is coupled to the microwave board with a slit coupling described below. A block diagram of the radar is shown in Fig. 6.

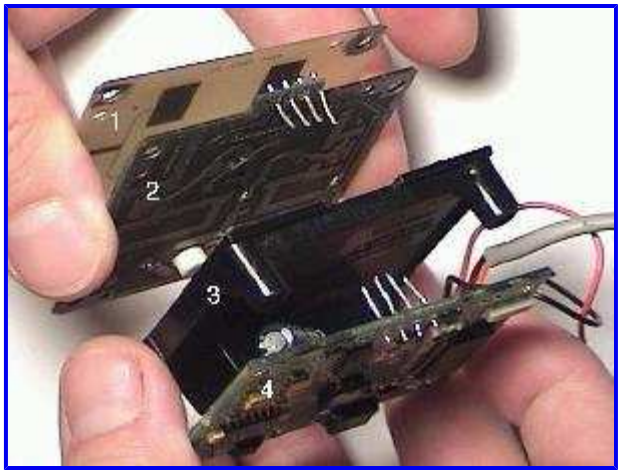


Figure 5. Disassembled radar module.

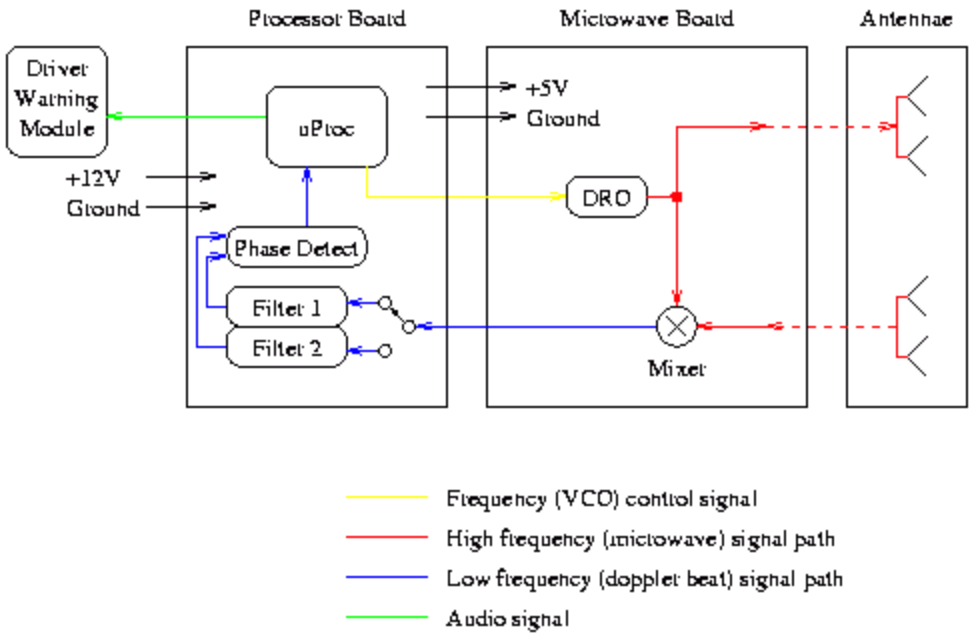


Figure 6. Block diagram of radar module.

The most complex component is the microwave board (Fig. 7), which uses a 10.5 GHz voltage controlled dielectric resonance oscillator (VCO-DRO) to generate the microwave signal. A DRO's resonant element is a puck of dielectric ceramic, coupled to the oscillator by its physical proximity to coupling pads. A VCO's frequency can be skewed by varying a control voltage, and in a VCO-DRO this is done by varying the voltage on a coupling pad. Active gain is provided by a microwave field effect transistor (FET). High-frequency signal flow is roughly top-to-bottom in the picture, and there are no hidden traces; this is a single layer PC board. Visible are the oscillator's +5V power supply line (1), the frequency control line (2), the high speed FET (3), the dielectric puck (4), the VCO coupling pad (5), the splitter (6), the transmit antenna coupling (7), the receive antenna coupling (8), the receive mixer (9), and the beat signal's low-pass filter (10) and return line. Ground shields are distinguishable by the small, plated-through holes that connect them to the ground plane on the rear of the board. Notice that there are no switching elements in the transmit signal path; this is a continuous wave (CW) radar. The four wires to the processing board connect at the bottom of this

picture. I explore the microwave design issues more in Guardian Alert - Part 2.

