Spring 2006

Network Infrastructure Essentials Course Development

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Abstract

Voice and data cabling enable people around the world to communicate by phone, fax, and computer. Cabling is the basis for virtually every network. Today’s voice and data cabling is engineered to balance high performance with cost efficiency. The quality of the service provided by the cabling is directly related to the quality of the installation. Properly installed cabling can provide years of service for networks, in most cases outlasting every device connected to the network. Experience has taught us that too many people don’t realize the importance of cable infrastructure.

At Alfred State College, in the Computer Engineering Technology curriculum there is not a course specifically targeted at the cable infrastructure. This project was to develop a new course aimed at the cable infrastructure to be implemented into the curriculum. This paper is about the entire course development process from project inception to course implementation. Although this project was to design a network infrastructure course, the process used could be applied to develop a new course for any curriculum.

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Introduction

At Alfred State College, in the Computer Engineering curriculum, there is not a course specifically targeted at the cable infrastructure. This project was to develop a new course aimed at voice and data cabling. The course was designed for students interested in the physical aspects of voice and data network cabling and installation. The course focuses on cabling issues related to data and voice connections and provides an understanding of the industry and its worldwide standards, types of media and cabling, physical and logical networks, as well as signal transmission. The course covers copper, fiber-optic, and wireless networking media. By developing this course the students will leave Alfred State College with a better understanding of the effects of cable installation. This will ultimately lead to better cable infrastructures as students enter the work force and begin to use what they have learned.

Need for Project and Background

History of Communications

Cabling for communications began with the telegraph, which found use in railroads and the stock exchange (stock tickers). The telegraph fell out of favor after the telephone was invented. Using their voices instead of having to rely on operators and delivery persons was appealing. Telephones also offered a little more privacy. People could speak their message rather than have an operator write it down for delivery. Soon telephones appeared in homes as well as businesses.

Fax machines eventually followed, and then computers that could communicate via modem. The Internet, originally a government project for defense purposes, blossomed. Alternatives to modems for Internet access drove communications into the domain of Digital Subscriber Line (DSL) and Cable modems, as well as some radio and satellite systems.

Most of these systems used a method of communications called Internet Protocol (IP). Ironically, the world is now heading rapidly towards IP Telephony, or Voice over IP. Wires that once carried a single voice conversation can now carry Digital Subscriber Line (DSL) signals that in turn carry many voice conversations at once. Industrial equipment and building automation systems are adopting IP as well.

At the same time as communications is settling toward a specific protocol, communications wiring is too. This ordered system is called structured cabling, and the rules are designed so that modern cabling is more or less the same worldwide.

Computer Cabling History

Originally, network cabling was unique to each manufacturer and bore little resemblance to the wiring used for telephones. Computer networks standardized first on coaxial cable, and then on twisted pair. The requirements for computer networks were more stringent than for voice, so the cabling was gradually improved. Today, telephones and computers can use the same general type of cable. All cables can travel in the same wiring trays and use the same telecommunications rooms, and adhere to the same rules of installation. This structured cabling system greatly simplifies facility wiring and eases maintenance and future expansion.

As computer and networking technology have advanced over the past few decades, the cost of the increasingly sophisticated technology has fallen dramatically. Those falling prices are at least partially responsible for the rising popularity of connectivity solutions in the business world and in personal lives. More solutions requiring bandwidth on the network requires that the network devices and cabling be more robust. Also, as the speed of computers increase, so does a need for faster interconnections between them. Technologies that are rising to meet this challenge include wireless, fiber-optic, cable modems and DSL.

The Relationship between High-Quality Cabling and Cabling Costs

The job of the cable installer is to provide good, technically accurate cabling between all communications devices such as telephones, fax machines, computers, or automated industrial equipment. It is not just the quality or expense of the wires that is important, but the manner in which they are placed.

Cabling will be in use for years. It is more economical for customers to pay a little more up front to make sure the job is done correctly, conforms to standards, and is scalable. To illustrate, consider the expense and effort of upgrading from a system that used non-standard cabling to a system that requires a modern structured cabling system.

Cabling is perhaps the most economical component of a network. Cabling typically represents less than 10 percent of the overall network investment, yet has a useable lifespan of typically 10 to 15 years. If they are well installed according to standards and codes, cables originally installed for one purpose or system can often be used for other roles.

The Relationship between High-Quality Cabling and Reliability

Many problems can be traced to inadequate wiring practices. It is amazing how many companies will insist on painting stripes on their parking lots regularly, yet will tolerate almost any kind of bird’s nest in their telecommunications rooms.

Many technicians hesitate to approach the telecommunications backboards for fear that they will inadvertently disconnect something by accident. This leads to a worse prospect. Undocumented hubs and switches may start sprouting in unknown locations. These may seem to solve an immediate situation but in doing so they cause a worse one. The timing of Ethernet signals requires that all paths from the telecommunications room to the work area be within a certain length. Extra switch gear not only violates wiring standards, it may cause network problems on its own.

Existing Project Situation

Alfred State College, a member of the technology college sector within the State University of New York (SUNY) system, offers educational opportunities for students in its 60 associate degree programs, 12 baccalaureate degree programs, and several certificate programs. As a department in the School of Management and Engineering Technology, the Electrical Engineering Technology Department offers both Associates and Bachelors degrees in Computer Engineering Technology.

The Computer Engineering Technology program provides the knowledge and skills necessary for employment as technologists who are capable of installing, designing, supporting, and maintaining computer systems and networks. This is a hands-on, technically oriented program with a focus on computer system hardware and network infrastructure. The program is designed to prepare students for the rigorous professional certification examinations leading to certifications such as CompTIA A+ and Network+, Microsoft Certified System Administrator (MCSA), Microsoft Certified System Engineer (MCSE) and Cisco Certified Network Associate (CCNA).

When talking about network infrastructures one of the areas lacking in the program is an in-depth study of cable infrastructures. Students graduating from the program needed to have an understanding of cabling infrastructures, how to install them and the standards associated with them. Therefore a new course needed to be developed to address this area.

Goal of the Project

This project entails the development of a new course aimed at voice and data cabling. The name of the course is Network Infrastructure Essentials. The course was designed for students interested in the physical aspects of voice and data network cabling and installation. The course focuses on cabling issues related to data and voice connections and provides an understanding of the industry and its worldwide standards, types of media and cabling, physical and logical networks, as well as signal transmission. The course covers copper, fiber-optic, and wireless networking media. The course is a required course in the spring semester for not only associate level and bachelors level students in the Computer Engineering Technology program but is also an elective course for the IT and Architectural curriculums.

The goal of this project was to develop a complete set of course materials for Network Infrastructure Essentials. The course materials consisted of the course description, course prerequisite, course objectives, grading policy, required text, course syllabus, course schedule, lecture materials, lab materials, exams and keys. The lecture materials included all PowerPoint's used in lectures as well as sample exams with keys for the instructor to use. The lab materials have labs as well as lab solutions. With the completion of this project the course is now available to be offered.

Barriers and/or Issues to Project

As with any project, there are barriers and/or issues to making the project a success. This project was no different. An issue that was addressed was the approval and support of the department faculty to create the Network Infrastructure Essentials course. The author discussed this with the department faculty and everyone agrees that a course like this is needed in the Computer Engineering Technology Curriculum.

The second issue is that the current curriculum requires 133 credit hours to graduate. As the college is pushing to get these programs to 130 credit hours adding another course to increase the required credit hours is not acceptable. Therefore, if a course is added one must be removed. The department has discussed this and has decided to remove an Electronic Communications course that is analog based and geared more to Electrical Engineering students.

The third issue is that this course must be approved at the college level. In order to be approved there must be no other course offered like it on campus. This course is unique and no other department is offering anything like it on campus. Therefore, no resistance to this course was expected and none was received.

The fourth issue deals with implementing the course. In order to run the course one must have the required equipment and classroom space. The department addressed the equipment issue by using money from a grant for the initial equipment and put money in the yearly budget for additional equipment and supplies. The department chair identified a classroom and will schedule this room for delivery of this course.

Scope of Project

The scope of this project was to develop the required materials for course approval at the college level and the development of course materials required to deliver the course. The course materials consisted of the course description, course prerequisite, course objectives, grading policy, required text, supplemental printed resources, supplemental Internet resources, course syllabus, course schedule, lecture materials, lab materials, and sample exams with keys.

Definitions, Acronyms and Abbreviations

ABET	Accreditation Board for Engineering and Technology
CCNA	Cisco Certified Network Associate
IP	Internet Protocol
MCSA	Microsoft Certified System Administrator
MCSE	Microsoft Certified System Engineer
SDLC	Systems Development Life Cycle
SUNY	State University of New York
DSL	Digital Subscriber Line
WBS	Work Breakdown Structure

Table 1 – Definitions, Acronyms and Abbreviations

Review of Literature / Research

Overview of all Literature and Research on the Project

Research on the project centered around three distinct areas: curriculum development, infrastructure and text selection.

Literature and Research that is Specific / Relevant to the Project

Curriculum Development Research

In doing the curriculum develop research one finds out that the most important aspect of designing a course is to develop the goals and objectives first and then design the course to achieve them. Research identified two resources for helping with this.

In "Understanding by Design," Wiggins and McTighe (2005) lay out a conceptual framework for instructional designers. Unlike many instructional design models that come from a training background, the Wiggins and McTighe model is well suited for the academic community. Two of their biggest contributions are:

- The "backwards design" instructional design model
- The "Six Facets of Understanding"

The backwards design model centers on the idea that the design process should begin with identifying the desired results and then "work backwards" to develop instruction. This is contrary to the traditional approach which is to define what topics need to be covered first. The Wiggins and McTighe “backwards design” model identifies three main stages:

- *Stage 1:* Identify desired outcomes and results.
- *Stage 2:* Determine what constitutes acceptable evidence of competency in the outcomes and results (assessment).

- *Stage 3***:** Plan instructional strategies and learning experiences that bring students to these competency levels.

The six facets of understanding try to answer the following questions. What is the enduring idea? What will they remember about the topic in five years?

Six Facets of Understanding

- *Explain:* Provide thorough and justifiable accounts of phenomena, facts, and data.
- *Interpret:* Tell meaningful stories, offer apt translations, provide a revealing historical or personal dimension to ideas and events; make subjects personal or accessible through images, anecdotes, analogies, and models.
- *Apply:* Effectively use and adapt what they know in diverse contexts.
- *Have perspective:* See and hear points of view through critical eyes and ears; see the big picture.
- *Empathize:* Find value in what others might find odd, alien, or implausible; perceive sensitively on the basis of prior indirect experience.
- *Have self-knowledge:* Perceive the personal style, prejudices, projections, and habits of mind that both shape and impede our own understanding; they are aware of what they do not understand and why understanding is so hard.

Another useful tool when developing course objectives and outcomes is something that Alfred State College uses. This is known as Bloom’s Taxonomy. Bloom’s Taxonomy defines categories of knowledge that help one to develop objectives for a course.

Bloom's Taxonomy

There are six levels in Bloom’s classification with the lowest level termed knowledge. The knowledge level is followed by five increasingly difficult levels of mental abilities:

comprehension, application, analysis, synthesis and evaluation. The table below displays the six levels of Bloom's taxonomy, definitions of each level and verbs that would be appropriate to use when one is writing instructional objectives in each level.

Level 1: Knowledge

Objectives written on the knowledge level require the student to recall specific information. The knowledge level is the lowest cognitive level. Below are verbs appropriate for objectives written at the knowledge level.

define	fill in the blank	identify	label
list	locate	match	memorize
name	recall	spell	state
tell	underline		

Level 2: Comprehension

Objectives written on the comprehension level, although a higher level of mental ability than knowledge objectives, require the lowest level of understanding from the student. Below are verbs appropriate for objectives written at the comprehension level.

convert	describe	explain	interpret
paraphrase	put in order	restate	retell in your words
rewrite	summarize	trace	translate

Level 3: Application

Objectives written on the application level require the learner to apply a rule or principle. Below are verbs appropriate for objectives written at the application level.

apply	compute	conclude	construct
demonstrate	determine	draw	find out
give an example	illustrate	make	operate
show	solve	state a rule or principle	use

Level 4: Analysis

Objectives written on the analysis level require the student to break an idea into component parts and describe the relationship. Below are verbs appropriate for objectives written at the analysis level.

analyze	categorize	classify	compare
contrast	debate	deduct	determine the factors
diagnose	diagram	differentiate	dissect
distinguish	examine	infer	specify

Level 5: Synthesis

Objectives written on the synthesis level require the student to put the parts together to form a new whole. Below are verbs appropriate for objectives written at the synthesis level.

change	combine	compose	construct
create	design	find an unusual way	formulate
generate	invent	originate	plan
predict	pretend	produce	rearrange

reconstruct	reorganize	revise	suggest
suppose	visualize	write	

Level 6: Evaluation

Objectives written on the evaluation level require the student to make a judgment about materials and methods. Below are verbs appropriate for objectives written at the evaluation level.

appraise	choose	compare	conclude
decide	defend	evaluate	give your opinion
judge	justify	prioritize	rank
rate	select	support	value

By using these two resources one can develop a course that is geared more toward the objectives and outcomes required.

Infrastructure Research

In doing the infrastructure research two items emerge. They are that most people do not realize the importance or issues concerning the infrastructure nor do they know or understand the standards associated with the infrastructure. The next two sections of this paper, Infrastructure Issues and Infrastructure Standards will try to highlight these two findings.

Infrastructure Issues

Networks are an essential part of modern life, and most networks require cabling. Whether we use networks in our professional or private lives, or both, they now are the basis of most modern communications. Most modern households have at least one computer, and many have home networks. This is largely due to the exponential growth and popularity of the Internet.

Virtually every home in the developed world depends on network cabling for telephone and home entertainment.

Network cabling supports worldwide electronic communications such as computer, phone or fax. This allows organizations, corporations and individuals to exchange information by both voice and data, including multimedia. With cabling costs decreasing while quality and performance increase and with the continued growth of networks including the Internet, the demand for correctly designed and installed premise wiring will continue to increase over time. Along with this increased demand, there is increased responsibility when working with cabling. There are a number of logistical, technical and legal guidelines relating to safety and other issues. Those in the cabling profession must have both technical knowledge and the ability to handle those parts of the job that require manual labor.

The quality of a network's performance is a combination of the characteristics of the cable used and the skill with which the cable is installed. Significant effort has been made in establishing standards that govern how each type of cabling should be implemented to ensure that cabling provides years of service for clients and creates a network infrastructure that will support several generations of hardware. When doing an installation, one should always plan for future bandwidth, throughput and technological needs.

