2006-395: THE DESIGN OF AN ABET ACCREDITED LASER TECHNOLOGY PROGRAM AND ITS RELATIONSHIPS WITH ENGINEERING PROGRAMS

Charles Neuman, Queensborough Community College

Charles Neuman is an Assistant Professor of Physics at Queensborough Community College of the City University of New York. His research interests include accelerator physics, free electron lasers, and education. He also serves as PI on a CUNY grant on education research.

David Lieberman, Queensborough Community College

David Lieberman is a Professor of Physics at Queensborough Community College of the City University of New York. His research interests include bio-physics, laser, and education. He had several NSF grants and is currently serving as PI on a NSF grant on designing remote laser laboratory for teaching technicians

Don Engelberg, Queensborough Community College

Don Engelberg is a Professor of Physics at Queensborough Community College of the City University of New York. His research interests include nuclear physics, laser physics, and education. He was awarded several NSF grants and is currently serving as PI on a NSF grant in laser physics education.

Alex Flamholz, Queensborough Community College

Alex Flamholz is an Assistant Professor of Physics at Queensborough Community College of the City University of New York. His research interests include bio-physics, electronics, and education. He worked in photonics research and development at IBM for many years before returning to teaching recently.

Paul Marchese, Queensborough Community College

Paul Marchese is an Assistant Professor of Physics at Queensborough Community College of the City University of New York. His research interests include geophysics, laser physics, and education. He also serves as PI on a NSF geophysics grant.

George Tremberger, Queensborough Community College

George Tremberger, Jr. is a Lecturer in the Physics Department of Queensborough Community College of the City University of New York. His research interests include astronomy, anthropology, and education. He also serves as PI on a CUNY grant for exo-planet study.

Tak Cheung, Queensborough Community College

Tak David Cheung is a Professor of Physics at Queensborough Community College of the City University of New York. His research interests include bio-physics, astronomy, and education. He also serves as PI on a CUNY grant in bio-physics.

The design of an ABET accredited laser technology program and its relationships with engineering programs

Abstract

An ABET accredited laser technology program was designed for an AAS degree curriculum as well as for a smooth transition to a 4-yr engineering program. Important issues such as calculus preparation, instruction level, and student mindset, were addressed in a flexible AAS program supplemented with graphical programming, e-portfolio student mentoring, internet assisted instruction and look-ahead capability for upper division courses. The teaching of graphical programming is conducted in LabVIEW, and data analysis is performed using Excel. The goal of e-portfolio student mentoring is to have an early focus on student mindsets. Internet assisted instruction is used for developing self-learning skills. The use of Schaum's engineering and technology series enables look-ahead capabilities for upper division courses in a cost effective way. Costs effectiveness is important as most students in our community college work to pay for their college expenses. The laboratory exercises are supplemented with numerical simulation in analogy to practical situations where there are no closed form mathematical expressions. The numerical simulation also has the advantage of setting the student's attitude to understand the difficulties of the associated inverse problems, which usually are the problems that demand attention in the upper division courses as well as in a workplace. With input from the program advisory board, the program is designed to enrich a student's life-long learning experience and keep abreast of new developments in laser technology. The laser program design could also be extended to other technologies with similar principles. Articulation issues with a BS degree program were also discussed.

I. Introduction

The Queensborough Community College City University of New York (CUNY) has a laser technology program accredited by ABET. Although it is a 2-year AAS degree program, many students transfer to 4-year college engineering programs regularly and some have continued to graduate school. Our college is located in New York City and many of our students are first generation college students. Queensborough also has a degree program in pre-engineering. All together, the transferring student spectrum is rather wide, ranging from the best students who are admitted to Ivy League colleges such as Columbia and Yale to others who continue in a general engineering program such as City College, another unit of CUNY. Some of our working graduates from the laser technology program attend school part time. In these cases it often takes many more years to complete the various 4-year degree programs. The laser program courses are listed on the college website (www.qcc.cuny.edu).

