

TC2K–Lessons Learned from Evaluation Visits

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Abstract

The author has participated in two Technology Criteria 2000 (TC2K) accreditation visits and has found a general lack of understanding about how to prepare for a TC2K visit. This paper provides some insights into the TC2K requirements, focusing on the revised 2004 criteria, and suggestions that may help with developing a program for a department. Suggestions include ideas for development of the Educational Objectives and Program Outcomes, preparation of the self-study report, course outlines, the assessment process, and arrangement of the display materials. The opinions expressed in this paper are solely those of the author and should not be considered to represent an official ABET position.

Introduction

With the adoption of TC2K for accreditation the Technology Accreditation Commission (TAC) of ABET requires accredited programs to define objectives and outcomes and to prove to the visitor that they are being met and that the program is being continually improved. TAC conducted TC2K pilot visits in 2001, which were followed by a two-year phase in for the new criteria. Institutions were able to choose to be accredited with the old or new criteria in 2002 and 2003; however, all accreditation visits by TAC will use TC2K beginning in 2004. In addition, the TC2K have been reorganized and modified for 2004.¹ The new TC2K includes eight criteria:

1. Program Educational Objectives
2. Program Outcomes
3. Assessment and Evaluation
4. Program Characteristics
5. Faculty
6. Facilities
7. Institutional and External Support
8. Program Criteria

The Self-Study instructions² provide guidance as to what must be included in the Self-Study report and the display materials, but experience from two visits has provided a number of lessons. In the next sections, we'll consider the criteria and offer some suggestions to help make your visit go more smoothly.

Criteria 1 to 3

Criteria 1, 2, and 3 are closely related and form the heart of the continuous improvement process with

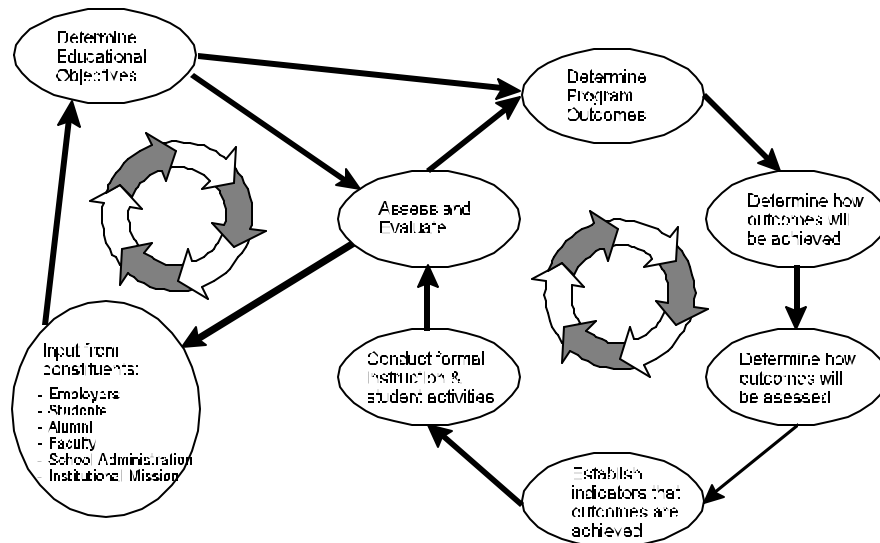


Figure 1: ABET Two-Loop Assessment/Evaluation Process

respect to the curriculum. Figure 1 shows the well-known ABET “Two-Loop” diagram, which encompasses the first three criteria. The left loop shows what ABET calls the Educational Objectives and is the “slow” loop, while the right loop shows the Program Outcomes and is the “fast” loop. ABET defines the terms Educational Objectives and Program Outcomes both in the criteria and in the self-study instructions. Recognizing that some schools have practiced continuous improvement for some time using their own terms, ABET allows you to use terms of your choosing. As a result, I highly recommend that at the beginning of your self study report you include a paragraph of definitions, indicating the terms you have chosen to use, even if you are using ABET’s terminology. This will make it clear to the evaluator what your terms mean.

In both visits in which I participated, the Educational Objectives (EOs) were not clearly defined, indicating that this might be an area of misunderstanding. One way to think of the EOs is that *Educational Objectives are the reasons your program exists*. They are how you represent your program to your constituents. Thus, ABET requires that the EOs be developed with input from your constituents. As shown in Figure 1, constituents could include employers, students, alumni, the faculty, the school administration, and the institutional mission. It is essential that you have documentation of how your EOs were developed and the inputs that were considered.

