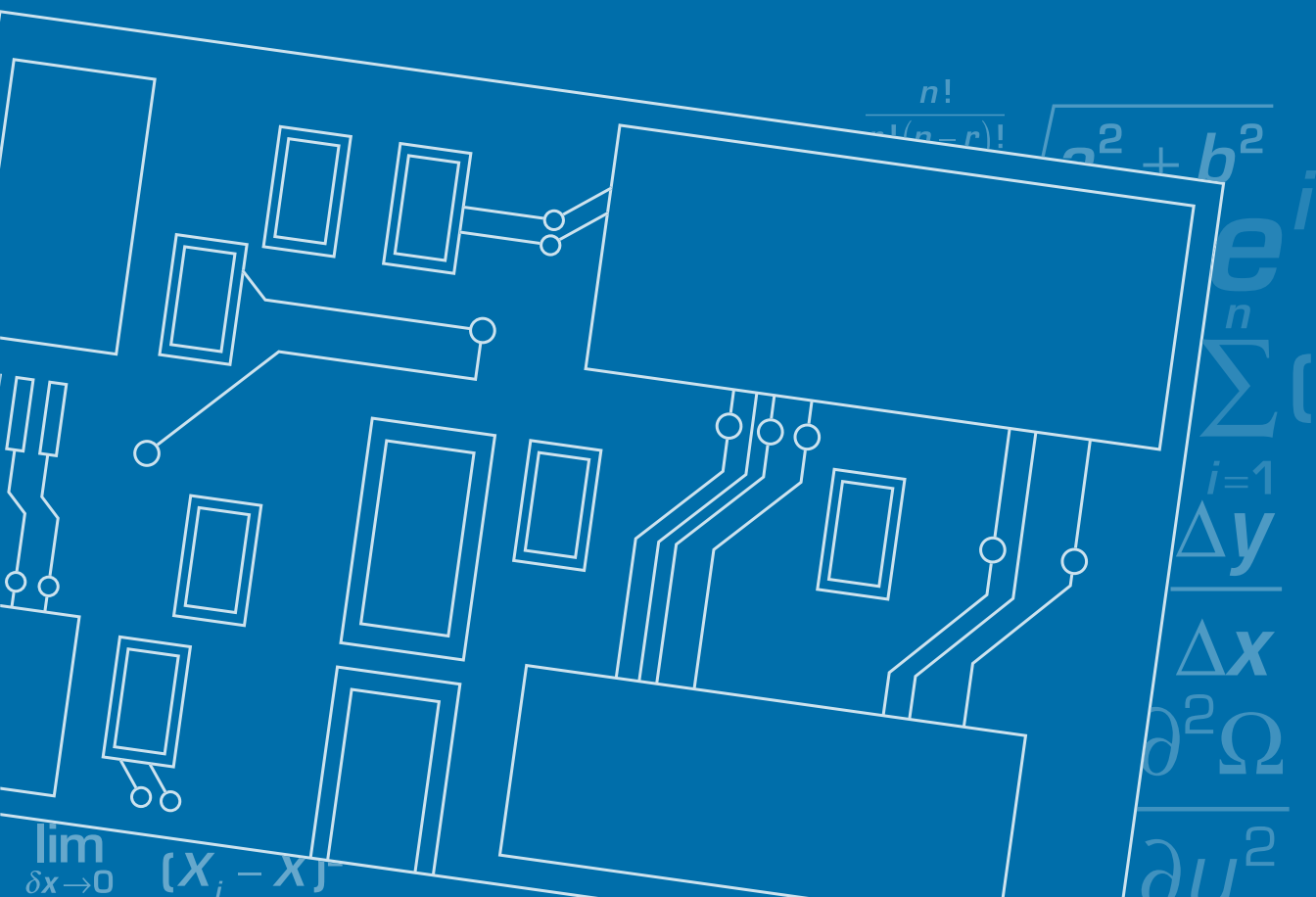
Achieve, Inc.

mathematics at work

Information Technology



Mathematics in the Information Technology Sector

Information technology (IT) is a unique area of the economy. Not only do IT-specific companies make up their own business sector, but IT also is a critical component in the success of companies across all industries. Gone are the days of an IT department being located in the basement of a business; IT is now central to the daily operations and strategic planning of many corporations. Not surprisingly, IT is one of the fastest-growing sectors in the economy — with a projected growth-rate increase of 38 percent between 2006 and 2016 and many opportunities for workers to advance. The challenge for businesses is finding qualified IT workers with flexible skills and a strong foundation in mathematics who can respond to the fast-paced and ever-changing demands of a career in IT.