Our experience shows that the initial advisement and high school preparation is rather important in order to properly place the transferring student into the correct program. Some students do change their minds on their courses of study and join our programs later on. We have devised plans to accommodate those students. The ABET accredited laser technology program contains a simplified calculus course that is not suitable for engineering programs. Fortunately, our laser technology program has a strong LabVIEW component and could be used to bridge the calculus gap.

We have been using internet assisted teaching and e-portfolio mentoring for our laser students. The electronic media prepares the mindset for life long learning. Schaum's outlines and simulation using Excel and LabVIEW prepare a student's mindset for a 4-yr program setting. Project and research opportunities are also available. The laser program advisory board keeps us abreast of the needs of the industry and helps us to design projects at the appropriate level for technology students as well as for those interested in transferring to a 4-year degree program.

II. Program Design

II-A Remedial courses and mathematics preparation

About 50% of our students need remedial courses in reading and mathematics. Our experience shows that a student who starts out in a remedial algebra course has very little desire to transfer to a 4-year degree program. The converse is true: Those who master algebra well like to keep the option to transfer open. To this end, we have supplemented our technical physics and laser courses with Excel spreadsheet capabilities. The philosophy is simple: a TI calculator in high school would evolve to Excel programming in college. The Excel programs are used in laboratory data analysis such as linear regression and matrix calculation in optics. Many engineering courses use Excel programming. For example, a search of the Proceedings of the American Society for Engineering Education Annual Conference & Exposition for the last two years, 2004 and 2005, produces a listing of multiple Excel application reports in various engineering courses.

The use of Excel programming has an added advantage in terms of calculus application. The following Excel simulation example would illustrate the advantage. The fundamental gravitational and electrical force-distance relationship in introductory physics is quite difficult to demonstrate. In the case of gravity, the standard use of a torsion balance would require a extremely stable environment. In the case of electrical force, the high voltage involved may pose an additional safety issue. The essence is not for the students to re-discover the laws of physics, but rather to learn how to go about to verify/discover the relationships. Therefore we developed a laboratory exercise to demonstrate the methodology using permanent magnets and a balance. The idea is rather simple. A bar magnet sits horizontally on a balance and another vertical bar magnet is moved across changing the balance reading. The difficulty is that the uncertainty is not directly obtainable from a formula.

Simulation could be used to calculate the expected result. There are four poles. Using the inverse square law, the balance reading (total vertical force) versus distance could be calculated easily in Excel. The Excel columns are essentially the columns that calculate the changing angles as the vertical magnet moves along horizontally. The experimental result can be compared to the simulated result to assess the uncertainty. A log-log plot can be used to compute the power law index. In fact, this simulation can also be done in a lecture setting where the electric field is being sought given a certain charge configuration. There are two essences in this simulation. First, we show the students that there is not always a formula to describe uncertainty. Second, if a student can understand the relationship between the data in Excel's columns and the changing angles, our experience shows that the transition to an engineering physics course, where a student is required to write down (or build) the integral, would be seamless.

In general, the laboratory exercises are supplemented with numerical stimulation in analogy to practical situations where there are no closed form mathematical expressions. Simulation as an education tool has been used for at least 45 years [1]. Using numerical simulation also has the advantage of setting the student's attitude to understand the difficulties of the associated inverse problems, which usually are the problems that demand attention in the upper division courses as well as in the workplace. For a technology student, the transition from technical physics to engineering calculus physics is the crucial required paradigm shift in that student's mindset. The calculus foundation is enhanced by the Excel programming.