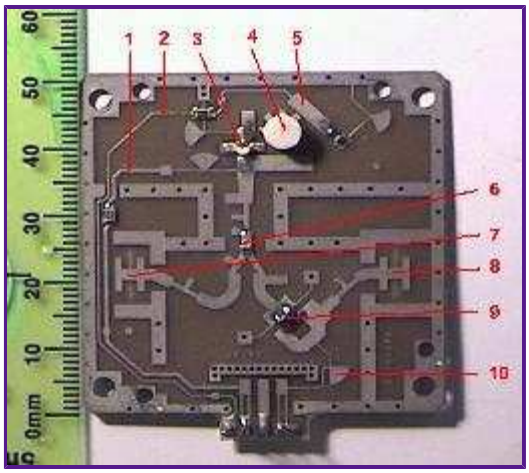


Figure 7. Microwave board, top view.

The antenna board is coupled via slots, shown circled, in the microwave board's ground plane (Fig. 8). The transmit slot is on the right in this view, and the plated-through holes are again visible.

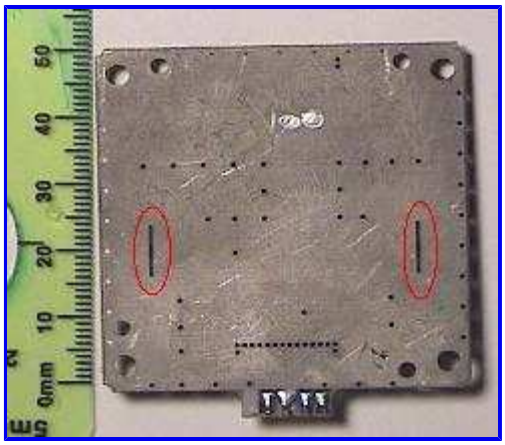


Figure 8. Microwave board, bottom view.

The antenna board (Fig. 9) is bare on the side that contacts the microwave board, so the microwave board's ground plane effectively acts as a ground plane for the antenna board as well. The microwave signal couples from the microstrip lines on the microwave board, through the slots in the (common) ground plane, to the microstrip lines on the antenna board, which connect to the antenna arrays. Each antenna array consists of a pair of patch antennas. The picture is oriented the same as the bottom view of the microwave board (Fig. 8). Visible is the recieve coupling (1), the receive antenna array (2), the transmit antenna array (3), and the transmit coupling (4).

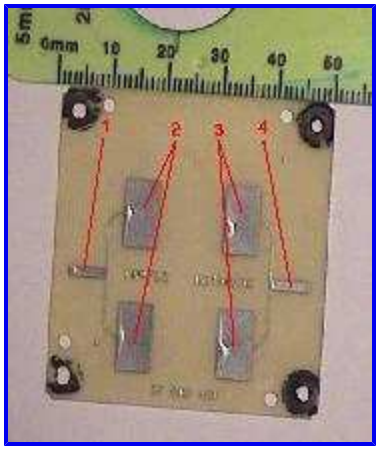


Figure 9. Antenna board.

The radar's "smarts" are contained on its low frequency processor board (Fig. 10). Visible are the microprocessor (1), a Motorola MC68HC705 with custom PROM; the frequency control section (2), which drives the microwave oscillator's VCO line; the +5V regulator (3); the four wires connecting to the microwave board (4); and the receive filter bank (5).