Available Information Technology Jobs

Within the IT industry, there are a variety of entry-level jobs that pay well and provide opportunities for advancement — jobs for high school graduates with postsecondary training or education but less than a four-year college degree. Although there is no one pathway students need to take to be on track for a good job in the IT sector, completing a two-year postsecondary program, passing an industry-recognized certification and even receiving extensive on-the-job training are all potential avenues to employment.

Core Mathematics Knowledge in Today's Information Technology Jobs

Developed by secondary, postsecondary, business, industry and government leaders, the national Career Cluster Pathway Plans of Study for *Network Systems* and *Information Support and Services* recommend a set of rigorous mathematics courses for students to take at both the secondary and postsecondary levels in traditional or vocational settings to pursue a career track in the IT sector. These Plans of Study show in detail how the foundation provided by courses such as Algebra I, Geometry, Algebra II, Trigonometry or Statistics, Calculus, Applied Physics, and Computer Applications equips high school graduates with the mathematical knowledge and skills needed for success on the job. Until high school graduates understand the advanced mathematical skills used in the IT sector, they will remain unable to meet the demands of this high-growth industry. For more information on the Career Clusters Initiative, see www.careerclusters.org/resources/web/pos.cfm.

Jobs	Median yearly salary	Percentage of total jobs by education/training (ages 25–44)*		Number of total jobs		
		High school	Some college	2006	2016	% change
Network systems and data communications analysts	$64,600	8.1%	34.8%	261,800	401,600	53%
Network and computer systems administrators	$62,100	8.3%	41.5%	309,200	392,500	27%
Computer support specialists	$41,500	13.4%	44%	552,500	623,600	13%

*Remaining percentage of workers in occupation have a bachelor's degree or higher

Source: Bureau of Labor Statistics, U.S. Department of Labor, *Occupational Outlook Handbook, 2008–09 Edition.*

Ensuring College and Career Readiness: The American Diploma Project

In 2001, Achieve and several partner organizations launched the American Diploma Project (ADP) to identify a common core of English and mathematics academic knowledge and skills, sometimes referred to as "benchmarks," that American high school graduates need for success in college and the workforce. These ADP benchmarks, released in the 2004 report *Ready or Not? Creating a High School Diploma That Counts,* are the result of two years of intensive research conducted in colleges and universities as well as workplaces across the country.

The real-world expectations identified by ADP are significantly more rigorous than many current high school graduation standards — which helps explain why many high school graduates arrive at college or the workplace with major gaps in their English or mathematics preparation.

To help pinpoint the academic knowledge and skills required for future employment, ADP commissioned leading economists to examine labor market projections for the most promising occupations — those that pay enough to support a family and provide real potential for career advancement. ADP then surveyed officials from 22 industries, ranging from manufacturing to financial services, about the most useful skills for their employees to bring to the job.

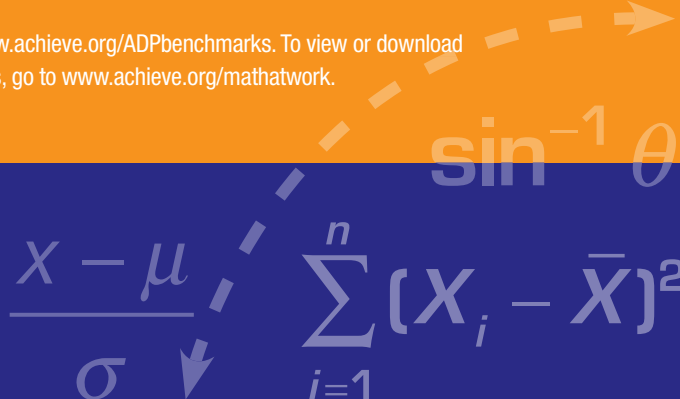
ADP also worked closely with two- and four-year postsecondary faculty from five partner states to determine the prerequisite English and mathematics knowledge and skills required to succeed in entry-level, credit-bearing higher education courses. These conversations revealed an unprecedented convergence of the knowledge and skills employers and postsecondary faculty say are needed for new employees and freshmen beginning credit-bearing coursework to be successful.

"Mathematics at Work" Series

Following up on the work of ADP, Achieve has produced a series of "Mathematics at Work" brochures to examine how higher-level mathematics is used in today's workplaces. The brochures present case studies drawn from leading industries nationwide to illustrate the advanced mathematics knowledge and skills embedded in jobs that offer opportunities for advancement and are accessible to high school graduates.

The series underscores the value of a rigorous high school curriculum in mathematics. All high school graduates — regardless of whether they enroll in college, join the workforce or enter the military — benefit from acquiring a comprehensive knowledge base and skill set in mathematics.