II-B Student financial aid issues

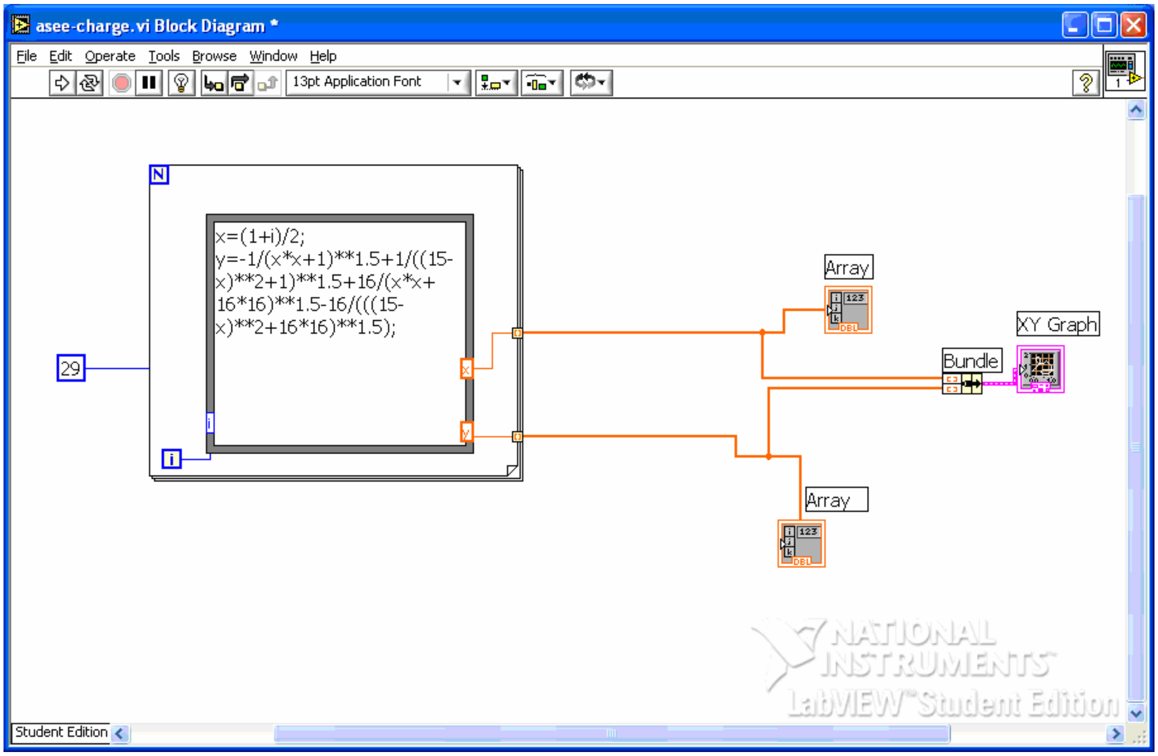
Financial aid issues are important in a student's college plan. Academic advisement must consider this aspect of a student's academic career as well as academics. Some of our students complete the 2-year laser technology program and then afterwards work a full-time job and attend night school. The night school program consists of pre-engineering courses such as more rigorous calculus and chemistry courses. The idea is that a degree in laser technology enables a student to get a reasonable income after only two years of college. The laser technology program contains some general science methods such as Fourier optics and laser gain mechanism. Exposure to these topics enables a student to understand the materials in a pre-engineering program readily. This preparation is important when a student works a full-time day job and attends night school.

II-C E-portfolio implementation

Our college encourages instructors to use e-instruction and students to use e-learning. The campus has wireless network. A technology fee is collected to upgrade high tech equipment such as computers. E-portfolio mentoring enables learning to tie in with writing in a comfortable environment. The City University of New York has implemented a writing intensive component in all its degree programs. Student writing is a good marker for critical thinking level. Those who only write in the "what" level have less critical thing skills than those who can also write in the "what if" level [2]. Depending on the questions and answers in the emails, the e-portfolio can serve as an adjustable tool for enhancing communication and critical thing skills at various levels.

II-D LabVIEW graphical parallel programming

The use of LabVIEW has two important aspects. LabVIEW provides an integrated environment for data acquisition and equipment control, with the possibility of a remote laboratory accessed via the internet for "not-hands-on-intensive" labs [4]. LabVIEW also provides the advanced students a tool for data analysis beyond that of Excel. Using the above magnet example, the ease of using LabVIEW to perform a calculation using a graphic display is demonstrated in the following block diagram. (The magnet example with Excel programming is illustrated in the Appendix.)