Your display materials should include minutes of meetings with your Industrial Advisory Board that show the EOs were presented and discussed as well as evidence of input from your other constituents. The EOs should follow from the institution’s mission and thus may be very different for two-year programs and four-year programs or community colleges versus R1 universities. For example, as part of its mission, a two-year community college might include workforce development to support of local industries. An R1 university, on the other hand, might have as part of its mission to develop the state’s economy and to contribute to the welfare and advancement of human societies throughout the world. In either case, the self-study should include the institutional mission and an explanation of how the EOs are derived from them. If possible, it might be desirable to make a matrix of the objectives expressed

in the institutional mission versus the EOs of the program and put it in the self-study report.

Assessment of the EOs will likely involve surveys of program graduates and employers, so your self-study should include copies of the survey and, if available, summaries of the analysis of the survey results. Of course your display materials will include detailed analysis of survey results and backup material such as the returned surveys. Other information that might show achievement of the EOs could include placement of new graduates and job titles of students several years after graduation. Of course, this is a continuous process, as implied by the circular arrow in Figure 1. Thus, there should be a regular interval for collecting data from surveys and evaluation of the EOs; e.g., every two or three years.

The right side of Figure 1 shows the development and assessment for the Program Outcomes (POs), which are defined by ABET as, "...statements that describe what units of knowledge or skill students are expected to acquire from the program to prepare them to achieve the program educational objectives." As the definition implies, the POs should be related to the EOs. The self-study instructions suggest a table to correlate the outcomes to the objectives. As an evaluator, I found that to be very helpful and believe it should always be included.

Of course, the EOs must also encompass the well-known items "a" to "k" that are listed in criterion 2. One way to come up with a set of POs is to adopt "a" to "k" with some modification to correspond to the program (e.g., for EET, MET, etc.); however, the preferred method is to develop a smaller set of outcomes that cover those in criterion 2, as well as program specific outcomes in criterion 8. The self-study instructions require a description of how the POs encompass the criterion 2 outcomes, so again a table is a good way to visually convey the information so the evaluator can rapidly understand the relationships. As a side note, I have seen self-studies with all tables at the end and ones with the tables inline in the report. Personally, I find it much easier to read the report when the tables appear as they are discussed so I don't have to flip back and forth.

Regardless of which method is used to come up with the POs, it is critical that all of the faculty be involved in the process. They should be aware of what TC2K contains, what the POs are and how they are assessed. Part of the accreditation visit is interviewing faculty members and in both visits, when I inquired about the process for developing and assessing outcomes, I found faculty who made statements like, "Well the department head took care of all that." Clearly, when faculty members make statements like that, it is hard to conclude that the continuous improvement process is institutionalized in the department.

Once the outcomes have been determined, it is necessary to decide how they will be achieved; i.e., where will the material to support them be included in the curriculum. The self-study instructions require a matrix or table to show which courses contribute to which POs. In developing such a matrix for our department, some faculty asked me why they should put down that their course contributes to some of the POs, because it might mean more work for them. My reply was that any course that doesn't contribute to the POs probably doesn't belong in the curriculum. They saw the logic in that and were willing to fill out the matrix.

Assessment of the POs can be by a variety of methods, both direct and indirect and these have been described in the literature, as well as at ABET Workshops. While the self-study instructions strongly suggest that display materials should be organized by Program Outcome, I would say, from an evaluator perspective, that this is an absolute must requirement. Under TC2K, each program is required to define its objectives and outcomes and to show how they are being achieved. It is the responsibility of the program personnel to demonstrate this to the evaluator and it is virtually impossible for an evaluator to determine if the outcomes are being met from a set of course notebooks.