Infrastructure Standards

For some time, companies in the technology industry, including telecommunications, established their own rules and guidelines for design and implementation. These guidelines are usually referred to as standards or protocols. Standard usually refers more properly to a particular technology's layout, operational and/or physical characteristics. In the cabling industry, standards directly govern both informal and structured cabling installations. Protocol more often refers to a description of a communication process or model. For example, protocols used in network communications are developed so that they conform to cabling and other physical-layer standards.

Standards

Standards permit differing technologies to interface. They might be specified and controlled by a single vendor or a consortium of vendors with similar interests in common. Standards are often born out of experience, especially negative experiences. Standards are intended to serve as benchmarks that guarantee quality and stability. This is particularly true in regard to network cabling.

As with many other new industries, the computer and telecommunications industries saw a need for standards as soon as intense competition developed. Such competition often warrants the development of "de jure" standards, that is, standards controlled by an independent judicial body or organization. Prior to the development of such standards, existing standards are "de facto". De Facto standards are set by a dominant vendor within the industry. However, certain areas of the industry are still volatile and do not yet have universally adopted standards. Many vendors view a common standard as an obstruction to their competitive edge.

A need for open systems developed, which are systems in which network components could be combined on any network. Standards bodies cooperated to ensure that consistent standards were available worldwide, creating many standards that overlap. A number of technologies have various identifications that correlate with more than one standards body. This can be somewhat confusing when examining the various technologies and standards, especially standards governing cabling and media.

Private (De Facto) Standards

De Facto standards are informal. De Facto means “existing in fact”. De Facto standards are developed either with the inordinate success of a single company or through a consortium of private corporate partners. De Facto standards often become de jure standards depending on the success of the developer when they are accepted by a substantial segment of the industry. What is often referred to as an “industry standard” is one that has been developed in the field rather than undergoing an official standards-setting process.

One popular de facto standard is the Ethernet local area network (LAN) technology. Bob Metcalf introduced it in 1972, originally as a graduate project. Metcalf, who eventually went to work for Xerox, helped to develop the Ethernet standard further. A modified standard was established later, often known as Ethernet II. It was referred to as DIX Ethernet in honor of the consortium of corporations that developed it: Digital, Intel and Xerox, Cisco Systems (2003).

The IBM personal computer (PC) is also an example of a de facto standard. IBM set the standard for the personal computer early on with the IBM PC and the XT. However, IBM’s market share declined with the development of the AT standard by a consortium of corporations who developed competing standards for PC hardware. More recently, Microsoft’s Windows operating system has become a de facto standard for PC operating systems. Alternatives to Microsoft Windows, such as Linux operating system, must conform to the de facto standards in order to be competitive.

Public (De Jure) Standards

De Jure means literally “according to law” and refers to an official standard, usually legislated by a standards body or organization with no ties to, or bias against, a particular company. De jure standards are meant to ensure compatibility among technologies, but are often used to bar monopolies or to give the users a choice of systems. Many of these standards bodies are large scale with a wide variety of interests. Some technologies have kept up with rapid growth in their industry through forums, which are special interest groups concerned with a specific topic. Asynchronous Transfer Mode (ATM) and Frame Relay are popular examples of standards that emerged from forums.

Every facet of networking, from physical media to user applications, uses de facto standards, some of which include:

- *TIA/EIA-RS-232:* An interface standard for serial connections
- *Transmission Control Protocol/Internet Protocol (TCP/IP):* The protocol suite used for internal intranets and the World Wide Web
- *X.25:* An international packet-switching standard
- *802.x:* A standard series for network architectures and data formats
- *Open Systems Interconnection (OSI) reference model:* An international protocol stack and reference model used in education and protocol development
- *V.90:* A recent standard for 56 Kbps modems that ended the debate over x2 and Flex

Ethernet originally emerged as a private standard, but is now available as a public standard called Carrier Sense Multiple Access/Collision Detection (CSMA/CD). It is more commonly known as IEEE 802.3.

The Purpose of Standards Bodies

Standards bodies provide the impetus for the development of de jure and industry standards. As with other governing bodies, there is an established process for proposing, developing and ratifying standards. These organizations, along with the vendors and users play a vital role in determining whether a standard exists for a technology. Often, standards bodies establish the middle ground and arbitrate technical conflicts between the users and the vendors.

Understanding Cabling Specifications and Standards

Cabling and media currently fall under a number of public and private standards. Cabling specifications and standards help to establish comprehensive guidelines for network cable planning, design and implementation. These guidelines cover cabling elements such as wiring, connections, supporting equipment, insulation, distribution centers and installation methods. These combined specifications and standards are called Structured Cabling Systems. A Structured Cabling System includes the following:

- Description of the media (wiring) and its layout for the work area, horizontal cabling and backbone cabling.
- Standards for cable connectors and other modular interfaces.
- A clear and concise design plan.
- Procedures for testing and certifying cable installation.
- Troubleshooting and maintenance procedures.

All of these elements are governed by various standards that ensure uniformity, safety and compliance of the design plan and finished installation. Designers must be aware of all local, state, national and international standards and codes that affect a particular cabling project.

A network that grows without a structured cabling system plan is ultimately extremely expensive to expand and maintain.

Textbook Research

The literature review of textbooks showed that many texts could be used as either the text for the course or as reference texts. Selecting a text involves more than just the text itself. The designer needs to consider things like who the author or authors are, the published date, does it get updated regularly, can it be used to teach at the college level, will it fit into a 16 week course, are there lab materials, does it have support from industry leaders and does it emphasize certification. All of these things had to be taken into consideration while evaluating texts.

The texts chosen to be evaluated were the following:

- Fundamentals of Voice and Data Cabling by Cisco Systems, Inc., 2003 Edition
- Practical Network Cabling by Frank Derfler and Les Freed, 2000 Edition
- Network Cabling Illuminated by Robert J. Shimonski, Richard T. Steiner and Sean M. Sheedy, 2006 Edition
- Guide to Network Cabling Fundamentals by Beth Verity, 2003 Edition
- The Complete Data Cabling Installers Certification by Brent Wright, 2003 Edition

After evaluation the text chosen was Fundamentals of Voice and Data Cabling by Cisco Systems, Inc., 2003 Edition as the textbook for the course. The following paragraphs explain the evaluation of each text and the reason for the selection.

Practical Network Cabling by Frank Derfler and Les Freed, 2000 Edition

This text seemed to have the majority of the right material but did not seem to be oriented to a college level technology course. It lacked information about signal transmissions. It also was published in 2000 which made it quite old for technology and there was no tie to industry leaders or certifications. Another negative factor for this text was there were no labs associated with it.

Network Cabling Illuminated by Robert J. Shimonski, Richard T. Steiner and Sean M. Sheedy, 2006 Edition

This was the newest text reviewed. Because of that it covered the latest technologies. The authors have years of experience in the field and understand the issues associated with cabling.

The only negatives found were the lack of industry support and no lab materials. This would be a second choice for a textbook or may even be used as an optional text for the course.

Guide to Network Cabling Fundamentals by Beth Verity, 2003 Edition

This text is published by Thomson Course Technology, who is very widely recognized in the education market. In spite of that it is lacking some information deemed as critical to the course. Because this course requires no prerequisite courses, materials such as networking fundamentals and signal transmissions are a must. This text does not cover either of these. The text also lacks ties to industry and lab materials.

The Complete Data Cabling Installers Certification by Brent Wright, 2003 Edition

This text like some of the others lacks material that covers basic networking and signal transmission. It does unlike some of the other texts prepare students for a certification. This is an important factor in the curriculum. Again there is no lab support for this text.

Fundamentals of Voice and Data Cabling by Cisco Systems, Inc., 2003 Edition

This text is part of the Cisco Academy Program of which Alfred State College is a participant. The text and materials are specifically written for technology schools and are supported by Cisco and Panduit. These are both major players in the networking and cabling industry. The text covers the basic networking and signal transmission which are needed for this course as well as all aspects of cabling. The textbook and program is structured for the students to take a certification test at the end of the course if they so desire. Again this is important as certifications are stressed in our programs. Cisco and Panduit also provide discounted products that the college can purchase for use in the labs. This is very important consideration due to the limited funds available to educational institutions. The only negative factor of the textbook is that it was published in 2003. Again this is outdated for use in technology. In talking with Cisco they said that they are working on updating the text and it will be released sometime in 2007. With this being the only negative factor and seeing that it should be resolved soon, this textbook was selected for this course.

Summary of what is known and unknown about the Project Topic

In summarizing what is known about this project topic the author researched three areas. The curriculum development research showed that there are many resources dealing with the proper way to do curriculum development. Two very important resources were highlighted in this report. Other resources that should not be overlooked are resources and guidelines available at peoples own institutions.

The infrastructure research showed that networks are everywhere today and that poorly designed and installed network infrastructures can have a negative affect on a networks performance. The research also pointed out that there are many standards to be aware of when designing and installing a network infrastructure.

The textbook research showed that there are many textbooks out there but many are out of date and do not cover the most important aspects required for course development.

So what is unknown about the project topic? The research performed showed that all information required to develop a course on infrastructure design is available. One needs only to research enough to find it.

Contribution this Project Will Make to the Field

As stated at the beginning of this paper there is a lack of understanding of network infrastructure design issues. This lack of knowledge by network design professionals as well as infrastructure installation personnel can cause significant problems with network performance. This project will help to alleviate this problem by teaching Computer Engineering Technology students the significance of good infrastructure design and installation practices. The hope is that they will then apply the knowledge they have learned about network infrastructures and as a result network infrastructures will be designed and installed more effectively. Thus having a positive impact on network performance.

Project Approach and Methodology

Research Methods

For this project the methods of research were observation, focus groups and online research. A brief discussion on each follows:

Observations

The observation research came from the author's experience in working for ten years with infrastructure design. The author was able to bring a wealth of knowledge to the subject because of personal experiences with bad designs and installations.

Focus groups

The focus groups used for input were students, the author's department, colleagues and the department advisory board. These groups are constituents and as such their input was required in order to judge the viability of the project.

Online research

Most of the research for this project was done online. The research included textbook research as well as research into infrastructure designs, issues and standards to name just a few.

Life-Cycle Model

This project adopted a variation of the Waterfall Model, a systematic and orderly approach to the Systems Development Life Cycle (SDLC). This approach consisted of five steps: Planning, Analysis, Design, Implementation, and Support. This is illustrated in the following diagram:

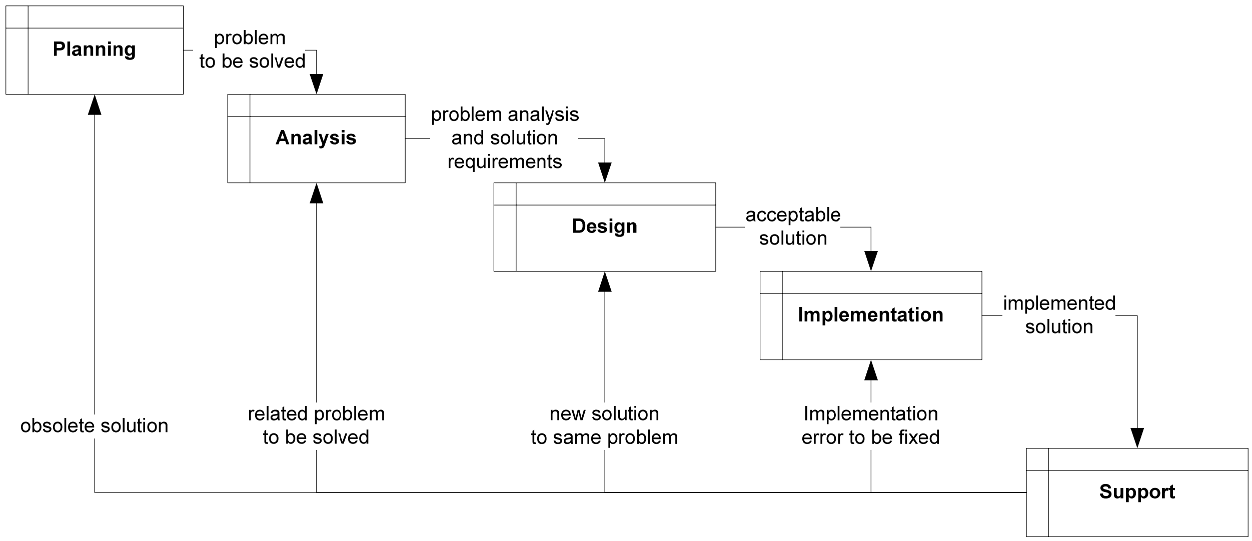

Figure 1 – Systems Development Life Cycle

Specific Procedures

The key tasks and deliverables for each phase of the SDLC are listed below:

Planning

Goal: Identify the need and scope of the course and plan the development strategy and goals.

Activities: Discuss need for course with colleagues, advisory board and students. Create plan for developing course.

Input: Response from colleagues, advisory board and students. Implementation timeframe from department.

Output: Timeline, Work Breakdown Structure, Costs

Analysis

Goal: Substantiate need for course and select text and lab materials.

Activities: Research cable infrastructure needs and requirements. Review textbooks and lab materials for course.

Input: Text books from vendors and cable infrastructure research.

Output: Feasibility Analysis. Recommendation of course requirements and textbook.

Design

Goal: Develop complete set of course materials.

Activities: Develop course description, syllabus, outline, lecture and lab materials, sample exams and keys.

Input: Text book and research, Bloom's Taxonomy levels 1-3 for development of objectives.

Output: Course description, syllabus, outline, schedule, lecture and lab materials, sample exams and keys.

Implementation

Goal: Get course approved by college and offer class as a technical elective.

Activities: Provide course description to college. Establish timeframe for offering course.

Input: Department input on timeframe and review of course description by college.

Output: Approved course and timeframe for offering course.

Support

Goal: Evaluate and improve course.

Activities: Solicit feedback from student and department advisory board on effectiveness of course.

Input: Survey from students and advisory board.

Output: Recommendations on course improvement.

Results / Deliverables

Planning

- Approved Abstract
    - After discussions with constituents an abstract for the project was developed and approved.
- Project Schedule
    - Developed Using Microsoft Project for project management
- Work Breakdown Structure
    - Used Microsoft Project for project management
- Costs
    - Only costs associated with project was time to develop course.
- Approved Proposal

Analysis

- Feasibility Analysis
    - Need for course was substantiated
- Selected Text
    - Texts were reviewed and one was selected

Design (see appendix for course materials)

- Course Description
- Course Syllabus
- Course Outline
- Course Schedule
- Course Lectures

- Course Labs
- Sample Exams and Keys

Implementation

- Approved Course
    - Course was submitted and approved in fall 2006
- Timeframe for course offering
    - Course will be offered in spring 2007

Support

- Student Evaluation
    - After each semester student evaluation will be conducted
- Advisory Board Recommendations
    - Yearly review of curriculum is done by board to recommend changes

Resources

Resources used for this project were the author's time, computer, software, the World Wide Web, book publishers, colleagues and the advisory board. All of the resources really related to time on the authors part. It did not require any additional expenditure from the college's standpoint.