The calculation box can be modified for any formula, and the link to the graphics is obvious. LabVIEW graphical parallel programming combines the power of Visual Basic, in the ease of calculation, and Excel, in the ease of data plotting. This LabVIEW tool exposure is very important to shape the student mindset for advanced courses in a 4-year engineering program. In fact, a search of LabVIEW reports in the Proceedings of the American Society for Engineering Education Annual Conference & Exposition for the last two years 2004 and 2005 produces multiple listings for various engineering courses.

Further information on the authors' use of Labview application is included in the paper, "LabVIEW graphical programming in an introductory engineering physics course", also presented in the 2006 ASEE conference.

II-E Textbooks and Schaum's outlines

Textbooks and look-ahead capability using Schaum's outlines are important aspects to the program. The laser textbooks are selected with the consideration of including students who are transferring to 4-year programs. We are using the standard 4-year college engineering textbooks in the laser program as well as many numerical examples and simulations to supplement the materials. Technical aspects such as laser alignment are demonstrated with in-class materials and examples from the internet. The technical aspects are usually very hands-on, and a particular hands-on skill usually depends on the specific manuals at that particular environment. The Schaum's outlines are used as references because it is within a student budget and the content levels are widely accepted in other colleges. The Schaum's outlines are particularly important for transfer students because they offer glimpses to the advanced upper division courses within a reasonable budget. The Schaum's outlines examples are excellent source materials for problem practice.

II-F Internet assisted instruction and life long learning

There are many websites that have extensive instructional materials. Beside the obvious use as supplementary materials in teaching, the internet also carries information about the companies and the industry. Many of our students have very little understanding of the difference between a 2-year technology program and a 4-yr BS (BSEE, BSME etc,) program. The internet can be used to clarify these misconceptions and help the students to make informed choices. For example, the products of a company and how they are produced stimulate the students' minds. The teaching of entrepreneurship is important [3], and a handful of students have eventually formed their own companies. The input from the advisory board is important to select the products since instructional time is limited. Information is the basis for life long learning and the readiness for internet information access would enhance the interest.

II-G Miscellaneous issues for transferring student

The practical issues such as course transferability, credit by examination and independent study have to be addressed to provide a smooth transition. There are cases where a student starts as a technology student, taking an algebra physics course, and wants to switch to a calculus physics course, and that calculus physics conflicts with a laser course. In this case, an independent study session is usually the best solution for the student. In some cases, a college to which the student would transfer would not accept algebra physics I and calculus physics II and III as a fulfillment of the a three-semester calculus physics requirement. The solution would be for the student to get credit for calculus physics I, using the "credit by examination" option. In our articulation agreement with Hunter College (BS degree), for example, a student can take a special 2-credit calculus optics course so that all the laser technology credits are then accepted.

The number of transfer credits that a student might receive is generally not of significant concern. Our community college students know that continuing to a 4-yr program is already an achievement. They understand that a low level remedial course is not transferable as that course does not exist in a 4-year curriculum. A high level sophomore-junior course sometime is also not transferable because of ABET accreditation considerations in a 4-year program. In this scenario, the important thing is to use standard textbooks and to build up a student's confidence. When that student repeats the course in a 4-yr program, the instructor who he/she learned from first will be vindicated. The psychological impact of boosting confidence for a new environment is extremely important for the transferring student, not to mention that he/she will spread word to other students in the community college that switching curriculum works.

III. Assessment

The assessment of the program and its courses are needed for the purpose of continuous improvement. It is also part of the requirement for ABET accreditation. Our survey of own graduates let us know about whether the preparation that we provide is sufficient. Dialogue with 4-yr college professors helps to select projects at the appropriate level for those transferring students. Statistical analysis of grades is important to check the design of pre-requisites and co-requisites for our courses. For example, a correlation of grades from a technical physics I course and the pre-requisite technical mathematics course was conducted. The data is displayed below.