I would recommend that the display include a notebook for each outcome (or possibly sub-outcome) showing how the outcome is assessed and evaluated and what actions were taken as a result. Appendix A to this paper contains an example of how a notebook might be laid out for assessing oral communications skills. The first page shows the outcome, where it is evaluated, who evaluates, what the standard is, who assembles the data, some specifics about the evaluation, and a table of contents for the notebook. Clearly, the more specific these are the better. For this outcome, we use a form to evaluate student presentations, so a copy of the form is the next page in the notebook (and in Appendix A of this paper). Section I of the notebook includes summaries of the results and their evaluation by semester. The first page of this section contains a running history of the results by semester and what changes were made to the process. Such summaries will allow the evaluator to rapidly determine whether continuous improvement is occurring as a result of the assessment activities. The summary page is then followed by more detailed summaries of the results and evaluation for each semester, two of which are shown in Appendix A. Not shown in Appendix A is Section II of the notebook. In this case, Section II consists of printouts of the spreadsheets used to record the individual scores by student and evaluator each semester. Finally, the actual score sheets for the most recent semester are included as backup in the notebook.

All of the assessment and evaluation procedures should be detailed in the program's continuous improvement plan, which should be an attachment to the self-study report. My department has a relatively large faculty and we have a number of committees for the curriculum, hiring, promotion, faculty affairs, etc. All of these committees have a role in the continuous improvement process and help to demonstrate faculty control of the program. I recommend that you examine your operation and be sure to include descriptions of your committees and how they contribute to the continuous improvement process.

Criterion 4

This criterion is titled Program Characteristics and deals with the curriculum. The self-study instructions require that course outlines containing specific items be provided as part of the advance materials. Neither program that I visited provided course outlines; course syllabi were provided instead. Although the syllabi may have much of the information requested in the course outline, they typically don't have all of it as a syllabus is intended for the students in the course. In addition, most syllabi are much longer than the two-page limit as they have a great deal of extraneous information (e.g., grading and attendance policies) that is not required for the course outline. Appendix B of this paper shows an example of a course outline. The course outline can be a useful tool for maintaining configuration control of the courses, especially if the assignment of instructors changes from one offering to the next.

In our case, we have a Curriculum Committee that approves all course outlines and any changes to them. Thus, the ABET course outline becomes the official document for what the course contains and what outcomes are expected.

Note that, with the revised criteria for 2004, there was a change in the course outline instructions. Specifically, previous versions of the self-study instructions stated that the course outline should explain the relationship of the course to the program *objectives*. The new version requires the relationship to the program *outcomes*.

The self-study also asks for a description of the process used to insure quality of the core courses, as well as for a description of display materials that will be available to demonstrate achievement related to criterion 4. This virtually requires that course-level assessment be done in addition to the program-level assessment. Thus, I strongly recommend that you also have a set of course notebooks, showing how the assessment and evaluation of each course is conducted. As an example, each course notebook might contain:

1. The course ABET outline
2. The most recent course syllabus
3. A page explaining how the course outcomes are assessed
4. Assessment reports for the course outcomes and evaluation reports for the course
5. Appropriate samples of material to back up the assessment of the outcomes. This could include samples of student work, survey results, etc., depending on how the assessment is done.

Criterion 5

While most of the changes from TC2K 2003 to TC2K 2004 involved reorganization of the criteria, criterion 5, faculty, was significantly modified for 2004. Gone are the mandatory degree levels and three-years industrial experience. Now it is incumbent on the institution to demonstrate that faculty members have sufficient qualifications to teach the courses and areas to which they are assigned. It is also critically important that faculty members participate in professional development activities (i.e., life-long learning) in order to stay current in their fields as the self-study report requires detailed descriptions of such activities for each faculty member. The department should have a professional development plan for faculty development, which should be available during the accreditation visit. As previously mentioned, the faculty will be interviewed and if opportunities for professional development are lacking that will probably come out in the interviews.

Criterion 6

Not every program can have new facilities and equipment, but every program can make the best of what it has. Be sure the facilities are clean and well organized. Bringing the evaluator into a laboratory that looks like a junk room is a sure way to make a bad impression in this area. This criterion also deals with student learning opportunities with modern engineering technology tools. A way to demonstrate that is with samples of student work in your course notebooks, especially if this is included in the course outcomes. One of the modern tools is, of course, the word processor. I strongly suggest

that, with the exception of introductory courses, lab reports by students should be typed on a word processor. Seeing hand-written lab reports on display signals to me, as the evaluator, that students are not learning some of the basic tools of the trade.