To view or download the ADP benchmarks, go to www.achieve.org/ADPbenchmarks. To view or download a PDF of additional "Mathematics at Work" brochures, go to www.achieve.org/mathatwork.



Mathematics maps the

Career Preparation for Information Technology Technicians

The IT field is filled with a wide variety of people who all share a passion for applying their understanding of mathematics to the world of computers. From assigning Internet Protocol (IP) addresses and ensuring network security to installing routers and managing bandwidth demand, certified IT technicians keep the information highway humming.

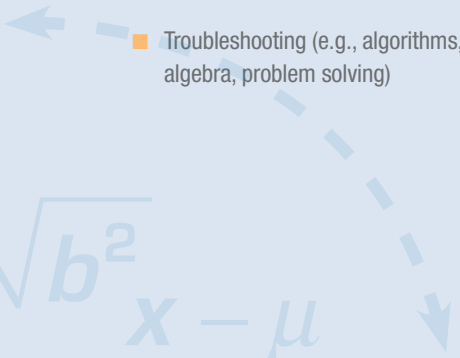
A broad understanding of advanced high school mathematics and its applications is essential for successfully earning certifications from respected industry leaders such as Cisco and the Computing Technology Industry Association (CompTIA). These certifications are highly valued in the marketplace, and some states and school districts build entry-level exams — such as Cisco's Certified Network Associate (CCNA) exam or CompTIA's A+ exam — into high school career pathways to better connect classroom experiences with the world of work. There also are advanced-level certifications in specific areas, such as networks and security, typically pursued by individuals with on-the-job experience.

Key objectives and related mathematical ideas covered in CompTIA's A+ exam and the CCNA exam include:

- IP Addressing (e.g., binary code, exponentials)
- Principles of Wireless Technology (e.g., wavelengths, electromagnetic spectrum)
- Computers and Electronics (e.g., voltage, rates)
- Troubleshooting (e.g., algorithms, logic, Boolean algebra, problem solving)

The specialized certification training that equips network technicians for on-the-job challenges requires a strong background in mathematics and covers many of the core concepts in the ADP benchmarks. Network technicians rely on mathematics to translate bits into bytes using powers, decipher code using multiple variables, calculate the likelihood of an event using permutations and combinations, and construct truth tables to determine outcomes. All these mathematical skills are grounded in a range of advanced high school and entry-level college mathematics courses such as Algebra II, Linear Algebra, Plane Geometry, Statistics, Discrete Mathematics, Calculus and the mathematics found in introductory physics, electrical and mechanical engineering, and finance courses.

Technicians must apply their understanding of mathematics to devise, implement and troubleshoot networks creatively. Their ability to solve real-world problems is rooted in their appreciation that for every challenge they face, there is a logical, mathematical solution. It also is important that IT employees can communicate effectively with co-workers and customers who are not as technologically savvy as they are. Teamwork skills are valued as well, as IT departments are themselves virtual networks of technicians who work together to keep a company's electronic infrastructure intact and secure. Network technicians are equipped with the latest training that ensures they and their employers will stay at the forefront of tomorrow's technological developments. For more information on Cisco and CompTIA's exams, see www.cisco.com/web/learning/netacad/index.html and http://certification.comptia.org.



Bit by Bit: Building Networks with Mathematics

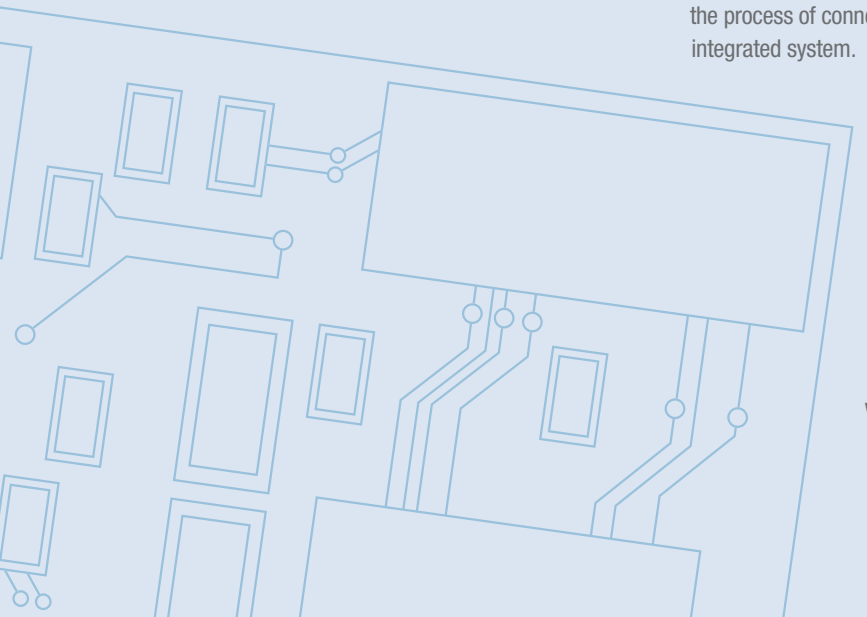
If there is one certainty about business in the future, it is that computers will play an increasingly vital role — as will the network technicians who keep the computers talking to each other. Setting up and maintaining computer networks require skilled personnel who know how to put mathematics to use in every facet of their jobs and can keep the information highway running smoothly today while anticipating the needs of tomorrow.