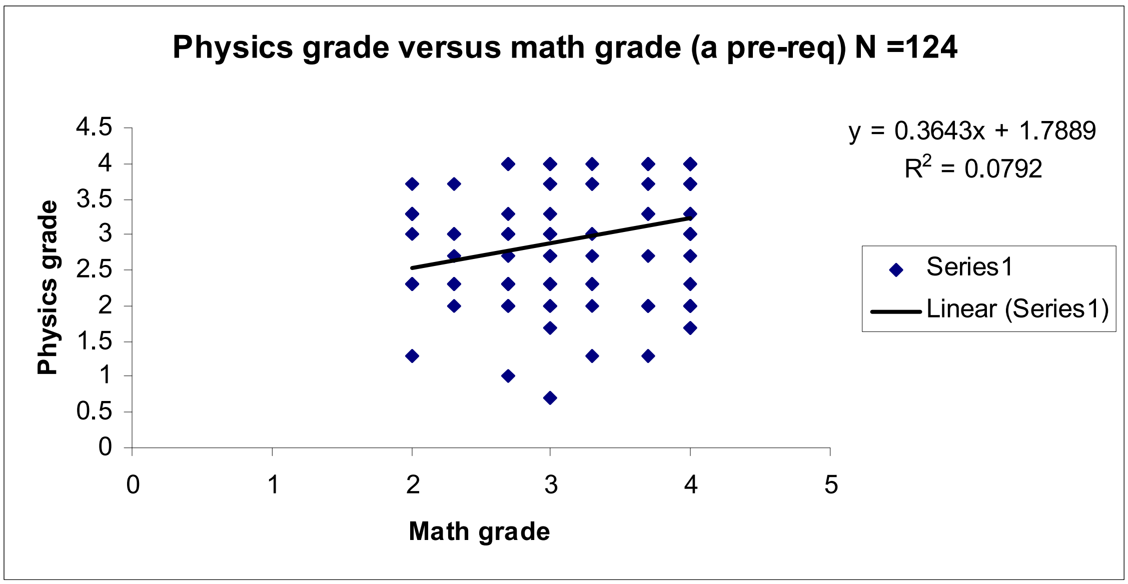


Figure 1. Physics grade versus Mathematics grade (a pre-requisite).

The correlation is rather poor as the data points form a wide band. This is in part due to open admissions with a very diverse student population in an inner city setting. The learning styles are probably diverse as well [5]. The students with high mathematics and physics grades are usually interested in continuing to a 4-year program.

Assessment has been an active issue in physics education [6]. The Force Concept Inventory and Dynamics Concept Inventory are good examples [7, 8]. For the second semester of a physics course, we design questions that are extensions of the first semester of the physics course. For example, the cross product in planetary angular momentum is used again as cross product in the Biot Savart law (considering the case where the current is elliptical). The matrix operation for ray tracing in the first semester of optics is used again for cavity stability design in the next optics course. Excel column programming steps and LabVIEW block diagram paths are important for the instructor to diagnose the conceptual mistakes. The use of rubrics was reported to enhance the assessment from year to year [9].

IV. Other technology programs

Besides the laser technology program, our college also has two other programs in electrical technology mechanical technology. Regardless of which engineering curriculum a technology student chooses, the student has to switch to the calculus physics engineering sequence. The technology courses may not be transferable to the chosen engineering curriculum. In these cases, a mixture of summer courses and independent sessions would help. In any event, our engineering physics sequence is designed with Excel programming together with some limited use of LabVIEW. The education techniques described in Section II that we used for our laser technology program can also be implemented for other technology programs.

Conducting research projects with students also help to keep the transfer option open for the students [10, 11]. The Excel and LabVIEW skills that we taught are particularly useful for these projects. Usually research involves equipment from other technology departments. Some research projects involve professors from 4-year programs.

V. Conclusion

The design of a laser technology program in relationship to an engineering curriculum is presented. The transition from technical physics to engineering calculus physics is the crucial required paradigm shift in a student's mindset. The use of Excel and LabVIEW in data analysis and simulation prepares students well for the paradigm shift and for keeping the transfer option open.