Criterion 7

This criterion requires institutional and external support. The industrial advisory committee (IAC) is a very important component of this criterion. If there only five members on the committee of whom only one or two attend semi-annual meetings, it is very difficult for the evaluator to conclude that the IAC is active and that industry input is used to shape the program. Make sure to have enough members that there is a reasonable representation at meetings, recognizing that on any given day probably only one-half of the members will be able to attend. Meeting minutes must be detailed enough for the evaluator to conclude that the IAC is having an impact. Minutes that say the committee met with the department head for dinner and discussed the program are not likely to convince anyone that that is the case. It is very important that IAC members attend the Monday luncheon to show support for the program and to discuss it with the evaluator.

Criterion 8

The final criterion encompasses the program specific criteria that are established by the professional societies. I believe these criteria should be incorporated in the Educational Objectives and the Program Outcomes.

Summary

TC2K affords each accredited programs the opportunity to define its outcomes and to demonstrate how they are being achieved, but this requires documentation to prove the case. In this paper, I have provided some perspectives and tips based on conducting two accreditation visits using TC2K. Organization of the display materials is critical to demonstrating achievement of the outcomes. In particular, notebooks or folders should be prepared for each outcome, as well as for core courses. Faculty involvement is also very important; it will rapidly become apparent to the visitor if one individual has done all of the preparations for the accreditation visit. Likewise, an active industry advisory committee or board is important both in developing the program objectives and in the continuous improvement of the program. Meetings of the advisory committee should be well-documented with detailed minutes of the meetings to show industry involvement.

References

1. *CRITERIA FOR ACCREDITING ENGINEERING TECHNOLOGY PROGRAMS*, Effective for Evaluations During the 2004-2005 Accreditation Cycle, November 1, 2003, Technology Accreditation Commission, ABET, Inc., Baltimore, MD, http://www.abet.org/info_prgrs.html
2. *Self Study Questionnaire*, Technology Accreditation Commission, ABET, Inc., Baltimore, MD, http://www.abet.org/info_prgrs.html
3. *Assessment Methods*, Gloria Rogers, in ABET Technological Education Initiative Regional Faculty Workshop, Lafayette, IN, March 2002
4. *Classroom Assessment Techniques, 2nd Edition*, Thomas Angelo and K. Patricia Cross, Jossey-Bass, 1993

Biographical Information

Tim Skvarenina was born in Chicago. He received the BSEE and MSEE degrees from the Illinois Institute of Technology and the Ph.D. in electrical engineering from Purdue University. He is the primary author of one textbook and is the Editor-in-Chief of a Power Electronics Handbook.. He has served as Chair of the ASEE PIC III, and as Vice President for Professional Interest Councils and member of the board of directors of ASEE.

APPENDIX A

ASSESSMENT OF ORAL PRESENTATION SKILLS

Outcome 1.2:	Students deliver effective oral presentations
Where evaluated:	Senior Design final project presentation
Who evaluates:	Faculty & Industry Advisors
How evaluated:	Completion of presentation evaluation form for each presentation by faculty, peers, and/or industry advisors
Standard:	Delivers well-organized presentation within specified time, displays confident manner, maintains audience contact, minimal distracting mannerisms
Who assembles data:	Department Assessment Coordinator

Specifics:

Senior design presentations occur in ECET 497 for the EET students and in ECET 396C for students in the EET Program with CpET Option. The 497 projects and presentations are individual efforts, while the 396C projects and presentations are team efforts. Students are expected to dress professionally for the presentation.

Senior design presentations are evaluated by groups composed of three or four faculty members and industrial advisors (as available). The presentation skills are evaluated using the attached form.

The assessment coordinator compiles the results of the evaluations in a spreadsheet for evaluation. Each of the 14 items on the form is averaged over the number of evaluators for every student. The 14 items are then averaged to obtain a total score for the individual. The goal for success is that the average score of the group be greater than 3.5 and that 90% of students obtain an average score of 3.0 (satisfactory) or higher. Results are also compiled for each of the 14 items to determine if any areas need to be emphasized more in class.