Resource Type	**Resource Description**
Hardware	Author's computer
Software	Microsoft Project
Software	Microsoft Word
Software / Hardware	World Wide Web
Personnel	Author's time

Personnel	Book publishers
Personnel	Advisory Board
Personnel	Department
Personnel	Colleagues

Table 2 – Resources

Outcomes

The outcome to a structured project approach and methodology is that it forces one to plan the project before you begin. It also helps to keep the project on task and following a logical sequence of events. Without a structured approach to any project it is hard to see where one is in the process, how much it is costing and if one is meeting their deliverables.

Summary

The research methodology used for this project was a combination of observations, focus groups and online research. The life-cycle model used for the project was a variation of the Waterfall Model, a systematic and orderly approach to the Systems Development Life Cycle (SDLC). This approach consisted of five steps: Planning, Analysis, Design, Implementation, and Support. Each step provided a deliverable for the project. In order to complete this project certain resources were used and they are also outlined in this chapter. The conclusion of this chapter is that in order to run a project effectively one needs to use a structured project approach.

Analysis of Project Results

Project Inception

Five years ago the author left the IT corporate world to accept a position as a professor at Alfred State College. The author accepted the position because of the work previously done as a consultant/trainer and as an adjunct professor. The author believed that having twenty five years of experience in the IT field would be a great asset to students. This project is a good example of how that experience can help to improve the IT education offering. This background leads to the inception of this project.

The last ten years that the author was working in the corporate world was as a Technology Director for an Architectural and Engineering firm. Responsibilities in this firm were two-fold. The author was responsible for directing the IT operations of the corporation as well as directing the technology design and consulting that was offered to clients. One of the things observed while consulting and designing networks was the general lack of knowledge of the network infrastructure. Clients and contractors were not aware of the significance of good installation practices, standards for installation or how this would affect network performance. This was a constant frustration and lead to educating people about the negative affects of bad designs and installations.

Upon arrival at Alfred State College and after looking at the curriculum for Computer Engineering Technology it was noticed that even here the knowledge of network infrastructures was not taught. Over the last five years using the author’s expertise the curriculum has been modified and enhanced. An Internship Program has been introduced and implemented and with this project a Network Infrastructure Essentials course has been developed and is being implemented in the spring 2007 semester.

By having this course the hope is to influence the students graduating to pay more attention to network infrastructures. This will hopefully lead to better networks with less network performance problems.

Project Management

Project management is a critical part of any project. Without proper project management projects come in late, over budget and out of scope. In order to manage a project effectively it is always helpful to use project management software. Project management software allows one to develop a timeline which helps to see where the project is at any time and to make adjustments as needed. It also shows very quickly what happens to a project should a change in the schedule occur.

Microsoft Project was used to manage this project. The project consisted of five tasks: planning, analysis, design, implementation and support. The course development was projected to be completed on December 18, 2005 with implementation or the offering of the course in the spring semester 2006. The timeline for completion of the project was established based on offering the course in the spring semester 2006. If this date was missed then the course would have to be offered in the spring semester 2007. This was not a critical issue, although offering the course sooner would be better. The course development actually was completed in August 2006 and the course will now be offered in the spring semester 2007. A Gantt chart for the initial baseline work schedule of this project is show below:

ID		Task Name	Duration	Start	Finish
1		**Planning**	**40 days**	**Mon 3/7/05**	**Mon 5/2/05**
2		Abstract	2 wks	Mon 3/7/05	Fri 3/18/05
3		Approved Abstract	0 days	Mon 3/21/05	Mon 3/21/05
4		Project Schedule	6 wks	Mon 3/21/05	Fri 4/29/05
5		Approved Proposal	0 days	Mon 5/2/05	Mon 5/2/05
6		**Analysis**	**80 days**	**Mon 5/2/05**	**Fri 8/19/05**
7		Feasibility Analysis	8 wks	Mon 5/2/05	Fri 6/24/05
8		Text Research	8 wks	Mon 6/27/05	Fri 8/19/05
9		Text Selection	0 days	Fri 8/19/05	Fri 8/19/05
10		**Design**	**80 days**	**Mon 8/22/05**	**Fri 12/9/05**
11		Course Description	4 days	Mon 8/22/05	Thu 8/25/05
12		Course Outline	4 days	Fri 8/26/05	Wed 8/31/05
13		Course Schedule	2 days	Thu 9/1/05	Fri 9/2/05
14		Course Lectures	7 wks	Mon 9/5/05	Fri 10/21/05
15		Course Labs	7 wks	Mon 10/24/05	Fri 12/9/05
16		**Implementation**	**80 days?**	**Mon 1/16/06**	**Fri 5/5/06**
17		Approved Course	0 days	Mon 1/16/06	Mon 1/16/06
18		Offered Course	80 days?	Mon 1/16/06	Fri 5/5/06
19		**Support**	**0 days**	**Fri 5/5/06**	**Fri 5/5/06**
20		Student Evaluations	0 days	Fri 5/5/06	Fri 5/5/06
21		Advisory Board Recoomr	0 days	Fri 5/5/06	Fri 5/5/06

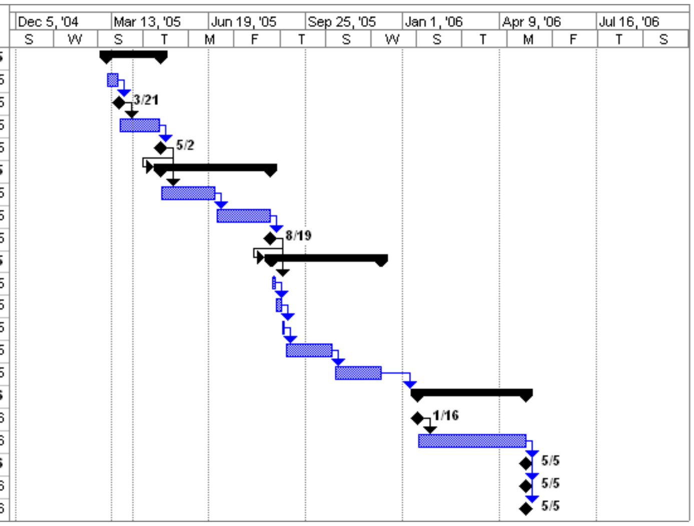

Figure 2 – Gantt Chart

Significant Events & Milestones

Significant Events

- Text research showed that most texts need to be updated.
- Design delays:
    - Personal issues – Due to personal family health issues the timeline was affected.
    - Accreditation Board for Engineering and Technology (ABET) Accreditation – ABET Accreditation for the department took place in the fall 2006 semester. Therefore work on ABET paperwork up to and including the fall 2006 semester affected the timeline.
    - Faculty member leave of absence – Due to personal reasons one of the faculty members of the Electrical Engineering Technology department took a leave of absence.

Milestones

- Department Approval – The department approved the development of the new course during a weekly department meeting
- Removal of Electronic Communications course from curriculum – In order to add a new course one had to be removed in order not to increase the current credit hours required to graduate. The department elected to remove Electronic Communications as a required course. This again transpired during a weekly department meeting.
- College level approval – All new course offering have to be approved at the college level. The proper paperwork was sent and the college approved the course in fall 2006.
- Funds for equipment – The initial equipment will be purchased through a NYSTAR grant that the department has. Additional equipment will be budgeted for in the annual budget.
- Classroom for delivery of course – The department chair selected Room 114 for the delivery of this course.

Task Name	**Start**	**Finish**
Planning		
Abstract	3/7/05	3/18/05
Approved Abstract	3/21/05	3/21/05
Project Schedule	3/21/05	4/29/05
Approved Proposal	5/2/05	5/2/05
Analysis		
Feasibility Analysis	5/2/05	6/24/05
Text Research	6/27/05	8/19/05
Text Selection	8/19/05	8/19/05

Design		
Course Description	5/06	9/06
Course Prerequisite	5/06	9/06
Course Objective	5/06	9/06
Grading Policy	5/06	9/06
Course Syllabus	5/06	9/06
Course Schedule	5/06	9/06
Lecture Materials	5/06	9/06
Lab Materials	5/06	9/06
Sample Exams	5/06	9/06
Implementation		
Approved Course	9/06	10/06
Offered Course	1/07	5/07

Table 3 - Milestones

Changes to the Plan

Changes to the plan centered on the timeline. Unlike other projects that have plan changes due to design discoveries or other design issues, the plan changes occurred solely due to scheduling conflicts. The project was adhering to the original timeline until it came time for the design phase. At this point three issued were introduced that affected the delivery date of the design. Two of the delays which were personal family health issues and a faculty leave of absence could not have been anticipated. The third delay was caused by the department's ABET accreditation and should have been anticipated and allotted for in the scheduled. This will be covered in more detail in the What Went Right and Wrong section of this paper. The project plan did not change just the timeline was affected. This meant that the course which was originally scheduled to be offered in the spring semester 2006 would not be offered until the spring semester 2007

Goal Evaluation

In order to evaluate whether this project met its goals or not one must look at each phase of the project as well as the overall goal of the project. The phases of the project were planning, analysis, design, implementation and support. Each will be reviewed here to evaluate the individual goals and then evaluate the overall goal.

Planning

Goal: Identify the need and scope of the course and plan the development strategy and goals.

Activities: Discuss need for course with colleagues, advisory board and students. Create plan for developing course.

Input: Response from colleagues, advisory board and students. Implementation timeframe from department.

Output: Timeline, Work Breakdown Structure, Costs

As outlined above, the goal of planning was to identify the need and develop a plan for development of this new course. The author met with the Electrical Engineering Technology department, colleagues from other departments and the advisory board members to discuss the proposal. All the people consulted liked the idea of the Network Infrastructure Essentials course and thought it was needed in the curriculum. From this information a work breakdown structure, timeline and costs associated with the project were developed.

Analysis

Goal: Substantiate need for course and select text and lab materials.

Activities: Research cable infrastructure needs and requirements. Review textbooks and lab materials for course.

Input: Text books from vendors and cable infrastructure research.

Output: Feasibility Analysis. Recommendation of course requirements and textbook.

In the analysis phase, research was done into cable infrastructure needs and requirements. In this research as outlined in the Review of Literature/Research section of this paper there was a confirmation of the need for an understanding of good cabling infrastructures. This substantiates the need for the course.

With the knowledge of the need for the course the feasibility of the course then needed to be investigated. In consulting the Electrical Engineering Technology department it was determined that funds were available, the course could be inserted into the program and that the timeline for implementation was achievable. Therefore the course development was deemed feasible.

Another part of the analysis phase was to review textbooks. In this phase many textbooks were reviewed and finally one was selected. In this phase one of the things discovered was that many of the existing textbooks need updating. The textbook finally selected was published in 2003. After discussion with the publisher there was a confirmation that the textbook will be updated in 2007.

Design

Goal: Develop complete set of course materials.

Activities: Develop course description, syllabus, outline, lecture and lab materials, sample exams and keys.

Input: Text book and research, Bloom’s Taxonomy level 1-3

Output: Course description, outline, schedule, lecture and lab materials.

The goal of the design was to develop a complete set of course materials. This phase of the project was both successful and not successful. It was successful because a complete set of course materials was developed. On the other hand it was not successful because it did not adhere to the original timeline. In this project not meeting the schedule was not a major problem, but on other time sensitive projects it could be a project breaker. This is where project management software can be of help, by showing what will happen to a schedule should a delay occur.

Implementation

Goal: Get course approved by college and offer class as a technical elective.

Activities: Provide course description to college. Establish timeframe for offering course.

Input: Department input on timeframe and review of course description by college.

Output: Approved course and timeframe for offering course.

The goal of the implementation phase of the project was to get college approval for the course and offer the course. The course has been approved by the college and it will be offered in the 2007 spring semester. The only change to the goal is that instead of a technical elective the course is being required for all Computer Engineering students. This change was implemented because of input from the department and advisory board members seeing the need for the knowledge.

Support

Goal: Evaluate and improve course.

Activities: Solicit feedback from student and department advisory board on effectiveness of course.

Input: Survey from students and advisory board.

Output: Recommendations on course improvement.

At this point in the project the support phase has not been done. As the course is taught and feedback is acquired the course will be evaluated and adjusted.

Overall Goal

The overall goal of this project was to develop a new Network Infrastructure Essentials course and to begin to offer it. Looking back at each phase of the project and evaluating it the goals of the project were met. The only negative that can be seen is that it took longer than anticipated to accomplish this. As stated before, for this project the timeline was not a project breaker. That is why the project can be considered a success.

What Went Right and Wrong

After undertaking a project it is a good thing to do an evaluation of what went right and what went wrong. Why do you do this? The biggest reason to do this is to learn from mistakes to make future projects better. Without this evaluation things never get better. That being said lets look at this project with a critical eye.

What went right?

One of the biggest things that went right is that the course developed was one in which the author had expertise. Having the experience in the corporate world in undertaking infrastructure projects made developing the project easier. The author lived infrastructure issues every day and therefore was able to select a text and develop a course to address the issues that are most important in infrastructure design. One should consider this when developing new courses.

Another thing that went right is that there was support from the Electrical Engineering Technology department. Without the proper support for a project it will never be successful. The Electrical Engineering Technology department is very open to making the program better and is willing to change things to make it happen. This is not always the case at all colleges.

Along with this idea of verbal support financial support is also required. Funding of equipment for the labs was required and the Electrical Engineering Technology department decided to use some NYSTAR grant money that it had received. Having verbal support without financial support could be a problem to proper implementation of a project.

The last thing that went right is that by planning the project and using a structured methodology the project was able to keep on task. Even though the timeline was delayed the task sequence was the same and the project plan allowed it to be followed.

What went wrong?

The major thing that went wrong with the project was the delay in the timeline. The timeline was originally established to offer the course in the spring 2006 semester. The only thing critical about this timeline was that the course must be offered in the spring semester. Whether that was 2006 or 2007 it did not matter.

The time delay was due to three issued that arose when entering the design phase of the project. These three issues were personal family health issues, a faculty member leave of absence and the department's ABET accreditation.

At the start of what was to be the design phase of the project, family health issues arose. One issue turned into two and then into three issues to deal with. As a result of these issues the design phase did not start as planned. These issues were not planned for because they were issues that could not have been anticipated. This delayed the project timeline five months.