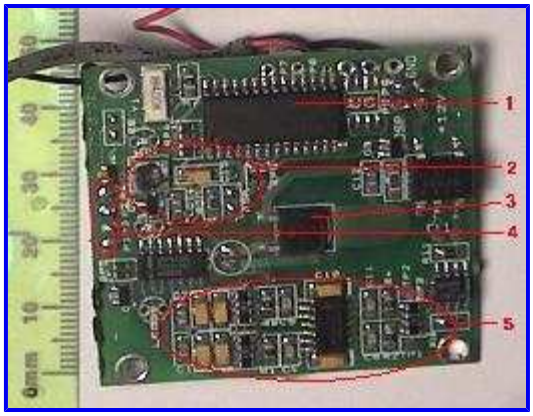


Figure 10. Processor board.

The radar module only has to detect doppler shifts, since the vehicle will be in motion and thus even stationary objects will have a net doppler shift. The wavelength of a 10.5 GHz signal is 2.84 cm, so an object moving at 1 m/s (about 2 miles per hour) will cross 35 wavelengths every second, showing a doppler shift of twice that (70 Hz), since the radar beam must cover the distance twice (out and back). Objects moving faster will show doppler shifts of higher frequencies. In short, objects moving between 1 and 25 miles per hour will doppler shift a 10.5 GHz carrier roughly from 20 Hz to 2 kHz. Since the microwave board mixes the receive signal with the unshifted oscillator signal, these doppler shifts will appear as low frequency beat signals going back to the processor board, where conventional op-amp filter sections can detect them.

Doppler shifts encode speed information, but it may not be clear how a continuous-wave (i.e, unpulsed) radar can detect distance. This is where the VCO comes into play. By varying the frequency of the microwave carrier, a phase shift can be induced in the doppler return signal (Fig. 11). For example, it's already been noted that a 10.5 GHz carrier has a wavelength of 2.84 cm.

However, a 10.55 GHz carrier has a wavelength of only 2.82 cm. An object 1m from the radar is thus a quarter wavelength "farther" at the higher frequency (35.21 vs 35.46 wavelengths), creating a 90° phase shift. In fact, this example is contrived; the phase shift is too large. A smaller frequency variance is used in practice.

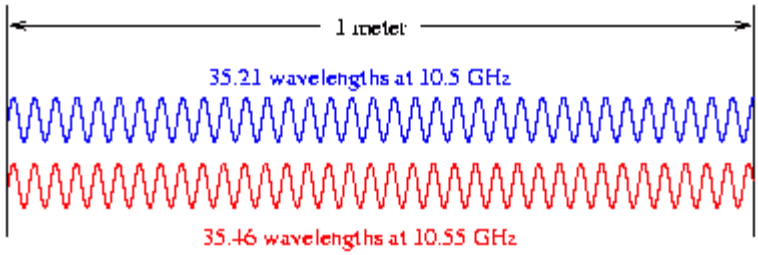


Figure 11. Phase difference between different frequencies

The Guardian Alert shifts back and forth between two frequencies at several kilohertz, switching the return signal alternately between two nearly identical filters on the processor board. This effectively becomes a sampling problem, and since the sampling rate is significantly higher than the frequency of the signals being detected, we effectively get two radars for the price of one, operating at slightly offset frequencies. The output of both filter banks is available to the microprocessor, which can compare their relative phases and thus infer distance information. A tuning potentiometer (visible in Fig. 10 at the left of ellipse #2) allows the VCO signal level, and thus the frequency offset, to be varied for precise range adjustments.

Possible Experiments

Because of its modular design, the Guardian Alert radar module can be assembled in various configurations, making it ideal for microwave experimentation. Both the processor board and the antenna array can conceivably be replaced; the design of the microwave board is too intricate to modify. Note that the antenna board, though simple in its design, requires tight tolerances in its construction due to the short wavelengths involved, which are made even shorter by the PC board's non-unity dielectric constant. Here are several possible experiments; if you attempt any of these, or others, please email me your results.

1. Replace the processor board with a standard PC and a data capture (A/D converter) card, such as any of those supported by Comedi. Write a software program to mimic the function of the processor board. Output the frequency of the doppler shift and the phase variance between two frequencies. Convert these values into speed and distance estimates. How accurate are they? Can you tell if the target is moving towards you or away from you?