Contents of this folder:

- Section 1: Evaluation of results by semester
- Section 2: Detailed scoring results by semester

Evaluation of Presentation

Your Name _____ Presenter _____

Circle the number that you feel represents your observations of the presentation

1=Needs major improvement; 2=needs some improvement;

3=satisfactory; 4=very good; 5 = excellent

Vocal quality of presentation:

1. Speaker could be heard easily 1 2 3 4 5
2. Speaker varied tone of voice 1 2 3 4 5
3. Speaker spoke at an appropriate rate,
not too fast or too slow 1 2 3 4 5
4. Speaker did not use distracting terms
(e.g., “uh”, “ok”, “you know”, etc) 1 2 3 4 5

Nonverbal quality of presentation:

1. Established & maintained eye contact with audience 1 2 3 4 5
2. Appeared confident 1 2 3 4 5
3. Avoided distracting mannerisms
(e.g., jingling keys/coins in pocket, hand on chin, etc) 1 2 3 4 5
4. Appeared comfortable interacting with audience 1 2 3 4 5
5. Speaker was not overly dependent on notes or script 1 2 3 4 5

Organization and content of presentation:

1. Provided introduction or stated purpose of presentation 1 2 3 4 5
2. Presented material in well-organized manner 1 2 3 4 5
3. Used language appropriate to presentation
(not too formal, not excessively casual) 1 2 3 4 5
4. Explained ideas clearly 1 2 3 4 5
5. Made effective use of visual aids 1 2 3 4 5

Summary of Changes Made to Senior Presentations and Evaluation

2000-2001 Academic Year: Students required to use PowerPoint presentations and to bring projects and any necessary test equipment to classroom for presentation and evaluation.

Spring 2001: Presentation skills evaluated separately using form with 14 items. Only 497 presentations evaluated this time. Results of presentation evaluations were very satisfactory. Some concerns expressed over requiring 497 students to move projects in and out of classroom in a short time.

Fall 2001: Both 497 and 396C presentations evaluated. The 497 evaluations were satisfactory; however, problems occurred with the 396C evaluations. Faculty had a hard time shuffling forms for the team members as they got up and down and weren't always sure who was talking. Future 396C students to be reminded to clearly identify themselves and the work they did on the project. Again the faculty expressed concerns over 497 students having to move projects and test equipment to the classrooms.

Spring 2002: EET 497 senior presentations returned to the laboratories so students could set up equipment prior to presentations. Computer projectors borrowed to allow PowerPoint presentations in the labs. All students receive an overall average of at least acceptable and averages for all students was greater than 3.5. The 396C students had a higher average this time than the 497 students. Faculty still complained about paper shuffling in the 396C presentations.

Fall 2002: Evaluation forms were redesigned to allow multiple individuals to be evaluated on a single page. This is particularly in response to faculty concerns in evaluating 396C presentations. All results were satisfactory (all students had average score greater than 3.0 and the overall average was greater than 3.5), although the faculty requested more time be allocated to the team projects.

Spring 2003: The time allocated for presentations was modified to allow 40 minutes for teams and 20 minutes for individuals. All results were satisfactory (only one out of 53 students had an average score below 3.0 and the overall average was greater than 3.5); no additional requirements for change were noted.

Evaluation of Senior Presentation Skills: Spring 2003

This semester there were 23 graduating seniors in EET 497 and 29 in EET 396C. All presentations were evaluated using the form shown in the introduction to this notebook. Again this semester, both 396C and 497 labs were assigned to the same labs; i.e., each group of evaluators looked at both types of project.

Table 1 shows the average scores for the students in 497, while Table 2 shows the average scores for the students in 396C. Note that the average score for each student is obtained by averaging the scores for the 14 items on the form.

Table 1: 497 Student Scores			Table 2: 396C Student Scores			
4.79	4.29	3.95	4.64	4.27	3.93	3.75
4.74	4.23	3.87	4.64	4.19	3.92	3.63
4.70	4.16	3.80	4.50	4.16	3.88	3.61
4.67	4.15	3.71	4.43	4.10	3.84	3.59
4.61	4.02	3.57	4.40	4.01	3.82	3.59
4.52	4.02	3.50	4.34	4.00	3.82	3.23
4.48	4.00	3.38	4.31	3.93	3.75	2.89
4.38	3.97		4.29			
Avg. = 4.15			Avg. = 3.98			

Table 3

Item #	Avg.Score 497	Avg. Score 396C	
1	4.37	4.08	Looking at Tables 1 and 2, only one of the 53 students had an overall average below 3.0 (satisfactory) and that one was 2.89. The class averages for both the 497 and 396C presentations were well above 3.5
2	4.02	3.87	
3	4.22	4.08	
4	4.13	3.82	
1	4.27	3.92	Table 3 shows the average scores for each of the 14 items both for 497 students and 396C students. Again, the results for each item were very good for the 497 and 396C students.
2	4.08	3.92	
3	4.12	4.12	
4	4.09	3.93	
5	4.25	3.90	The schedule for presentations was modified this semester to allow 40 minutes for groups and 20 minutes for individuals, as shown on the attached page. The faculty seemed much happier with this schedule. No additional changes were suggested for next year.
1	4.17	4.05	
2	4.06	4.05	
3	4.20	4.19	
4	4.06	3.88	
5	4.09	3.94	