After dealing with the personal issues the design phase was scheduled to start again. This time another delay was experienced due to a faculty member in the Electrical Engineering Technology department taking an unscheduled leave of absence. This caused an additional workload to be placed on the author for the spring 2006 semester. With this additional workload the design phase could not start again. This caused another delay of four months.

The third issued that caused a delay in the project was the Electrical Engineering Technology department's ABET accreditation. This work which was originally taken into consideration by the author turned out to be more work than anticipated. Due to the unscheduled faculty member leave of absence the author was asked to take on a major role in preparing for the ABET accreditation.

These three issues caused the start of the design phase of the project to be delayed until May 2006.

Project Variables and Their Impact

The major project variable in this project was the time delay. Due to the issued outlined in the What Went Wrong section of this paper the project was delayed nine months. The impact this had on the overall project was that the course originally scheduled to be offered in the spring 2006 semester could not be offered until the spring 2007 semester. This course was designed to be only a spring course and by delaying the project there was no choice but to delay the implementation until 2007. For this project the delay caused a delay in implementation but did not affect the overall project success. This is because the success was not measured by when the course was implemented but if the course was implemented.

Findings / Analysis

In analyzing the project here are the things that are significant findings when developing a new college course. Some of these findings would have been expected but some just kind of jumped out of the project while evaluating it.

The first thing is, new course development comes from faculty. This may seem to be an obvious statement but think about it. Presidents, vice presidents, deans and chairs don’t dictate what courses should be in a curriculum. That is the faculty’s responsibility. Faculty members have the expertise and know what is required for their students to succeed. So don’t be afraid to explore possibilities.

Another thing that should not be taken for granted is the experience one has in a particular area. In this project the author had prior experience in network infrastructure design. This helped immensely when deciding on what to put in the course and selecting text books and other materials. So when thinking about a new course, it will help to have some previous experience in the particular area.

Any project requires the support of other people or entities, in this case, the department, the faculty, and the advisory board. Having support from these constituents as well as financial support for needed equipment is an essential part to a projects success.

Failure to anticipate unforeseen project variables and analyze their impact could negatively affect the outcome of a project. In order to analyze project variables and keep a project on track the use of project management software and a project methodology is required. This project experienced time delays but luckily it did not adversely affect the outcome of the project other than time.

Summary

This project started with the desire of a faculty member in the Electrical Engineering Technology department to teach students the significance of good infrastructure design. This would hopefully lead to better designed infrastructures once the students were in the work force. This was a deficiency in the current Computer Engineering Technology curriculum that the faculty member noticed. Having years of experience in infrastructure design made the faculty member the perfect person to develop the course.

A plan was put together in order to develop the course. The timeline was established based on offering the course in the spring 2006 semester. This information was then put into Microsoft Project in order to manage the project.

Using a structured approach to the project the author was able to evaluate each step along the way and make any necessary changes required.

During the course of the project significant events happened. The first thing of significance was that during text research it showed that most texts needed to be updated. The text ultimately selected was confirmed to be updated in 2007. The second issue that was significant was that the project got delayed at the onset of the design phase. This delay was unanticipated and therefore an adjustment had to be made to the original timeline. This delay lasted nine months and forced the implementation of the course to be postponed until the spring 2007 semester. This turned out not to be a project breaker as the timeline for implementation was not critical.

The analysis of this project indicates that, faculty are the ones who develop new courses. These are the people who are most qualified to develop a new course. Along with this, faculty should develop courses within their realm of expertise. Having experience in a particular area is invaluable when developing a new course. Another important factor when developing new courses is support. Support is required from constituents as well as financial support for needed equipment. This is a key to a projects success. Lastly, failure to anticipate unforeseen project variables and analyze their impact could negatively affect the outcome of a project. This project experienced a significant delay at the onset of the design phase. Because the implementation date was not critical the project was considered a success.

Lessons Learned and Next Evolution of the Project

What Was Learned From the Project Experience

The first thing to learn from this project is that all projects have to have someone who is a champion of the main idea. In other words, someone has to propose an idea and then follow through with the development of it. This person usually has some experience in the area and has a passion for what they are working on or developing. This is a must because there will always be people who will try to discourage someone from doing what it is they are proposing.

The second thing learned was that all projects need support. This support needs to come not only from verbal support but also come in the form of financial support. Having a great idea is one thing, but if one cannot gain support for it then it will go nowhere.

The third thing learned was that any project including a new course development project is a process. What is meant by this? A process is defined as a particular course of action intended to achieve a result. In order to define this course of action one should use a structured approach. This project used the Systems Development Life Cycle (SDLC) as that approach and Microsoft Project to document the process. This structured approach allowed the project to proceed in a logical sequence of events. It also helped to see what would happen to the schedule if it had delays.

The fourth thing learned was that changes to any plan are inevitable. No matter how well one plans there will always be something that causes the plan to change. In this project there was a significant time delay that had to be dealt with. Again this goes back to having a structured approach and using project management software which will allow one to see what impact the changes will have on the overall project.

The last thing learned was that course development takes time. It is not just a one semester process. From the inception of an idea to the implementation of the course there are many issues to be addressed. Issues such as department approval, when to offer the course, financial support, text selection, the course development itself and college level approval can take many semesters. If the idea is sound and there is a champion for the idea it will find its way to implementation.

What Might Have Been Done Differently

The thing that caused the most problem in the project was the time delay at the onset of the design phase. Two of the issues were unanticipated and could not have been planned for. This being said, one might put time in the schedule for unanticipated issues that may arise. The third issue which was the department ABET accreditation should have been anticipated better. Even though the author picked up more work due to an unforeseen faculty leave of absence the author should have anticipated that the whole ABET process would be very time consuming. What is learned here is “plan for the worst and hope for the best.”

Did the Project Meet Initial Expectations

The goal of this project was to develop a new Network Infrastructure Essentials course and to begin to offer it. By evaluating each stage of the project and determining that they were a success, then one can say that the project as a whole was a success.

When the idea of a network infrastructure course was conceived, it was envisioned as a course that could be offered in the Computer Engineering Technology curriculum. This course would provide the students graduating from the program the critical knowledge of network infrastructure that was lacking from their education. This project has succeeded in developing the course and getting college approval. As of this writing the course is already over capacity for the spring 2007 semester. This is an indication that students are indeed interested in this as part of their education. As a result this project has met its initial expectations.

Next Stage of Project Evolution

Now that the project has met its initial expectations what is next? After the spring semester a survey will be conducted of the students who take the course. Their responses will be analyzed and adjustment made to the course as needed. As the course is taught and issues arise the course will be adjusted to make the offering better. As students get into the workforce and feedback is received from them on the relevance of the course changes will also be made to the course. This will help keep it relevant to an ever changing industry.

Conclusions / Recommendations

So someone thinks they have an idea for a new college course. Here are some things that need to be considered to turn that idea into a course.

- Be passionate about an idea (be a champion)
- It helps to have experience in that area
- Gain support for project (verbal & financial)
- Use a structured project approach like SDLC
- Use project management software
- Anticipate project variables and their impact on the project
- It takes time to develop a new course, it does not happen overnight
- Make sure to evaluate the success of the new course

Summary

This project began with a desire to develop a course to teach students the significance of good network infrastructure design. This was something thought to be lacking from their education. Experience in this area made the author the perfect person to pursue this idea. Support was gained both verbally and financially from the Electrical Engineering Technology Department, colleagues and the advisory board. A structured project approach was used to develop a plan which was then put into Microsoft Project to help manage the project. With a structured plan the author proceeded to follow the plan and develop a course that could get college approval and begin to be offered as part of the program. The course development was completed, college approval has been obtained and the course is now being offered as part of the Computer Engineering Technology Program. As of this writing the course is over capacity for the spring 2007 semester. This over capacity represents students who not only are required to take the course but students who are taking it for an elective. Seeing this makes the author believe that the right decision was made to spend the time to develop this course. Time will tell if this will have an impact on future network infrastructure designs.

Appendices

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Exhibits

College Approval Forms

VPAA___________________________

Date ___________________________

Vice President/ Academic Affairs Office use only

STATE UNIVERSITY OF NEW YORK
College of Technology at Alfred

SCHOOL: Management and Engineering Technologies
DEPARTMENT: Electrical Engineering Technology
COURSE NAME: Network Infrastructure Essentials
COURSE NUMBER: ELET 4174
SEMESTERS OFFERED: Spring
PREREQUISITE: N/A
COURSE FORMAT: ____3____ (# of hours--lecture/week)

____3____ (# of hours--laboratory/week)

COURSE LEVEL: *Lower*

Date Approved by Faculty Senate:____________________

COURSE DESCRIPTION

Students learn the basics of telecommunications and network cabling and wiring devices, as well as suggested best practices and safety issues. The students, through hands-on activities and labs, learn to install horizontal (work area) and backbone cable. This hands-on, lab-oriented course stresses documentation, design, and installation issues, as well as laboratory safety, on-the-job safety, and working effectively in group environments. This course prepares students for the Panduit Authorized Installer (PAI) certification.

STUDENT OBJECTIVES
At the end of the course the student will be able to do the following:

1. Explain what cabling standards are, how they are developed, when to use them and why it is important to following them.

2. Explain how to survey customer sites to determine cabling needs for various situations.
3. Understand how to create and read blueprints for cabling installations.
4. Understand and describe the cable installation process.
5. Demonstrate the proper use of various tools that are used in cabling installations.
6. Demonstrate how to design and install copper and fiber optic cabling infrastructures.

TEXTS

Cisco Systems, Inc. *Fundamentals of Voice and Data Cabling.* Cisco Press, latest edition.

DIVISION OF SUBJECT MATTER

Topic	Total Lecture Hours	Total Lab Hours
A. Cabling and Safety Overview	3	3
1. Introduction to Cabling		
2. The Cabling Job Market		
3. Safety Codes and Standards for the United States		
4. International Safety Codes and Standards		
5. Safety around Electricity		
6. Lab and Workplace Safety Practices		
7. Personal Safety Equipment		
B. Networking Basics	3	3
1. Network Topologies		
2. OSI Model Overview		
3. Physical Layer Functions		
4. Data Link Layer Functions		
5. Network Layer Functions		
6. Transport Layer Functions		
7. Session Layer Functions		
8. Presentation Layer Functions		

9. Application Layer Function

C. Signals and Wires	3	3

1. Signal Transmission
2. The Basics of Electrical Signals
3. Direct Current
4. Alternating Current
5. Electronic Characteristics of Cable
6. Optical Theory
7. Wireless Theory
8. Signals on Networks
9. Digital Subscriber Line Systems
10. High-Bandwidth and Backbone Signals

D. Copper Media	3	3

1. Copper Cable Basics
2. Twisted-Pair Cables and Terminations
3. Twisted-Pair Cable Fundamentals
4. Other Twisted-Pair Configurations
5. Video
6. Outside Plant Cables
7. Coaxial Cable

E. Fiber-Optic Media	3	3

1. Fiber-Optic Cables
2. Fiber-Optic Enclosures
3. Advantages
4. Disadvantages
5. Construction
6. Connectors
7. Transmission
8. Testing Fiber-Optic Cables

F. Introduction to Cabling Standards	3	3

1. What are International, National and Local Standards

2. Introduction to Cabling Standards and Codes
3. What are Codes?
4. What are Standards?
5. IEEE's Standards
6. U.S. Standards
7. U.S. Codes
8. Canadian Standards
9. Australian Standards
10. Evolution of Standards
11. New Zealand Standards
12. European Standards
13. Japanese Standards

G. Structured Cabling	3	3

1. Structured Cabling Systems
2. Demarcation Point
3. MCs, ICs and HCs
4. Telecommunications Room Equipment
5. Work-Area Cabling
6. Telecommunications and Equipment Rooms

H. Tools of the Trade	3	3

1. Professionalism
2. Tools of the Trade (Diagnostic Tools)
3. Tools Usage and Material Handling
4. Tools of the Trade

I. Cable Installation Process	3	3

1. The Installation Process
2. Request for Proposals
3. Prebid Meeting and Bid Creation
4. Requirements Gathering
5. Labor Cost Calculation
6. Material and Labor Issues

7. Contract Development, Negotiations and Planning		
8. Design Documents		
9. Software Tools		
10. Communication and Conflict Resolution		
J. Cabling Rough-In	3	3
1. Rough-In Phase Basics		
2. Rough-In Support Tools		
3. Horizontal Cable Installation		
4. Vertical Cable Installation		
5. Roughing In Other Cable Types		
6. Upgrades and Retrofits		
7. Firestops		
K. Trim Out Phase	3	3
1. The Installation Process		
2. Patch Panels		
3. Terminating Copper Media		
4. Terminating Fiber-Optic Cable		
5. Cable Management		
L. Finish Phase	3	3
1. Testing Cable		
2. Troubleshooting Cable		
3. Cable Certification and Documentation		
M. Customer Support Phase	3	3
1. Determining Upgrade Opportunities		
2. Customer Support		
3. Cabling Project Completion		
N. The Future of Cabling	3	3
1. Demand for Bandwidth		
2. Vertical Market Drivers		
3. Market Opportunities		
4. Emerging Cabling Technologies		

5. Active Cable Management
6. Emerging Network Technologies
7. Exams

7. Exams	3	3
Totals	45	45

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Dean of School	Department Chair
Instructor of Course	Date

[redacted]

STATE UNIVERSITY OF NEW YORK
College of Technology at Alfred
Request for Course/Curriculum Submission

[redacted]

Request Submitted By:_Michael Case__________________________ Date:_9/19/06__________

Course/Curriculum Title:_ELET 4174 Network Infrastructure Essentials____________________

Forward this with your proposal package to the Curriculum Development and Review Committee after answering the following questions.

1. What are the primary purposes of the course/curriculum change?

Required course for AAS in Computer Engineering Technology and BS in Computer Technology.

2. What will be the impact on current programs - dropping courses, combining courses taught less frequently, increase in required courses, ...?

Will serve as an elective course for other BS programs.

3. In what ways will faculty be affected - teaching load, professional development, ...?

Can be taught by existing faculty.

4. What are the resource requirements - faculty resources, equipment, supplies, travel, classroom and/or laboratory space, computer usage, library, ...?

The necessary facilities are in place in the SET 114 laboratory.

5. What date do you recommend the change to become effective?

Course will be offered in Spring 2007.