2. Build an "antenna board" that connects two radar modules (A and B) together, feeding the transmitter of A to the receiver of B. Provide a quarter wavelength stub to shunt off B's transmitter. Observe the beat frequencies produced at B's output. Are they stable over time?

Temperature? Study how they change when A's VCO control is varied. Plot A's VCO voltage vs. frequency curve. It is linear? Switch A and B, and plot B's curve. Are they the same?

3. Build a microwave interferometer. If the oscillator's frequency is stable over time, this can be done using two modules, several meters apart, with A's transmitter pointed at B, and B's transmitter shunted. Adjust them to get a suitable beat frequency. Now, moving one of the modules over a measured track, observe the phase change in B's output. How far do you have to move to produce a 360° change? Careful measurement of the distances required to produce given phase changes reveals the exact wavelength. How accurately can you measure the wavelength, and how close is it to 10.5 GHz? Are you measuring A's wavelength, or B's?

4. Design an antenna board using a single antenna array, instead of two. Use a directional coupler, probably a quadrature hybrid, to achieve isolation between the transmit and receive paths.

5. Replace the antenna board with a more highly directional array. See Kraus, Section 16-12 ("Patch or Microstrip Antennas") and the references listed there.

6. Implement an FM radar system by continually varying the VCO control signal, conventionally with a ramp or triangle wave. By the time the radar signal has gone out and returned, the oscillator's frequency should have changed enough to produce a beat frequency, even for stationary targets! Convert the beat frequency into a distance estimate.

7. Use the directional array and FM radar of the last two experiments, as well as the PC data capture design of the first experiment to construct a practical radar system. Directional arrays can be "steered" electronically (using phase shifters), but mechanical beam steering is simpler. Mount the radar module and its directional array on a rotating mount. Modify the FM radar software to show a plan position indicator (PPI), the traditional radar display. How good a radar can you build?

References

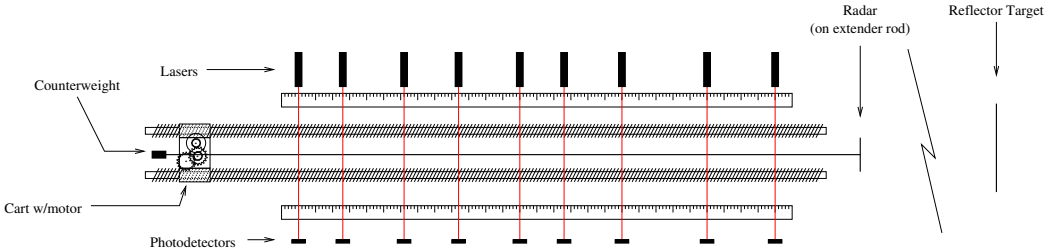
Kraus, John D, *Antennas*, second edition, 1988, McGraw-Hill, ISBN 0070354227.

Pozar, David M, *Microwave Engineering*, second edition, 1997, John Wiley & Sons, ISBN 0471170968.

Skolnik, Merrill Ivan (ed), *Radar Handbook*, second edition, 1989, McGraw-Hill, ISBN 007057913X.

Next: Guardian Alert - Part 2

Experiment A: Wavelength of radar module via Doppler shift



I'll mount the radar module on a rod extending from a cart traveling along rails at a constant speed and measure the Doppler shift to a stationary target by measuring the beat frequency returned from the radar module. Since the signal must travel both out and back, we expect a full 360° phase shift every time the module transverses a half wavelength. Thus, if the radar is traveling at speed v, we expect a Doppler shift of $\frac{v}{2\lambda}$. I'll maintain a near-constant velocity by using a motorized cart sliding on a pair of threaded rods, with a small electric motor driving a gearing mechanism engaged to one of the rods. The velocity will be measured by timing the cart as it covers a measured distance. The Doppler shift will be measured by sampling the beat signal using an ADC, then performing a discrete Fourier transform on the sampled data. The computed wavelength will then be $\frac{l}{2ft}$, where l is the length of the test track, f is the frequency of the Doppler shift, and t is the time required to transverse the test track.