VI. Acknowledgements

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VII. Appendix:

An Excel program is used to calculate the force in a 4-charge configuration.

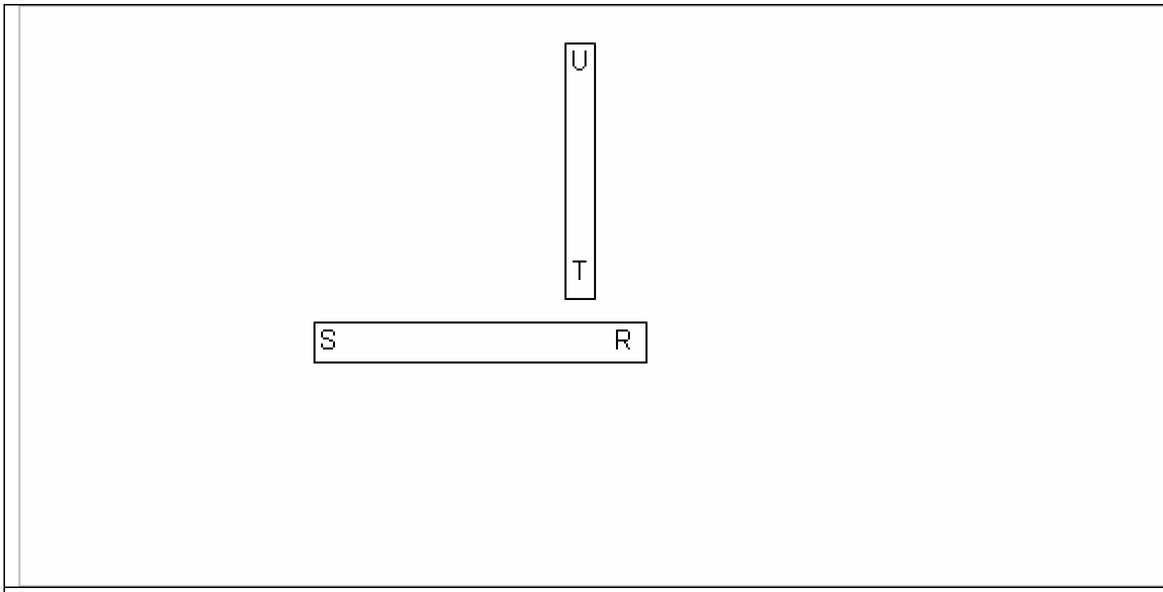
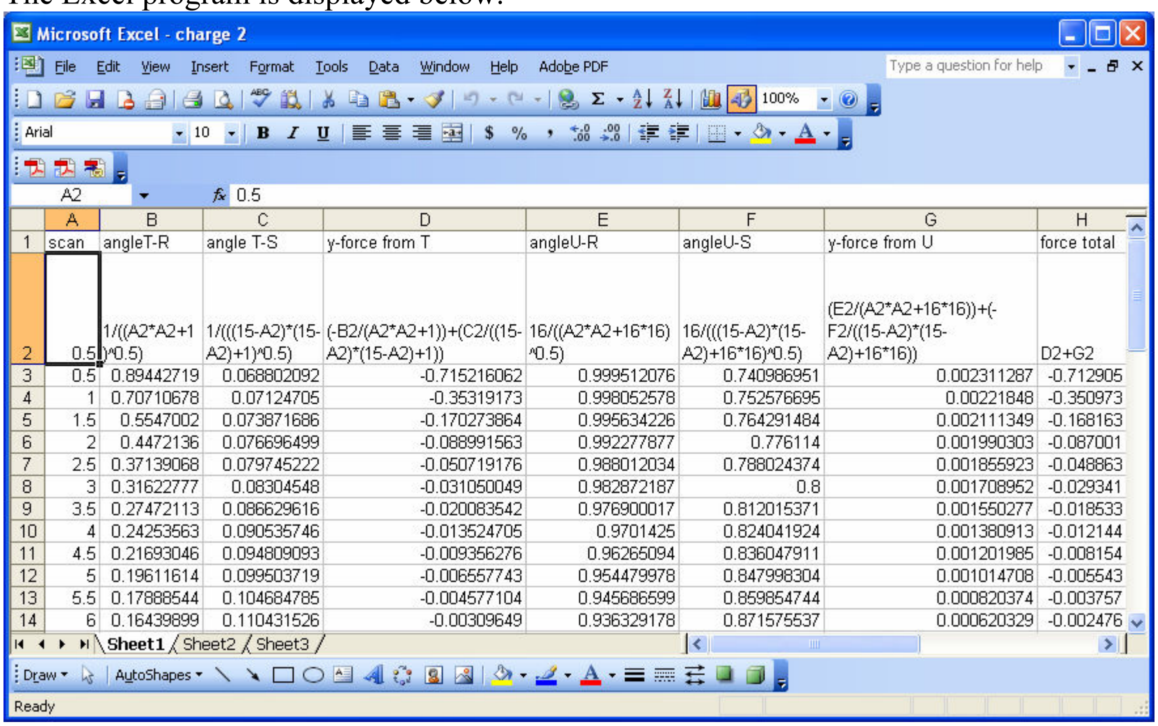