6. What do you anticipate will be the effect on the employability and/or transferability of your students?

Increase in employability due to shortages in skilled Network Engineers knowing and understanding cable infrastructure issues

7. Has the proposal been discussed at a full department meeting?

Yes

8. Which other departments would this proposal affect; has it been discussed with them?

Have discussed the possibility that it could be used as an elective for CISY and Architecture

9. Has a list of at least five (5) available resources, pertinent to the course, been included in the course outline?

Yes

Course Syllabus
ELET 4174 Network Infrastructure Essentials
Spring Semester 2007

Instructor: Michael A. Case, (Lecturer) Electrical Engineering Technology
Office: Room 108, Engineering Technology Bldg
Telephone: 607-587-4630
E-mail: casema@alfredstate.edu
Office Hours:

Course Description:
Students learn the basics of telecommunications and network cabling and wiring devices, as well as suggested best practices and safety issues. The students, through hands-on activities and labs, learn to install horizontal (work area) and backbone cable. This hands-on, lab-oriented course stresses documentation, design, and installation issues, as well as laboratory safety, on-the-job safety, and working effectively in group environments. This course prepares students for the Panduit Authorized Installer (PAI) certification.

Course Objective:
Upon successful completion of this course, the student will receive a Certificate of Completion for Panduit Network Infrastructure Essentials (PNIE): The student will also be prepared to undertake the Panduit Authorized Installer (PAI) examination. Successful completers will also be significantly aided in their quest for BICSI Installer Level 1 or Level 2 Registration, as well as the CompTIA HTI+ certification for residential technology integration. Some of the skills taught in the course regarding terminating cables that are Category 5 or greater may also be of benefit to candidates for the CompTIA Network+ and CompTIA A+

At the end of the course the student will be able to do the following:

1. Explain what cabling standards are, how they are developed, when to use them and why it is important to following them.
2. Explain how to survey customer sites to determine cabling needs for various situations.
3. Understand how to create and read blueprints for cabling installations.
4. Understand and describe the cable installation process.
5. Demonstrate the proper use of various tools that are used in cabling installations.
6. Demonstrate how to design and install copper and fiber optic cabling infrastructures.

Textbook:
Cisco Systems, Inc. *Fundamentals of Voice and Data Cabling.* Cisco Press, 2003.

Grading Policy:

Module Exams	25%
Lab Participation and Attendance	25%
Lab Completion	25%
Final Exam	25%

Lecture & Lab Policies:

Student Handbook / Planner (Policies for the access and utilization of college computing facilities)

No internet surfing unless required for lecture or lab
No instant messenger
No music or videos in lecture or lab
No cell phones usage during lecture or lab

The Alfred State College Principles of Community recognize the right of every individual to pursue a quality education without hindrance. Furthermore, the principles define the manner in which we show one another respect and dignity and maintain an environment that promotes personal and professional growth. For these reasons, the college has developed the following addendum of policies regulating classroom demeanor. These classroom regulations are a part of every course syllabus by the action of the Faculty Senate.

1. ATTENDANCE POLICY: The College requires that students attend all regularly scheduled classes and laboratories for which the student is registered. The meeting times of these classes are advertised in the master schedule and students should make the appropriate arrangements to be available for all such classes. Students should consult the college catalog for the policy governing religious observations and Academic Regulation 503 regarding the college attendance policy.

The instructor may make appropriate allowances for students who are absent because of illness or other unanticipated problems, providing the student contacts the instructor as soon as possible and before the absence. These absences will be dealt with at the instructor's discretion. Students should assume in general that absenteeism would have consequences reflected in their grades.

LATENESS: As a rule, students should assume that classes will begin at the advertised hour and that lateness may be treated by the instructor in the same manner as an absence. Correspondingly, instructors will exercise due diligence to begin and end class on time so that students can get to their next class or scheduled activity.

2. Learning cannot occur in an environment that tolerates physical or psychological intimidation. The college exercises zero tolerance with regard to acts of violence and intimidation. Any such behavior will be immediately followed by appropriate action to remove the offending individuals from the college community. Acts of physical intimidation that occur in a classroom will result in the instructor's direction to the responsible parties that they leave the classroom immediately. Failure to comply will result in the summoning of a University Police officer to enforce the directive.

3. Civilized discourse can support exchange of ideas and verbal disagreement without resort to obscene, harassing or intimidating language. Tenets of academic freedom do not extend to acts

of intimidation or harassment. The gratuitous use of language constituting intimidation or harassment in Alfred State College classrooms will not be tolerated.

Students cannot learn in an environment in which there is disruption. For that reason, students who disrupt class, arrive late, or leave early, without the instructor's prior consent or for reasons other than illness, may be deemed as absent from class without excuse.

4. APPROPRIATE DRESS: Certain types of dress show disrespect to the academic enterprise. Teaching faculty may choose to support learning in their classes by requiring certain types of dress (i.e., safety equipment, shoes, shirts, and prohibition of wearing hats during class). In addition, use of headphones that are not part of the instruction process is not permitted in scheduled classes and laboratories.

5. ACADEMIC INTEGRITY: Absolute academic integrity is expected of all students at Alfred State College. Students will perform independently on all tests and written assignments. Students must not misrepresent their work or fraudulently or unfairly advance their academic status. Attempting to cheat or cheating will not be tolerated. Plagiarism, misrepresenting another's work as one's own, is not acceptable. Students are responsible for all academic work submitted and, if knowingly misrepresent the work of others as their own, shall be guilty of dishonesty. Students who knowingly collaborate in cheating or other breaches of the Integrity Code will be held equally responsible.

6. STUDENTS WITH DISABILITIES: Students who request accommodations in academic coursework for their documented disabilities are advised that this process begins by contacting the Office of Disability Services, Learning Assistance.

Adopted by Alfred State College Faculty Senate – 4/8/97; amended – 5/13/03
Adopted by Alfred State College Student Senate – 4/8/97

Course Schedule
ELET 4174 Network Infrastructure Essentials
Spring Semester 2007
Schedule

Week	**Lecture Topics**	**Reading Assignments** (To be completed before lecture)	**Labs**	**Exams**
1	Module 1 Cabling and Safety Overview	Chapter 1 Cabling and Safety Overview	Job Market Research Electrical Safety Ladder Safety Fire Safety Tool Usage and Safety	Module 1 Exam
2	Module 2 Networking Basics	Chapter 2 Introduction to Networking	Networking Two Computers Mnemonics for Cabling	Module 2 Exam
3	Module 3 Signals and Wires	Chapter 3 Signals and Wires	Using Troubleshooting Tools Safely Stripping Fiber-Optic Cable	Module 3 Exam
4	Module 4 Copper Media	Chapter 4 Copper Media	Identification of Cables Examination of Termination Types 25-Pair UTP Cable Color Code	Module 4 Exam
5	Module 5 Fiber-Optic Media	Chapter 5 Fiber-Optic Media	Stripping and Cleaving Fiber-Optic Cable Examining Single-Mode and Multimode Fiber-Optic Cable	Module 5 Exam
6	Module 6 Introduction to Cabling Standards	Chapter 6 Cabling Standards	Cable Industry Presentation	Module 6 Exam
7	Module 7 Structured Cabling	Chapter 7 Structured Cabling	Telecommunications Rooms	Module 7 Exam
8	Module 8 Tools of the Trade	Chapter 8 Tools of the Trade	Using a Crimp Tool Working Effectively in Groups	Module 8 Exam
Spring Break				
9	Module 9 Cable Installation Process	Chapter 9 Cable Installation Process	Understanding Blueprints Creating Rack Diagrams	Module 9 Exam
10	Module 10	Chapter 10	Sheet Rock Walls	Module

	Cabling Rough-In	Cabling Rough-In	Installing Surface Mount Raceways Running Cable in a Raceway Cable Pulling Pulling Fiber-Optic Cable	10 Exam
11	Module 11 Trim Out Phase	Chapter 11 Trim-Out Phase	Telecommunications Grounding System Dressing Cables Labeling Systems Terminating 25-Pair Cable Twisted Pair Outlet Termination Terminating Twisted Pair Cable to a 110 Block Examination of Fiber-Optic Kit and Fiber-Optic Tray Terminating SC Fiber-Optic Connectors on 3mm Fiber Cable Terminating SC Fiber-Optic Connectors on 900 Micron Fiber Cable Terminating a Twisted Pair Cable at a Patch Panel Cross Connecting Punch-Down Panels and 110 Punch Blocks	Module 11 Exam
12	Module 12 Finish Phase	Chapter 12 Finish Phase	Tone and Trace Testing Testing Variations Troubleshooting Copper Cable Creating Final Documentation	Module 12 Exam
13	Module 13 Customer Support Phase	Chapter 13 Customer Support Phase	Structured Cabling Exercise	Module 13 Exam
14	Module 14 Standardization Around the World	Chapter 14 The Future of Cabling Chapter 15 Localization	Fiber-Optic Final Project	
15	Final Exam Preparation		Final Exam Preparation	
16	Final Exam			

Lecture Outline

Week 1 (Chapter 1 – Cabling and Safety Overview)
Lecture 1

- Course Introduction
- Review Syllabus
- Review Schedule

Lecture2
Chapter 1 (Slides 1-16)

- Introduction to Cabling
- The Cabling Job Market
- Safety Codes and Standards for the United States
- International Safety Codes and Standards

Lecture3
Chapter 1 (Slides 17-41)

- Safety around Electricity
- Lab and Workplace Safety Practices
- Personal Safety Equipment

Week 2 (Chapter 2 – Introduction to Networking)
Lecture 1
Chapter 2 (Slides 1-19)

- What is a Network

Lecture 2
Chapter 2 (Slides 20-36)

- Network Topologies
- OSI Model Overview

Lecture 3
Chapter 2 (Slides 37-54)

- Physical Layer Functions
- Data Link Layer Functions
- Network Layer Functions
- Transport Layer Functions
- Session Layer Functions
- Presentation Layer Functions
- Application Layer Function

Week 3 (Chapter 3 – Signals and Wires)
Lecture 1
Chapter 3 (Slides 1 – 26)

- Signal Transmission
- The Basics of Electrical Signals
- Direct Current

Lecture 2
Chapter 3 (Slides 27 – 45)

- Alternating Current
- Electronic Characteristics of Cable
- Optical Theory
- Wireless Theory

Lecture 3
Chapter 3 (Slides 46 – 58)

- Signals on Networks
- Digital Subscriber Line Systems
- High-Bandwidth and Backbone Signals

Week 4 (Chapter 4 – Copper Media)
Lecture 1
Chapter 4 (Slides 1 – 12)

- Copper Cable Basics

Lecture 2
Chapter 4 (Slides 13 – 24)

- Twisted-Pair Cables and Terminations
- Twisted-Pair Cable Fundamentals

Lecture 3
Chapter 4 (Slides 25 – 38)

- Other Twisted-Pair Configurations
- Coaxial Cable
- Video
- Outside Plant Cables

Week 5 (Chapter 5 – Fiber-Optic Media)
Lecture 1
Chapter 5 (Slides 1 – 20)

- Fiber-Optic Cables
- Fiber-Optic Enclosures
- Advantages

Lecture 2
Chapter 5 (Slides 21 – 36)

- Disadvantages
- Construction

Lecture 3
Chapter 5 (Slides 37 – 49)

- Connectors
- Testing Fiber-Optic Cables
- Transmission

Week 6 (Chapter 6 –Cabling Standards)
Lecture 1
Chapter 6 (Slides 1 – 11)

- Introduction to Cabling Standards and Codes
- What are Codes?
- What are Standards?
- What are International, National and Local Standards

Lecture 2
Chapter 6 (Slides 12 – 26)

- IEEE's Standards
- U.S. Codes
- U.S. Standards

Lecture 3
Chapter 6 (Slides 27 – 38)

- Canadian Standards
- Australian Standards
- New Zealand Standards
- Japanese Standards
- European Standards
- Evolution of Standards

Week 7 (Chapter 7 –Structured Cabling)
Lecture 1
Chapter 7 (Slides 1 – 12)

- Structured Cabling Systems
- Demarcation Point

Lecture 2
Chapter 7 (Slides 13 – 23)

- Telecommunications and Equipment Rooms

- Telecommunications Room Equipment
- Work-Area Cabling

Lecture 3
Chapter 7 (Slides 24 – 32)

- MCs, ICs and HCs

Week 8 (Chapter 8 –Tools of the Trade)
Lecture 1
Chapter 8 (Slides 1 – 10)

- Tools of the Trade

Lecture 2
Chapter 8 (Slides 11 – 16)

- Tools of the Trade (Diagnostic Tools)

Lecture 3
Chapter 8 (Slides 17 – 20)

- Tools Usage and Material Handling
- Professionalism

Week 9 (Chapter 9 –Cable Installation Process)
Lecture 1
Chapter 9 (Slides 1 – 15)

- The Installation Process
- Request for Proposals
- Prebid Meeting and Bid Creation
- Requirements Gathering

Lecture 2
Chapter 9 (Slides 16 – 25)

- Labor Cost Calculation
- Material and Labor Issues
- Contract Development, Negotiations and Planning

Lecture 3
Chapter 9 (Slides 26 – 34)

- Communication and Conflict Resolution
- Software Tools
- Design Documents

Week 10 (Chapter 10 –Cabling Rough-In)
Lecture 1
Chapter 10 (Slides 1 – 11)

- Rough-In Phase Basics
- Rough-In Support Tools

Lecture 2
Chapter 10 (Slides 12 – 25)

- Horizontal Cable Installation
- Vertical Cable Installation

Lecture 3
Chapter 10 (Slides 26 – 40)

- Roughing In Other Cable Types
- Firestops
- Upgrades and Retrofits

Week 11 (Chapter 11 –Trim-Out Phase)
Lecture 1
Chapter 11 (Slides 1 – 11)

- The Installation Process

Lecture 2
Chapter 11 (Slides 12 – 34)

- Cable Management
- Terminating Copper Media

Lecture 3
Chapter 11 (Slides 35 – 47)

- Terminating Fiber-Optic Cable
- Patch Panels

Week 12 (Chapter 12 –Finish Phase)
Lecture 1
Chapter 12 (Slides 1 – 21)

- Testing Cable

Lecture 2
Chapter 12 (Slides 22 – 28)

- Troubleshooting Cable
- Cable Certification and Documentation

Lecture 3
Cable Industry Presentation

Week 13 (Chapter 13 –Customer Support Phase)
Lecture 1
Chapter 13 (Slides 1 – 7)

- Cabling Project Completion

Lecture 2
Chapter 13 (Slides 8 – 12)

- Customer Support

Lecture 3
Chapter 13 (Slides 13 – 15)

- Determining Upgrade Opportunities

Week 14 (Chapter 14 – The Future of Cabling)
Lecture 1
Chapter 14 (Slides 1 – 14)

- Demand for Bandwidth

Lecture 2
Chapter 14 (Slides 15 – 21)

- Vertical Market Drivers
- Emerging Network Technologies
- Emerging Cabling Technologies

Lecture 3
Chapter 14 (Slides 22 – 28)

- Active Cable Management
- Market Opportunities

Week 15
Lecture 1
Cable Industry Presentation

Lecture 2
Final Exam Review

Lecture 3
Final Exam Review

Week 16
Final Exam

Sample Labs

Lab Activity: Using a Crimp Tool

Estimated Time: 60 minutes

Number of Team Members: two to four

Objectives:

- Create twisted pair crossover and rollover cables.
- Create a straight-through adapter cable.
- Test and troubleshoot cables.