Evaluation of Senior Presentation Skills: Fall 2002

This semester there were 15 graduating seniors in EET 497 and 24 in EET 396C. All presentations were evaluated using the form shown in the introduction to this notebook. This was the first time for the form with multiple evaluations on a single page. This was done to allow the evaluators to use a single form for the team presentations in 396C, but was also convenient for 497. This semester, both 396C and 497 labs were assigned to the same labs; i.e., each group of evaluators looked at both types of project. Table 1 shows the average scores for the students in 497, while Table 2 shows the average scores for the students in 396C. Note that the average score for each student is obtained by averaging the scores for the 14 items on the form.

Table 1: 497 Student Scores		Table 2: 396C Student Scores			
4.66	4.08	4.89	4.19	3.76	3.49
4.52	3.94	4.68	4.13	3.73	3.48
4.46	3.86	4.64	4.07	3.66	3.46
4.41	3.81	4.64	3.97	3.66	3.39
4.36	3.67	4.41	3.90	3.64	3.21
4.15	3.63	4.21	3.83	3.50	3.08
4.09	3.58				
	3.26				
Avg. = 4.03		Avg. = 3.87			

Table 3

Item #	Avg. Score 497	Avg. Score 396C	
1	4.42	4.02	Looking at Tables 1 and 2, all students achieved overall averages above 3.0 (satisfactory) and the averages for both the 497 and 396C presentations were well above 3.5
2	3.83	3.75	
3	3.99	3.85	
4	3.97	3.76	
1	3.94	3.83	Table 3 shows the average scores for each of the 14 items both for 497 students and 396C students. Again, the results for each item were very good for the 497 and 396C students.
2	3.98	3.78	
3	4.00	3.83	
4	3.99	3.72	
5	4.18	4.16	
1	4.18	3.86	The use of the new evaluation form seemed to alleviate the faculty problems with the team evaluations. There were complaints, however, of insufficient time for all the presentations, but especially the 396C team presentations. The schedule was essentially 30 minutes for groups and 20 minutes for individual, as shown on the attached page. The faculty recommended more time for the 396C presentations.
2	4.20	4.06	
3	4.08	3.91	
4	3.62	3.57	
5	4.08	4.13	
			The course coordinator agreed to modify the schedule next time to allow more time for the group presentations.

APPENDIX B

Course Outline

Catalog Data: ECET 231 Electrical Power and Controls Class 3, lab. 3, cr. 4.

Prerequisites: ECET 207, MA 221, PHYS 218.

This course introduces magnetic materials and properties followed by analysis of transformers and power conditioning equipment, induction motors, and single-phase and three-phase power systems. Motor control devices, programmable logic controllers, PLC input and output devices, and power system communications and monitoring are introduced.

Required Texts: Electrical Power and Controls, Skvarenina and DeWitt, Prentice Hall, 2001

Electrical Power and Controls Laboratory Manual, Skvarenina and DeWitt, Learning Systems, (Updated Annually)

Coordinators: Timothy L. Skvarenina and William E. Dewitt, Professors of ECET

Course Objectives:

After completing this course, the student should be able to:

1. State and practice the principles of electrical safety.
2. Apply circuit analysis principles to calculate real, reactive, and apparent power in single and three-phase circuits.
3. Explain the operating principles of electric machines and transformers.
4. Use mathematical models to solve engineering technology power problems.
5. Explain the origins of, and problems caused by, harmonic currents in the power system.
6. Design basic power and motor circuits in accordance with applicable standards, including sizing wires, circuit breakers or fuses, and overload protection.
7. State the correct wire colors for single and three-phase power circuits.
8. Design, connect, and operate basic relay control circuits.
9. Program PLCs to accomplish basic control functions, and interface them to variable speed drives.
10. Express experimental results and conclusions in concise, technically correct, written discussions with properly labeled graphs.
11. Identify ethical misbehavior or situations and suggest courses of action.
12. Explain some international implications of the use of technology.