Figure A-1: The R, S, T, U charges are located on two bars. R-S and T-U are different polarities for the case of magnets. The T-U bar scans horizontally. The two bars are of equal length (15 cm). The vertical T-U bar is 1 cm above the horizontal R-S bar

The Excel program is displayed below.



Microsoft Excel - charge 2

A2 fx 0.5

	A	B	C	D	E	F	G	H
1	scan	angleT-R	angle T-S	y-force from T	angleU-R	angleU-S	y-force from U	force total
2	0.5	1/((A2*A2+1)^0.5)	1/(((15-A2)*(15-A2)+1)^0.5)	(-B2/(A2*A2+1))+(C2/((15-A2)*(15-A2)+1))	16/((A2*A2+16*16)^0.5)	16/(((15-A2)*(15-A2)+16*16)^0.5)	(E2/(A2*A2+16*16))+(-F2/((15-A2)*(15-A2)+16*16))	D2+G2
3	0.5	0.89442719	0.068802092	-0.715216062	0.999512076	0.740986951	0.002311287	-0.712905
4	1	0.70710678	0.07124705	-0.35319173	0.998052578	0.752576695	0.00221848	-0.350973
5	1.5	0.5547002	0.073871686	-0.170273864	0.995634226	0.764291484	0.002111349	-0.168163
6	2	0.4472136	0.076696499	-0.088991563	0.992277877	0.776114	0.001990303	-0.087001
7	2.5	0.37139068	0.079745222	-0.050719176	0.988012034	0.788024374	0.001855923	-0.048863
8	3	0.31622777	0.08304548	-0.031050049	0.982872187	0.8	0.001708952	-0.029341
9	3.5	0.27472113	0.086629616	-0.020083542	0.976900017	0.812015371	0.001550277	-0.018533
10	4	0.24253563	0.090535746	-0.013524705	0.9701425	0.824041924	0.001380913	-0.012144
11	4.5	0.21693046	0.094809093	-0.009356276	0.96265094	0.836047911	0.001201985	-0.008154
12	5	0.19611614	0.099503719	-0.006557743	0.954479978	0.847998304	0.001014708	-0.005543
13	5.5	0.17888544	0.104684785	-0.004577104	0.945686599	0.859854744	0.000820374	-0.003757
14	6	0.16439899	0.110431526	-0.00309649	0.936329178	0.871575537	0.000620329	-0.002476

Sheet1 / Sheet2 / Sheet3

Ready

The above Excel columns are used to compute the vertical forces on the horizontal bar as exerted by the vertical bar. The vertical bar scan across the horizontal bar and a plot of force versus scan distance can be generated. A log-log plot would extract the power law dependence of force versus distance. The simulation result can be used to compare to the experimental data when the force is measured by a balance. Furthermore, students who understand the Excel columns usually have no trouble in constructing the integral for a continuous charge configuration.

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