Overview:

In this lab, several types of common cables will be built utilizing IDC type terminations. All cables will be tested once they have been terminated.

This is a good exercise to show how cables are terminated, the pinouts of the different types of cables, and the different color schemes. Normally, patch cords are not field terminated. Therefore, it is usually unacceptable to create patch cables for use in a structured cabling infrastructure. The reason for this is that the cable has not been “certified”. Special certification meters are used in the manufacturing process to ensure that the cable is capable of transmitting quality signals with minimal interference, not only through the cable, but through the hardware that terminated the cable as well.

Tools and Resources:

- Three ISO-D (Category 5e) cables of at least 1 m (3-4 feet)
- Crimp tool
- 8P8C (RJ-48) plugs
- Wire snipping tool
- Wire stripper tool
- Mini-Jack modules
- Mini-Jack termination tool
- Safety glasses
- Cable meter
- Permanent marking pen

URLs:

http://www.panduit.com

http://www.flukenetworks.com

Safety:

Wear safety glasses for the duration of the lab.

Note: Be careful that fingers do not get caught in a crimp tool. Many crimp tools will not release until the tool has completed the termination process.

Step 1 Crimp Tool Overview

Examine the crimp tool. Is the die removable? **Crimp tools will differ**

What type of die is used in the crimp tool? **If it is removable, an RJ45 should be used.**

How does the plug fit into the tool?

It is inserted into the tool until it clicks into place.

Close the handles fully to experience the ratcheting motion, then release. What benefit does the ratcheting motion give an installer?

The handles do not release until the plug is fully crimped, insuring a complete crimp every time.

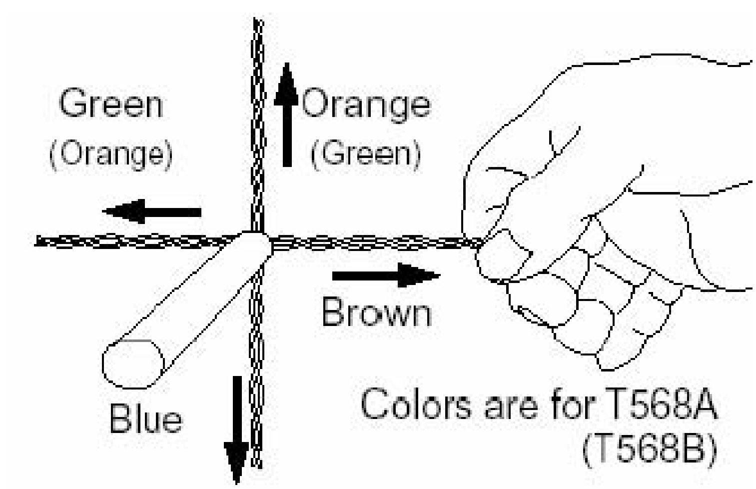
Step 2 Building a Straight-Through Adapter Cable

In order for the Category 5e cable to connect to equipment and devices in the structured cable infrastructure, the cables must be terminated properly. To create a straight-through adapter cable, adhere to T568A or T568B on both ends.

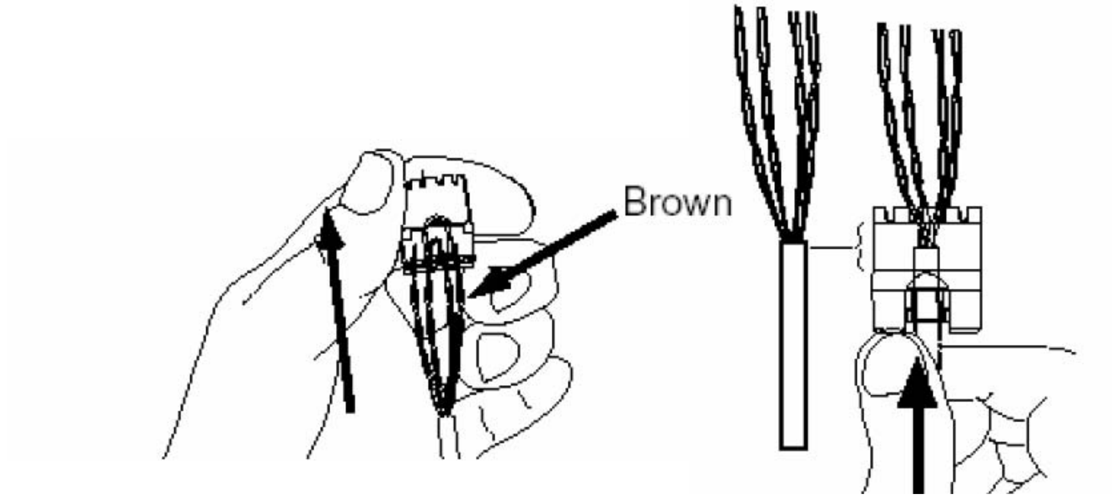
Use the wire stripper tool to ring the cable 7-8 cm (3 inches) from each end of the cable. Remove the sheathing that has been cut off by the copper strip tool.

Use the T568B color scheme to terminate one end of the cable using a modular Pan-Plug.

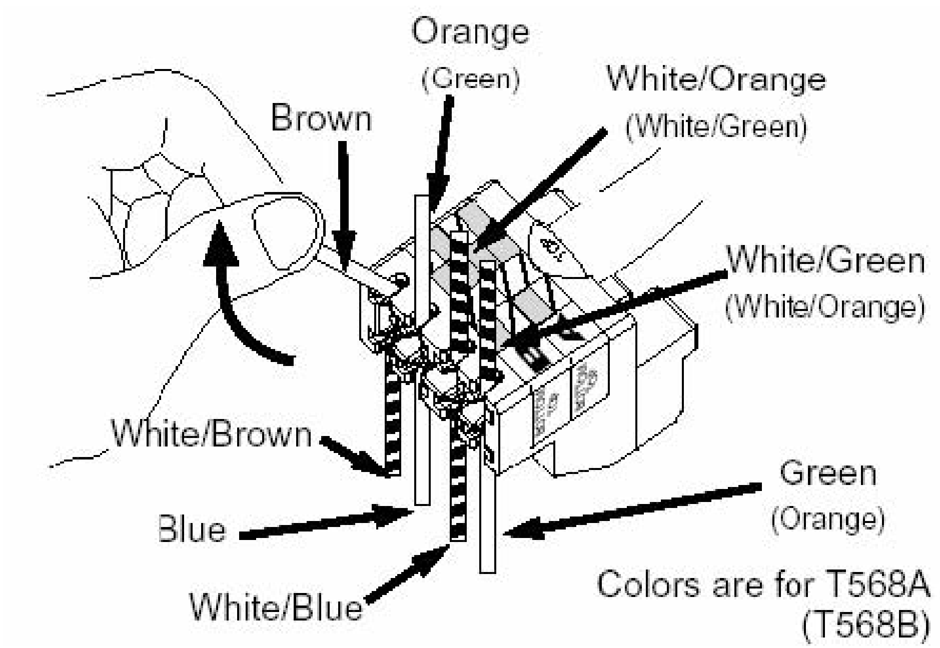
Follow the steps below and use the T568B color scheme to terminate the other end of the cable with a Mini-Jack.



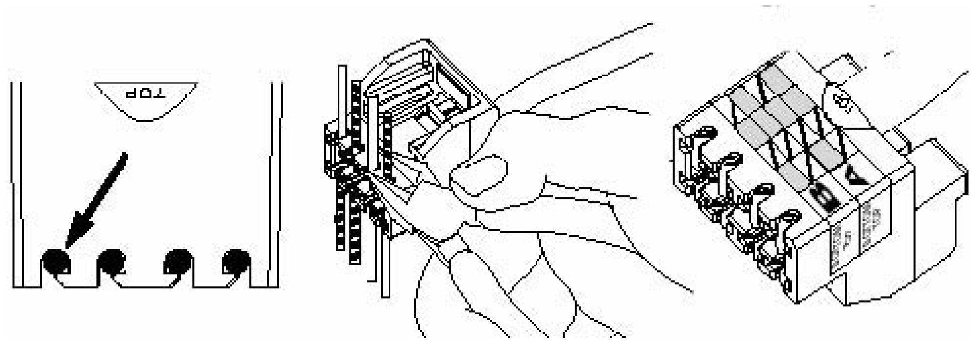
Separate the twisted pairs from each other without untwisting the pairs. Pull the wire pairs to set their positions. Use the T568B color scheme when terminating this jack.



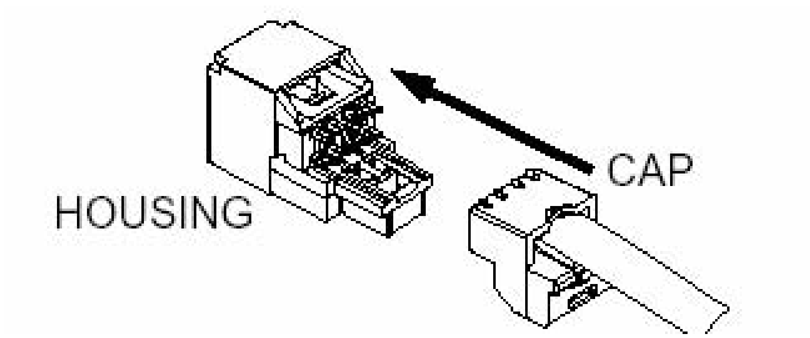
Gather the twisted pairs and insert them into the cap. Push the cable jacket until the jacket end is located under the label.



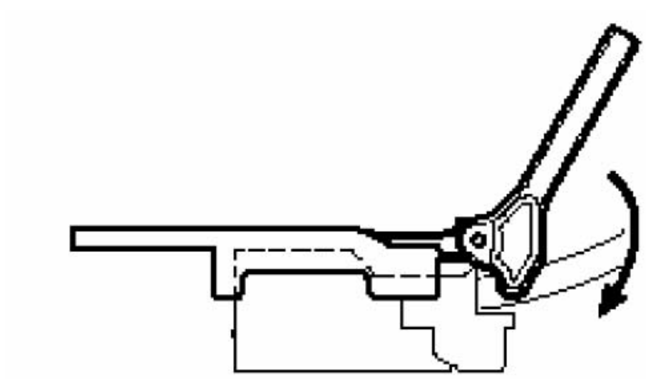
Untwist the pairs, one at a time starting with the outside pairs, and place them into the correct slots. It is very important to untwist each pair only as far as required to place the conductors in the correct slots.



Trim each conductor flush with the cap with the wire snipping tool. Be sure that all of the conductors are still seated in their slots.



Slide the front of the Mini-Jack into the backing, making sure that it is straight.

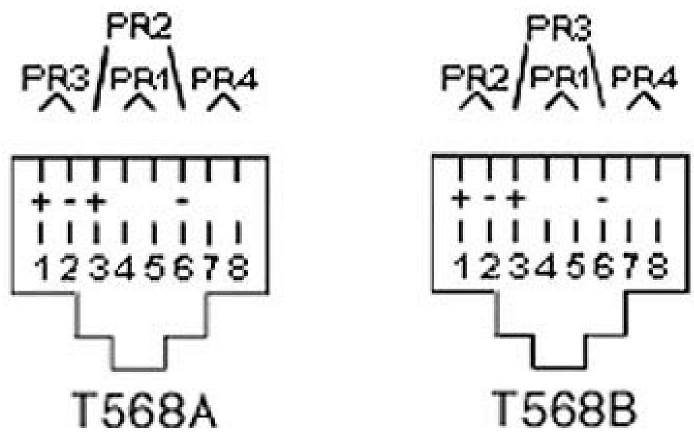


Use the Mini-Jack tool to press the two pieces together until they snap. The cable has now been terminated.

Test the cable with the cable meter. If the cable fails the test, find which end has the problem, re-terminate it, and test the cable again.

Step 3 Building a Crossover Cable

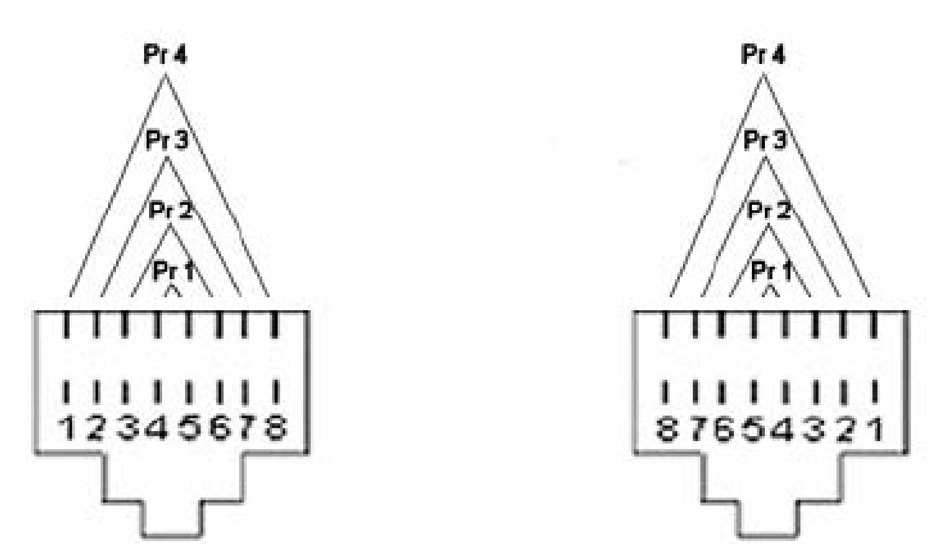
Terminate the second cable with plugs following the T568A color scheme on one end and the T568B color scheme on the other end to create a crossover cable. A crossover cable is used to connect two Ethernet devices directly together.



Once the testing of this cable is complete, mark it with an “X” to show that it is a crossover cable.

Step 4 Building a Rollover Cable

In order to create a rollover cable, one end of the cable must have the conductor order reversed. One side will have pins 1-8 and the other side of the cable will have pins 8-1. A rollover cable is used to configure a router by way of a console port.



Rollover Cable Pinout

Pair	Pins	Colors

1	4 and 5	White /Blue and Blue
2	3 and 6	Orange and White /Orange
3	2 and 7	Green and White /Green
4	1 and 8	Brown and White /Brown

Terminate the ends of the cable following the pinouts above.

Once the testing of this cable is complete, mark it with an “R” to show it is a rollover cable.