Prerequisites by Topic:

- | | |
|---|--|
| 1. Vector algebra | 5. Fourier Series |
| 2. Phasor representation of AC quantities | 6. Energy, work, and power concepts |
| 3. Three phase balanced circuit analysis | 7. Introduction to magnetic quantities |
| 4. Derivatives and integrals | |

Topics Covered (3 lectures, 50 min. each per week for 15 weeks, minus one holiday):

Ethics (1 hr)	Polyphase induction motors(4 hrs)
Power review (1 hr)	Variable-Speed Drives (1hr)
The Power System (1 hr)	Single phase motors (1 hr)
Three-phase power (1 hr)	Relay control circuits (3 hrs)
Power quality (1 hr)	National Electrical Code calculations (1hr)
Power Factor correction (1 hr)	Motor circuit protection (2 hrs)
Magnetic fields/materials (3 hrs)	120/240 volt wiring calculations (1 hrs)
Transformer operation (1 hr)	Fuses and circuit breakers (including GFI) (2 hrs)
Transformer calculations (3 hrs)	PLCs (6 hrs)
Three phase--transformers (2 hrs)	International implications of technology (1 hr)
Generator & motor action (2 hrs)	Four 1-hour lecture exams (4 hrs)
DC machines (1 hrs)	Two-hour final exam in finals week.

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Relationship of the course to program outcomes: This course is required in the Associate program and contributes to Associate Program Outcomes 1, 3, 4, and 5.

1. Communications. Students develop written communication skills by preparing laboratory reports with a word processor that are graded for spelling and grammar, as well as technical content. Students are asked to explain what they are doing in lab, giving them oral communications practice. Lab reports include spreadsheet charts and downloaded graphics from power instruments, which develops graphical communication skills. Graphical communication skills are assessed for the program in this course (sub-outcome 1.3).

3. Problem solving. Students are required to complete homework assignments and examination problems. Homework problems often extend beyond the examples in the text and in class. Exam results are used to assess ability of students to apply physics principles to electrical problem solving (sub-outcome 3.4).

4. Ethics. A case study (Enron) is used to demonstrate the importance of professional ethics. Students are required to submit typed answers to several case study questions and are quizzed on the material after the class discussion of the case study. Results of the homework and quiz are used to assess the achievement of sub-outcome 4.3.

5. Social awareness. A case study (Global Warming) is used to demonstrate some of the international implications of the use of technology. Students are required to submit typed answers to several case study questions and are quizzed on the material after the class discussion of the case study. Results of the homework and quiz are used to assess the achievement of sub-outcome 5.3.

Laboratory Experiments and Related Activities: Lab meets once a week for three hours. Labs 2-6, and 8-10 require a Power Harmonics Analyzer (e.g., Fluke F41)

1. Introduction to electrical safety, multimedia presentation
2. AC Power Measurement: single phase induction motor, resistive and RLC loads
3. Three-Phase Power Measurement: resistive and RLC loads
4. Power Quality: nonlinear loads, Uninterruptible Power Supply
5. Single Phase Transformer: short-circuit, open-circuit, and full-load tests
6. Three Phase Transformer Connections, Observation of Third-Harmonic Current
7. DC Generator Saturation Curve: tachometer, DC motor prime mover and DC generator, resistive load
8. University Power Plant Tour: Observe steam boilers, control center, 10 MW and 30 MW generators
9. Three Phase Induction Motor: induction motor, dynamometer, tachometer, resistive load
10. Variable Speed Control of three-phase Induction Motor: variable frequency drive, induction motor
11. Control Circuits for Motor Starters: Motor controllers, relays, three-phase induction motor
12. Reversible motor starter: Motor controllers, relays, three-phase induction motor
13. PLC Programming.
14. PLC control of a variable-speed AC motor drive.
15. Makeup session/holiday depending on lab schedule

Use and operation of analytic and measurement equipment:

Students use harmonic analyzers to take a variety of power measurements, many of which are downloaded to the computer. Spreadsheets are used for calculations and plotting, and a word processor is used to prepare laboratory reports including graphs and figures. A dynamometer is used to measure motor torque, and a tachometer is used to measure motor speed.

Student competence with design practices, tools, and techniques

Although this course is not a design course, students are required to design relay and PLC control circuits for homework and in lab. They also design a motor feeder circuit for homework, including wire size, protective devices, and disconnects.

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