Since the calculation involves nothing but multiplication and division, we can forgo a complicated propagation of variables and reason that to achieve n digits of accuracy in the final result, we need n digits of accuracy in each of the measured values. Assuming a 1 meter test track, a 10 GHz radar module (yielding a wavelength of roughly 3 cm), and a 10 second test run at 10 cm/s, we can draw the following rough estimate of errors in our three measured quantities:

- **Time.** Probably the most accurate of the measurements. Using simple laser diodes (like from a pen projector) aimed across the track at photo-transistors at both the beginning and end of the test track, we can measure the time using a computer. Using RTAI, [1] reported worst case timing jitter of 15 μs at 100% CPU load, which would yield 6 digits of precision on a 10 second run. The precision could easily be increased to at least 10 digits with careful use of an Intel Pentium's Time Stamp Clock. Calibration can be achieved by using the Network Time Protocol (NTP) to synchronize with several network time servers themselves synchronized to atomic clocks. [7] reported achieving clock agreement of $1.85 \pm 1.28\mu$s in a 802.11 wireless environment, enough for 7 digits of accuracy.
- **Frequency.** My ADC samples at a maximum rate of 100 kHz. For a 10 second run, this will yield about 1 million samples. Since a discrete Fourier transform is invariant to the number of data points, and the Nyquist frequency is 50 kHz, this yields a frequency resolution of 50 kHz/10^6=.05 Hz. A 10 GHz radar, with a 3 cm wavelength, moving at 10 cm/s, would Doppler shift approximately 6.667 Hz, meaning that .05 Hz yields about 2 digits of precision. This precision can be increased, however, by zero padding the data. Adding, for example, 9 million zeros, for a total sample size of 10 million, yields a order of magnitude improvement in frequency resolution to .005 Hz and 3 digits. This process adds error to the calculation, of course, so we are essentially trading signal-to-noise ratio for increased precision. How much precision can ultimately be extracted in this manner depends on the original signal-to-noise ratio, which itself depends heavily on using good experimental procedure to produce a nice clean Doppler beat. See "Spectral Analysis" later in this paper.
- **Length.** This will be measured by mounting two parallel rulers on opposite sides of the track and aligning the laser diodes (used for timing) with the markings on the rulers. It should be possible to align the lasers by shining them onto the rulers, eliminating parallax effects, and aligning them under a microscope if necessary to achieve greater precision. The precision in the length measurement can be estimated by using multiple laser diodes, staggered along the track, and then using least-squares methods to compute a standard deviation for the length. Of greater concern, however, is the accuracy. Example 1-1 in [3] involves a measurement with a steel meter stick that exhibits error in its third digit due to thermal expansion. This example is somewhat contrived, however, since it assumes a coefficient of thermal expansion of $500 \times 10^{-6}\,/^\circ\mathrm{C}$ while p. 12-211 in [4] "Common Metals and Alloys" lists typical values of this coefficient for various metals (including two different steels and various aluminum alloys); only zinc exceeds $30 \times 10^{-6}\,/^\circ\mathrm{C}$. If we assume that this coefficient is no higher than $20 \times 10^{-6}\,/^\circ\mathrm{C}$ (a condition met by both of [4]'s steels), and the temperature swing from calibration to measurement is no greater than $5\,^\circ\mathrm{C}$, then we can expect four digits of accuracy — a tenth of a millimeter. In any event, without some kind of certification statement in hand, I see no reason to believe than a meter rule would be calibrated to greater than $\frac{1}{10}$ mm, since this is roughly the resolving power of the naked eye and rulers are intended to be read visually.

In summary, we can expect no more than 4 digit accuracy from a standard meter rule, though precision rulers are commercially available [5] accurate to $\frac{1}{100}$ mm. With such a ruler, we could push our length measurement to an accuracy of 5 digits, but anything beyond that would require a different measurement technique, probably a laser interferometer. The uncertain precision of the frequency measurement is a source of concern, and some preliminary work with a signal generator and the ADC would probably help clarify just how much precision can be extracted from this equipment.