TIP: Creating a rollover cable is easy. The key is to use the same color code for each end but create the first plug with the key facing the floor. Create the other end of the cable with the key facing away from the floor.

Step 5 Clean Up

Ensure that all tools are properly stored and remove all trash and debris. Store the cables for use in future labs.

Lab Activity: Creating Rack Diagrams

Estimated Time: 45 minutes

Number of Team Members: one

Objectives:

- Learn to read rack diagrams.
- Create a rack diagram of the lab rack.

Overview:

Knowing how to read a rack diagram is essential for installing wire management or equipment in a relay rack.

In this lab, an example is given of relay racks with equipment installed. This will provide the opportunity to see how racks are designed, how to sketch a diagram of a rack, and how to select the rack with the appropriate height and width to accommodate the equipment that will be used.

Note: There are several software programs that allow you to draw rack diagrams. These programs include Visio, AutoCAD, and Adobe Illustrator.

Tools and Resources:

- Lab relay rack
- Pen or pencil and paper
- Visio

Additional Materials:

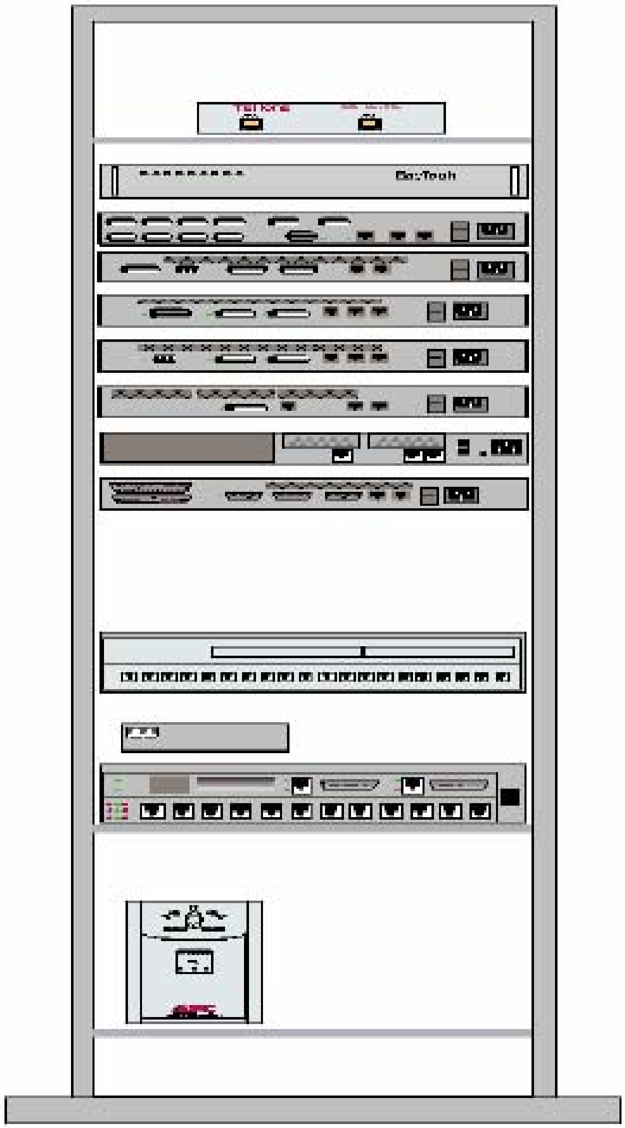
- Empty relay rack diagram provided

Rack Diagrams

Study the following diagram. It indicates measurements that will assist in gauging the amount of equipment that can fit in a rack. It also shows the positions of the equipment. On the left side, the rack is measured by feet to indicate usable space. On the right side, the rack is measured by Rack Units (RUs) to indicate mounting spaces. One RU is equal to 4.45 cm (1.75 inches). Equipment typically mounts to the rack using mounting brackets that measure a certain number of RUs. Screws are threaded through the equipment’s mounting brackets and into the rack.

There are two widely used rack widths available: 19 inches (generally for data communications) and 23 inches (generally for telecommunications).

Relay Rack Diagram



Rack Layout Guide

The following spreadsheet will help a cabling technician or networking technician ask the correct questions to ensure that the correct width, height, and weight requirements are met for the customer's equipment. Complete the spreadsheet for equipment found on the lab rack.

Item	Description	Quantity	Width	Height	Depth	Weight	Power Y or N
1	**Fiber Panel**	**1**	**19”**	**1.75**	**11.5**	**NA**	**N**
2	**24 port patch panel**	**2**	**19”**	**1.75**	**1.5**	**NA**	**N**
3	**Horizontal Wire Mgmnt**	**2**	**19”**	**3.5**	**10**	**NA**	**N**
4	**Mod. Patch Panel**	**1**	**19”**	**1.75**	**1**	**NA**	**N**
5	**110 Panel**	**1**	**19”**	**3.5**	**2.25**	**NA**	**N**
6							
7							

Using Visio create a rack diagram of the equipment found on the lab rack

Lab Activity: Using Troubleshooting Tools Safely

Estimated Time: 60 minutes

Number of Team Members: two to four

Objectives:

- Learn about troubleshooting tools and equipment.
- Learn about troubleshooting tool safety.

Overview:

The communications industry uses specialized testing and diagnostic equipment. Familiarity with this equipment will aid the installer in troubleshooting efforts.

In this lab, test equipment will be handled and used to generate and listen for tones. There are many different testers that can be used to make basic tests on twisted pair and coaxial cable. The figures and instructions used in this lab may differ from the ones being used in the classroom, but many of the features are the same. Ask the instructor to demonstrate the use of the testers being used, read the instructions that accompany the tool, or visit the manufacturer's website to learn how each tool depicted here differs from the tools being used in this lab.

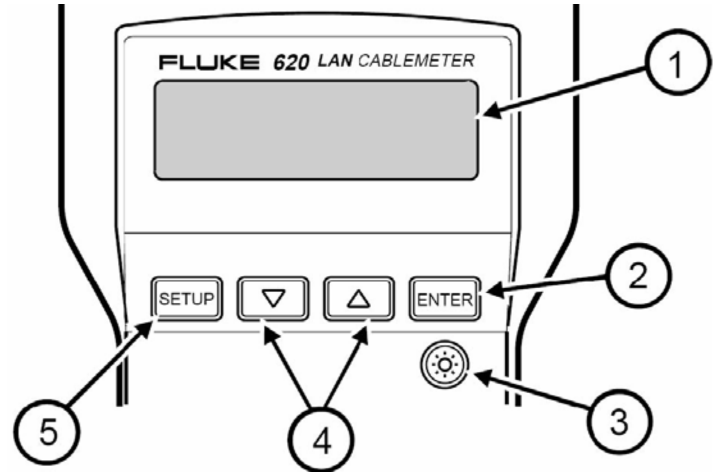
Tools and Resources:

- Cable tester
- Banjo adapter
- Multimeter
- Telecommunications test set
- Tone and trace Tester

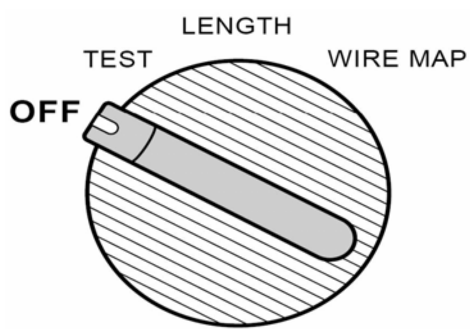
Step 1 Cablemeter Overview

A cable tester is a battery operated, handheld instrument that identifies cable failures, may measure length, and checks the wiring of cables used for Ethernet Local Area

Network (LAN) systems. This tool tests for incorrect pairing (split pairs), miswires, shorted and open wires on all twisted pair cables, as well as shorts on coaxial cables.



1. LCD – When there is more information than can be displayed on two lines, an up arrow, down arrow, or bi-directional arrow appears on the left side of the display. Press the corresponding arrow key (4) to display the additional information.
2. ENTER – Enters a selection into the test tool and moves to the next setup selection. This will cause the current cable selection to be displayed and a new measurement cycle initiated when not in Setup Mode.
3. Light – Turns the display backlight on or off. Backlighting turns off automatically after 70 seconds.
4. Arrow Keys – Enables the user to scroll through a selection of choices or multiple displays.
5. SETUP – Provides access to cable selection, calibration, and other settings.



There are three different tests that can be performed on a cable with this tester:

- TEST – Tests the attached cable and indicates a “pass or fail” based on the parameters specified for the selected cable.
- LENGTH – Measures the length of coaxial cables and each pair inside twisted pair cable in feet or meters and tests for anomalies.
- WIRE MAP – Displays wiring connections, shorts, opens, and split pairs.

The setup mode provides the user the ability to select cable characteristics and customize the operation of the test tool. Once changed, these settings are stored and remain in the test tool even when it is turned off. Setup selections that rarely need changing are under a special “Power-up” menu. Setup allows the user to:

- Select cable type (UTP, STP, ScTP, or COAX)
- Select a wiring type
- Select a cable level or category
- Select a wire size
- Calibrate the test tool to a specific cable
- Enable or display the Beeper for PASS and FAIL • *Adjust the display contrast •
- *Select the display language •
- *Select length measurement units between meters (m) and feet (‘) •
- *Select wire size units between millimeters (mm) and AWG •
- *Set the noise filter for 50 Hz or 60 Hz

Power-up” setup selections on this tester.

To make a SETUP selection, do the following

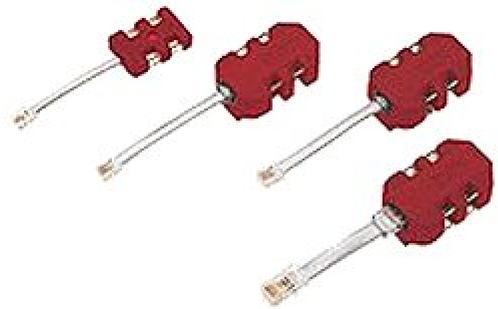
1. Press SETUP.
2. Press ENTER to step through the selections.
3. Press the arrow buttons to select the desired setup condition.
4. Press SETUP to exit the setup mode, or press ENTER to move to the next setup selection.

To make a “Power-up” setup selection, do the following:

1. With the meter OFF, press and hold SETUP while turning the rotary switch to TEST.
2. Press ENTER to step through the selections.
3. Press the arrow keys to select the desired setup condition.
4. Press SETUP to exit the setup mode, or press ENTER to move to the next setup selection.

Connect the test tool to inactive cables only. The input circuitry is protected to withstand low voltages, but prolonged connection to active telephone lines and networks may damage the unit.

Step 2 The Banjo Adapter



The banjo adapter provides access to the cable pairs inside of a completed jack installation without having to remove the wall plate or disassemble the jack. The small modular cable supplied with the banjo adapter is plugged into a modular outlet.

The metallic tabs on the banjo adapter are numbered according to the pins on the jack. It is important for the technician to know the wiring standard to use when testing. Pair one will always appear on tabs 4 and 5, pair 2 may appear on tabs 3 and 6 if the T568A wiring scheme is being used, or 1 and 2 if the wiring scheme is T568B.

Other test equipment that may not have a modular plug that can be connected to the banjo adapter. Multimeters, tone generators, and telecommunications test sets can access the conductors of twisted pair cable through the use of the banjo adapter.

Step 3 The Multimeter

A Digital Multimeter is a volt/ohm meter. It can be used to measure foreign voltage on a communications circuit or to determine if there are opens or shorts in a circuit.

The dial on the multimeter allows the student to select functions. The basic functions are resistance (ohms), AC volts, and DC volts. Some will allow the student to measure capacitance and amperage as well.
Since most multimeters use probes to access the wires or contacts instead of a modular cord or plug, the banjo adapter is required to provide access to the wires being tested.

Hint: When measuring an open, ask another class member to go to the opposite end of the wire and momentarily put a short on the cable while the multimeter is connected. If this momentary short can be read, the cable pair is good to that end.

- Do not use the meter or test leads if they appear damaged, or if the meter is not operating properly.
- Always use proper terminals, switch position, and range for measurements.
- Verify the meter's operation by measuring a known voltage. If in doubt, have the meter serviced.
- Do not apply more than the rated voltage, as marked on the meter, between terminals or between any terminal and earth ground.
- Use caution with voltages above 30 V AC rms, 42 V AC peak, or 60 V DC. These voltages pose a shock hazard.
- To avoid false readings that can lead to electric shock and injury, replace the battery as soon as the low battery indicator appears.
- Disconnect circuit power and discharge all high-voltage capacitors before testing resistance, continuity, diodes, or capacitance.
- Do not use the meter around explosive gas or vapor.
- When using test leads or probes, keep fingers behind the finger guards.
- Remove test leads from the meter before opening the battery door or the case.

Step 4 Telecommunications Test Set

The telecommunications test set can be used to monitor noise on a telecommunications circuit. It can be used to place and receive phone calls on working telecommunications circuits as well.

A common use for the telecommunications test set is to find a tone that is placed on a specific pair of wires. When used with a modular jack, it is usually necessary to use the banjo adapter. Two telecommunications test sets can be used to communicate with one another over a pair of wires without going through a telephone switch. A battery source is required for this.

The test set incorporates a standard tone pad for tone dialing. Buttons on the test set include a monitor button, a talk button, and a mute button.

Some test sets include a ringer that is built into the test set. With this option, the test set can be called by a telephone or another test set. The test set must be plugged into the public telephone network to use this option.

- Replace any worn or damaged parts or cords immediately following the manufacturer's replacement guidelines in the instruction booklet.
- Do not perform any maintenance on this device other than what is outlined in the instruction booklet.

Step 5 Tone and Trace

A tone and trace tester allows the student to place a tone on a pair of wires and track that tone without metallic contact to the wires or the termination points.

- Do not open the units or attempt to repair in case of malfunction. Send the units back to the distributor for repair or replacement.
- Telephone circuit voltages can be hazardous. Never touch the metal of the test leads while the unit is attached to a telephone line.
- The tester is designed for checking low voltage (less than 48 V dc or 24 V ac only). Do not connect to any high voltage circuits.

What piece of test equipment generates a tone?

Fluke Intellitone

What two pieces of test equipment receive a tone?

Telecommunications test set and Fluke Intelliprobe

If the tester shows an open on a cable pair, what can be done to verify that the correct pair is being tested?

Have a tech place a short on the end of the pair, then read the short with an Ohm meter.