Verification of Results

Once the wavelength has been measured, the result can be checked against the frequency of the radar by measuring the frequency directly using a spectrum analyzer, though constructing a suitable interface circuit will present a major challenge. The Tektronix RSA6114A, for example, ranges up to 14 GHz and is specified by the manufacturer to exhibit 7 digits of accuracy in its reference frequency [6], so it or something like it should be suitable to check this result. Page 6-154 "Permittivity (Dielectric Constant) of Gases" of [4] gives 1.0005364 as the dielectric constant of dry air and a value of 1.00022 for saturated water vapor at 20 °C. Clearly, any wavelength measurement with four or more digits of accuracy must be corrected for the fact that we are in air and not vacuum as it's converted to a frequency (or vice versa).

Additional errors

- Neither the radar nor the reflector are point sources, though we are treating them as such. Ideally, we would simply move them far enough apart to get into the "far field", but due to the low power of the device this is not really practical. A more comprehensive treatment, taking into account the non-ideal natural of the antenna and the reflector, would result in a more complicated spectral analysis problem that I don't (yet) know how to handle. However, the actual, more complicated return pattern will present itself as "spectral smear" around a dominant Doppler frequency determined by the point source approximation. As such, it will degrade, not invalidate, the simpler analysis. Therefore, I'll use the point source approximation and empirically determine a distance between the radar and the reflector that minimizes the computed error estimates and should therefore represent a balance between the approximation error introduced at short distances and the degraded signal-to-noise ratio present at large distances.
- Any objects within the radar's radiation pattern but not directly in its line of motion will produce extraneous Doppler effects at a frequency reduced by a factor of $\cos\theta$, where θ is the angle between the path of motion and the line from the radar to the object. The best way to handle this effect is to operate the experiment in as open an environment as possible. Ideally, we'd like the radar to "see" nothing except the reflector target. Instead of mounting the radar module directly on the moving cart, it would be better to mount the radar on a rod extending from the cart and parallel to the test track, removing the test track from the radar's radiation pattern, though the mechanical instability of such a design might introduce additional error.
- The changing distance between the radar module and the target during a test run will result in amplitude modulation of the returned signal. I expect this effect to become significant; see "Spectral Analysis" on the next page.
- The ADC may not sample at exactly its specified rate (it has its own internal clock source). Once the computer's clock has been synchronized and calibrated, it should be easy to check the ADC's sampling rate against it. Related to this problem is...
- The computer's clock may not oscillate at a constant rate. Measuring its average rate over a long period of time against an NTP source seems fairly straightforward, but accounting for short term fluctuations in frequency seems more difficult. Without a lot of extra work, I'll probably have to assume stability of the computer's oscillator within the 4–5 digits of accuracy expected from the experiment.
- Most mechanical imperfections in construction are likely to degrade the quality of the data and will not be systematic, however...
- The rulers may not be exactly parallel to the track. This will result in the motion of the radar module occurring at an angle to the measured distance and be shorter than the true distance.
- The electric motor will not apply constant torque. The one I'm considering using (a Radio Shack 273-256) is constructed using five coils ganged around a central drive shaft, with two permanent magnets in the casing. As the shaft turns, two copper fingers extending from the case engage with a ring of five contacts on the shaft to energize the coils in sequence. A detailed analysis of this design seems unnecessary; it's enough to note that the motor has a 36° anti-symmetry, i.e, rotate the shaft by 36° and the motor's configuration is now a mirror image of what it was. Thus, any irregularities in the motor's applied torque will likely be periodic at ten times its operating speed. During operation of the experiment, variations in the radar's speed will appear as frequency modulation of its Doppler shift. Approximate knowledge of the velocity, coupled with knowledge of the rod threading and the gearing ratio used to couple the motor to the rod should allow prediction of the modulating frequency, and spectral analysis theory could be modified to take this into account.
- Likewise, the gearing mechanism may not apply constant force to the threaded rod. Again, knowledge of the approximate velocity and the rod threading will allow the frequency of this effect to be predicted and searched for in the data.