Sample Exams
ELET 4174
Network Infrastructure Essentials
Module 1 Exam

1) Why are plenum cables not jacketed with PVC?
   a) PVC is not strong enough to resist the stresses the cable faces
   b) PVC does not provide enough electrostatic shielding
   c) PVC will give off poisonous fumes when it burns
   d) PVC will shrink with age and may cause cable separation

2) What can be the result of poor cabling practice? (Choose three.)
   a) Increased number of installation technicians
   b) Network becomes obsolete
   c) Difficulty of installation
   d) Unreliable network
   e) Increased maintenance

3) When an intermittent connection problem is detected, it is determined that the problem is associated with a bad ground connection. What is the proper procedure for obtaining a good ground connection?
   a) Attach the ground wire to an existing grounding electrode or main grounding wire
   b) Attach the ground wire to cold water pipes where they enter the building
   c) Attach the ground wire to an underground water main
   d) Attach the ground wire to I-beams and girders

4) The lights and power outlets in a phone room are not working. The circuit breaker that supplies power to the room is off and there is a padlock attached to it. Who is authorized to remove the padlock so that power can be restored to the room?
   a) Building superintendent
   b) Construction site supervisor
   c) Team leader
   d) Worker who installed the padlock

5) An installer is punching down cable onto a 110 block in the telecommunications room. After lunch, the installer flips on the light switch and realizes there is no power in the room. The installer finds the circuit breaker box and sees that the main switch is in the off position and it has a tag on it with someone's name. What is the appropriate action to take to return power to the telecommunications room?
   a) Rip the tag off and move the switch to the on position
   b) Find the person whose name is on the tag
   c) Call the supervisor and get permission to turn the power on
   d) Return to the telecommunications room and continue working with a flashlight
6) When using a straight ladder that is 4 meters in height, how far should the base of the ladder extend from the building wall?

a) 0.25 meters
b) 0.50 meters
c) 0.75 meters
d) 1 meter

7) While a worker is installing networking cable at an airport, the noise level frequently exceeds 110 decibels. The worker looks into their toolbox for hearing protection and finds earplugs and earmuffs. What should this person do in this situation?
a) Use earmuffs since they are more effective
b) Use earplugs since they are more effective
c) Use both earplugs and earmuffs together
d) Take a break every twenty minutes, this will prevent the need for hearing protection at this noise level

8) During the termination of a fiber-optic cable connector, the technician drops several scraps of fiber on top of the workbench. What should the technician do next?
a) Brush the scraps into the trash can with a small broom
b) Wipe the area clean with a damp cloth
c) Carefully place the scraps in an approved container
d) Brush the scraps onto the floor with a small broom

9) What is the safest course of action to take if clothing is contaminated with glass shards during the termination of fiber-optic cable?
a) Brush them off by hand
b) Throw the clothing away
c) Use a piece of adhesive tape to remove the shards
d) Remove the clothing and wash it

10) A worker is wearing athletic shoes on the job site. The supervisor reminds the worker of the company dress code and sends the worker home to change into the appropriate shoes. What is the main reason for this decision?
a) That particular style was wrong for the company image.
b) The supervisor does not like athletic shoes.
c) Nails, scrap metal, and other materials could puncture the soles of the shoes.
d) Athletic shoes do not promote professionalism in the work place.

11) Eric is working on the fourth level of a scaffold when a co-worker drops a tool from the fifth level, narrowly missing him. Eric thinks that it was rather clumsy of the worker. However, since there is nothing connecting him to the scaffold or the building, it is easy for him to climb down and retrieve the tool. When Eric gets to the bottom, a representative from OSHA waves him over for a talk. Which concern will the OSHA representative likely have regarding this incident?
   a) Filling out an incident report on the worker that dropped the tool
   b) That Eric should not have been working directly under another worker
   c) The regulation that states that all workers need to work on the same level of the scaffolding
   d) The regulation that states a body belt must be worn when working on scaffolding higher than two sections

12) Which organization promotes worldwide standards for telecommunications?
   a) EIA/TIA
   b) ISO/IEC
   c) ISO/UT
   d) OSHA

13) Which of the following would the EPA likely be interested in at a job site?
   a) Improper disposal of toxic solvents
   b) Use of non-certified cable installers
   c) Discrimination against disabled workers
   d) Use of cable that does not support the customers speed requirements

14) Which term describes using a single wiring scheme to handle all voice, data, and other services?
   a) Structured cabling
   b) Proprietary cabling
   c) Multiplexed cabling
   d) Network cabling

15) Which of the following would the NEC likely be concerned with?
   a) Communication standards at high speeds
   b) Communication standards at low speeds
   c) The temperature required for a cable to burn
   d) Video communication standards considering throughput

16) A worker in an office building is installing a run of cable in the riser between two floors. Which type of cable is appropriate for the installation?
    a) FEP jacketed wire
    b) Nylon jacketed wire
    c) Kevlar jacketed wire
    d) Teflon jacketed wire

17) What is the major purpose of grounding electrical equipment?
    a) Stops the electricity
    b) Stores the electricity so that it can be discharged slowly
    c) Provides a low-resistance electrical path from the chassis of a device to the earth
    d) Provides a direct electrical path from the chassis of a device to a main circuit

18) A worker is required to run aerial coaxial cable between two buildings that are only 20 meters (60 ft.) apart. The worker notices that there is a thunderstorm several miles away. What is the proper action?
    a) Ensure the wire is properly grounded before running it between the two buildings
    b) Do not run the wire until the thunderstorm clears
    c) Provide a grounding electrode at both ends of the wire
    d) Use insulated connectors and tools

ELET 4174
Network Infrastructure Essentials
Module 2 Exam

1) At which OSI layer does twisted pair, fiber-optic, or coax operate?
   a) Network layer
   b) Session layer
   c) Transport layer
   d) Physical layer

2) Which type of transmission is sent over copper wiring?
   a) Light pulses
   b) Electrical current
   c) Radio waves
   d) Infrared

3) What do logical topologies describe?
   a) How data flows
   b) Where the cabling is
   c) Major devices on the network
   d) How data packets are created

4) At which OSI layer does the cable installer primarily work?
   a) Data link
   b) Transport
   c) Network
   d) Physical

5) What are two Layer 2 devices?
   a) Hubs and routers
   b) Bridges and switches
   c) Hubs and switches
   d) Bridges and routers

6) Which type of physical topology uses a single length of cable end-to-end?
   a) Bus
   b) Mesh
   c) Ring
   d) Star

7) What is an advantage of a mesh topology?
   a) Less connections
   b) Total redundancy
   c) Simple to maintain
   d) Less cable installed

8) Which OSI layer is commonly referred to as Layer 2?
   a) Network
   b) Physical
   c) Transport
   d) Data link

9) Which OSI layer is commonly referred to as Layer 1?
   a) Network
   b) Physical
   c) Transport
   d) Data link

10) Which OSI layer converts information into bits, 0s, and 1s?
   a) Network
   b) Physical
   c) Session
   d) Transport

11) Which OSI layer is responsible for reliable delivery?
   a) Network
   b) Physical
   c) Application
   d) Transport

12) Which term describes the problem of signals weakening as they travel across media?
   a) Attenuation
   b) Congestion
   c) Collisions
   d) Cancellation

13) Collisions are more likely to occur on a network that has which of the following conditions?
   a) High number of switches
   b) Large collision domain
   c) Small collision domain
   d) High number of segmentation devices

14) Which topology connects all cables to a central point such as a hub?
   a) Bus
   b) Mesh
   c) Ring
   d) Star

15) Which list displays the layers of the OSI model in the correct order?
   a) Application, presentation, transport, session, network, data link, physical
   b) Application, session, presentation, network, transport, data link, physical
   c) Application, session, presentation, transport, data link, network, physical
   d) Application, presentation, session, transport, network, data link, physical

16) What is a PBX?
   a) A piece of telephone equipment which connects an organization to the Internet
   b) A cable configuration in which voice and data are carried over the same line
   c) A private telephone network confined to an organization
   d) A computer network which utilizes telephone lines for its Internet connectivity

17) What is the main disadvantage of a physical star topology?
   a) It is not easily scalable.
   b) A break in the cable affects the entire network.
   c) It requires the use of terminators.
   d) If the central hub fails, the entire network is affected.
   e) The cable needs to be grounded.

18) Most network problems fall into which layer of the OSI model?
   a) 1
   b) 2
   c) 3
   d) 4

19) Which network device is responsible for path determination?
   a) Router
   b) Hub
   c) Switch
   d) Bridge

ELET 4174
Network Infrastructure Essentials
Module 3 Exam

1) A technician needs to run a backbone cable between buildings. Which type of cable is best suited for this?
   a) Thicknet coax
   b) Category 5e ScTP
   c) Category 6 UTP
   d) Fiber optic

2) Which device should be installed at the top floor of a tall building, and every third floor down?
   a) Ground equalizer
   b) Lightning arrester
   c) Telecommunications grounding busbar (TGB)
   d) Telecommunications main grounding busbar (TMGB)

3) Which term is given to the practice of interconnecting various pieces of equipment so that they connect to the ground?
   a) Bonding
   b) Grounding
   c) Splicing
   d) Terminating

4) Which method of signal transmission uses radio waves to carry signals?
   a) Electrical
   b) Optical
   c) Wireless
   d) Acoustic

5) Which characteristic of a cable is affected by improper handling or terminating?
   a) Current
   b) Voltage
   c) Power
   d) Impedance

6) What is the result when too much wire is untwisted when the connector is attached to the wire?
   a) There is no effect
   b) Far-end crosstalk
   c) Near-end crosstalk
   d) Middle crosstalk

7) Where does the responsibility of the service provider end and that of the customer begin?
   a) At the desktop
   b) At the outside power pole
   c) At the demarc
   d) It depends on the contract between the two

8) Which factors can cause signal loss in a fiber optic cable? (Select two.)
   a) Electromagnetic interference
   b) Crosstalk
   c) Small particles trapped inside the glass
   d) Misaligned connectors

9) Which statements are true of alternating current? (Select three.)
   a) The magnetic field continually collapses and rebuilds.
   b) It is the type of electricity available from the power mains in most countries.
   c) It is produced by batteries.
   d) Magnetic lines of force occur in one orientation.
   e) It can cause interference in nearby structured wiring cables.
   f) Current flows in one direction.

10) Which property describes the forming of fields around a wire?
   a) Inductance
   b) Resistance
   c) Voltage
   d) Capacitance

11) What is the maximum length of a cable segment using 10BASE-T?
   a) 100 meters
   b) 185 meters
   c) 200 meters
   d) 500 meters

12) Which standard is used by most large cable companies for sending data over cable television cables?
   a) DOCSIS
   b) CATV
   c) HFC
   d) MCNS

13) What is meant by asymmetrical DSL?
   a) Its two frequencies are not used evenly.
   b) It is used more often for voice than for data.
   c) Throughput is better at certain times of day than at others.
   d) More bandwidth is allocated for downloads than uploads.

14) What is the movement of electrons called?
   a) Voltage
   b) Current
   c) Resistance
   d) Power

15) What is the unit of measurement for resistance?
   a) Ampere
   b) Ohm
   c) Watt
   d) Volt

16) What is IP Telephony?
   a) Connecting to the Internet over a telephone line
   b) Connecting to a LAN over a telephone line
   c) Using the IP protocol on a telephone system
   d) Using the Internet as a telephone system

17) What is one function of a modem?
   a) To convert analog signals to digital signals before sending them over a phone line
   b) To convert digital signals to analog signals after receiving them over a phone line
   c) To convert digital signals to analog signals before sending them over a phone line
   d) All of the above

18) What happens when a sufficient amount of current is sensed on the ground wire of a GFCI device?
   a) The flow of electrons is stopped in the GFCI device
   b) The main circuit breaker is tripped
   c) A red warning light is activated on the GFCI device
   d) An amber warning light is activated on the GFCI device

ELET 4174
Network Infrastructure Essentials
Module 4 Exam

1) How many twisted pairs are in Category 6 cable?
   a) 4
   b) 8
   c) 10
   d) 12

2) Which type of cable insulation can be used in high temperature applications?
   a) Rubber
   b) Elastomers
   c) Flouropolymers
   d) Thermoplastics

3) Which category cable is still being installed for telephones today?
   a) Category 1
   b) Category 2
   c) Category 3
   d) Category 4

4) Which term denotes the solid color wire in a pair?
   a) Tip
   b) UTP
   c) Ring
   d) ScTP

5) Which color is pair 2 in twisted-pair cabling?
   a) Green
   b) Orange
   c) Blue
   d) Brown

6) Why is 900 pair rarely exceeded when running cable between buildings?
   a) Too much cable weight
   b) Too much space required for surge-protecting devices
   c) Will not meet Code requirements
   d) Too much crosstalk

7) Which color is pair 23 in a 25 pair cable?
   a) Red blue
   b) White slate
   c) Violet green
   d) Yellow green

8) When terminating 4-pair UTP cable onto a 25-pair cable using a 110 punch block, which pair in the fifth group is left unused?
   a) Violet and slate
   b) Red and slate
   c) Black and slate
   d) Yellow and slate
   e) White and slate

9) In most business LANs, which connector is used with twisted-pair networking cable?
   a) BNC
   b) RJ-11
   c) RJ-45
   d) Type F

10) Why should the T568A and T568B wiring schemes be used instead of the USOC standard?
   a) The USOC connector is not compatible with an RJ-45 jack.
   b) The USOC scheme does not support four-pair cable.
   c) The USOC scheme is for telephone use only.
   d) The USOC scheme separates cable pairs and can lead to increased crosstalk

11) Which combination of wiring schemes produces a crossover cable?
   a) T568A and T569A
   b) T568A and USOC
   c) T568B and T568A
   d) T568B and T569B
   e) USOC and T568B

12) How is the tip wire usually identified in a four-pair UTP or ScTP cable?
   a) It is the solid colored wire.
   b) It is the translucent colored wire.
   c) It is the black colored wire.
   d) It is the red wire with the colored trace.
   e) It is the white wire with the colored stripe.

13) Why is analog video one of the most demanding types of signals?
   a) Must be transmitted over fiber optic cables
   b) Limited to two voltage levels

c) Must be transmitted at very high data rates
d) Covers a wide range of frequencies

14) Why are some outside plant cables filled with anti-hygroscopic gel?
a) To reduce strain on the wires inside
b) To provide UV protection
c) To prevent water from entering the cable
d) To reduce EMI from power lines

15) When running cable through a firewall, what is the purpose of fire-stopping?
a) Stops drafts
b) Stops smoke
c) Restores the appearance of the firewall
d) Restores the integrity of the firewall

16) What is bonding?
a) Splicing two wires together
b) Interconnecting grounded equipment
c) Attaching cables to terminators
d) Joining two network segments

17) Which connectors are used with coaxial cable? (Select two.)
a) BNC
b) RJ-11
c) RJ-45
d) Type F

18) In radio and networking, what is the typical impedance of coaxial cable in Ohms?
a) 37
b) 50
c) 75
d) 93
e) 150