Of these effects, I expect only the amplitude modulation due to distance variation to be more significant than the imperfections due to assuming a point source and a point reflector. Other than operating in an open environment to eliminate extraneous Doppler effects, the other effects will be largely ignored.

Spectral Analysis

Jaynes [8] showed that when searching sampled, time-series data for a sinusoidal signal at a single constant (but unknown) frequency and phase, the highest peak in the Schuster periodogram indicates the most likely value for the frequency. Bretthorst [2] expounded and extended Jaynes's results to include more complicated signals, particularly multiple well-spaced sinusoids. Other methods to perform this kind of analysis have been proposed and used. [9]

Jaynes and Bretthorst approached the problem as follows. We assume that our sampled data is of the form

$$d_n = A\sin(\omega\frac{n}{r} + \theta) + \epsilon_n$$

where n ranges from 0 to $N-1$ (i.e, we have N regularly spaced data points), r is the known sampling rate, A, ω and θ are the unknown amplitude, frequency and phase (all three constant), and ϵ_n is a noise sequence, assumed to be independent random variables taken from a Gaussian distribution of zero mean and constant (but unknown) variance σ^2. Probability theory is then used to calculate an analytic expression for the probability distribution of ω, after eliminating everything else as nuisance variables:

$$P(\omega|d_n) \propto \left[1 - \frac{2C(\omega)}{N\overline{d^2}}\right]^{\frac{2-N}{2}}$$

where the Schuster periodogram has appeared:

$$C(\omega) = \frac{1}{N}\left[P^2(\omega) + Q^2(\omega)\right]$$

$$P(\omega) = \sum_{n=1}^{N} d_n \cos(\omega\frac{n}{r}) \qquad Q(\omega) = \sum_{n=1}^{N} d_n \sin(\omega\frac{n}{r})$$

$$\text{and} \quad \overline{d^2} = \frac{1}{N}\sum_{n=1}^{N} d_n^2$$

A discrete Fourier transform can now be used to find $C(\omega)$'s peak within the resolving power of the transform. Two techniques suggest themselves for improving this resolution — zero padding the data input to the DFT, or using numerical techniques to search for the local maxima. We can estimate the error in ω by numerically integrating under $C(\omega)$ and picking an error bar that encloses some suitable probability.

However, this entire analysis is based on the assumption that we are sampling a simple sinusoid (plus noise). In fact, we know from the previous page that our sampled signal is more complicated than a simple sinusoid and we should take this into account, if for no other reason than to improve our error estimate. I expect the most dominant deviation from a simple sinusoid to be the amplitude modulation due to varying distance between the radar and the reflector target. This spectral analysis theory will have to be modified accordingly. Bretthorst [2] develops a more general version of this theory that I haven't yet studied and therefore don't yet know if it is suitable for this analysis.

Incidentally, this enhancement will produce an estimate of the distance from the radar to the target.

Auxiliary data

Preliminary analysis suggests some non-obvious data that should be collected along with the primary data:

- Temperature and relative humidity of the air (in case our calculations are accurate enough to require correction for air's dielectric constant)
- Distance from experimental apparatus to reflector target (both to monitor the near-to-far-field transition and in case our analysis, modified for amplitude modulation, is good enough to estimate a distance to the target)
- Diagrams or photographs of the reflector target and its positioning relative to the apparatus (in case we wish to later modify the analysis to improve on the point source assumption)

References

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[5] http://www.schlenkerenterprises.com/21-whittam_precision_scales.htm

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[9] Vityazev, *Time series analysis of unequally spaced data: Intercomparison between the Schuster periodogram and the LS-spectra*, Astronomical & Astrophysical Transactions, Volume 11, Issue 2, November 1996, pages 139 – 158.

[10] Bretthorst, "Excerpts from Bayesian Spectrum Analysis and Parameter Estimation" in *Maximum-Entropy and Bayesian Methods in Science and Engineering*, **1**, pp. 75-145, Kluwer, 1988.