Determining the Electrical Demands of the Network

Algebra, Measurement and Statistical Analysis

Installing a network is a major undertaking that involves routing miles of cables to a central transfer hub. "Wireless" systems might appear wireless to consumers, but they are anything but. Beyond measuring the equipment needs for the network, technicians must know the precise demands the system will be placing on the electrical grid. For technicians to determine the electrical demands of the network — and to be able to factor in the additional air conditioning requirements for keeping the mainframes, servers and network equipment cool enough to work at maximum efficiency — they must calculate present-day electrical needs and the anticipated future expansion of the network. This requires the application of various algebraic and numerical operations and statistical data analysis.

At their core, networks link together and empower individual computers to interact and collaborate with one another. Making sure that each and every computer knows the "name" and location of every other computer is the first step in building a network. Network technicians begin the task of joining them together by assigning distinct and unique IP addresses to every computer and network device — while factoring in the possibility of growth in any particular sector of the company. They then must convert those specifications into a specific numeric code — an IP address — associated with each computer in the network. By linking the identity of each computer to its subnet and network capabilities, network personnel begin the process of connecting the hardware into a smoothly integrated system.



Managing the Network

Algorithms, Algebra and Logic

IT technicians must determine the baseline usage across the network for each and every computer using mathematical averages and statistical analyses to allot precious bandwidth with precision. Watching the speed

> *"A solid foundation in mathematics is the lynchpin to success in today's information technology world. Analytical skills, like those required in math, are a critical component to successfully creating the solution sets EDS clients need."*
>
> Chris Spiller
> Senior Human Resources Business Partner, *EDS*

at which packets of information cross the network and managing routing times to maximize efficiency require using a complex series of formulas. Those calculations are performed using data collected on an hourly or even minute-by-minute basis to determine when and where spikes in bandwidth demand occur. Using a combination of algorithms, Boolean algebra and logic, technicians write subroutine scripts for the domain controller — small programs involving multiple variables that read the unique identity of each computer to see the demands it is placing on the network at that split second. Technicians then write additional subroutines to allocate bandwidth across the network based on anticipated future demand using linear programming and optimization calculations that shift bandwidth allocations to where the need is greatest.

Addressing Network Failures

Reasoning and Problem Solving

Ensuring system integrity and security is a crucial element of a network technician's job to prevent network crashes and hackers from breaking through the network firewall. Writing login programs that route each employee through the maze of protection layers involves Boolean logic in the design of the network's defense features. Being ready to address network failures also is crucial — especially in today's interconnected world, where doctors in Kansas rely on the expertise of radiographers in the Carolinas.

Performing a "root cause analysis" for network failures is critical to determine the source of the problem quickly and accurately — another important IT skill based on a solid foundation in algorithms, Boolean algebra and logic. Communicating with the user to isolate the source of the problem — hardware, connectivity, software, etc. — also leads the network technician through an algorithmic set of possible solutions. Knowledge of the entire network and the role mathematics plays in its smooth operation is essential for keeping the system running.

Tracking Finances and Planning for Tomorrow

Optimization, Spreadsheets and Statistical Analysis

As the software that powers the network is licensed and often needs to be upgraded and equipment costs are prorated, keeping track of the financial budgetary needs of a network requires a sophisticated understanding of spreadsheets and formulas for calculating costs. Making projections based on linear-growth modeling requires a firm foundation in mathematics. Writing Boolean code to alert engineers when a license on a piece of software is set to expire, as well as statistically analyzing patterns of usage to allot financial resources in the future, requires network technicians who can work together to determine the best direction — and the budget — for tomorrow.

Mathematics + Teamwork = Success

Network technicians put their mathematical knowledge to use at every stage when building and maintaining a computer network. Technicians regularly apply algebra and statistical analysis to calculate the electrical demands of network equipment and draw on their understanding of number functions to assign unique identification codes to each and every computer. Their knowledge of mathematical averaging and statistical analysis comes into play in the allocation of bandwidth as they craft programming subroutines employing multiple variables to identify where to send information across the network. They use Boolean algebra for designing and implementing security features, formulas and linear algebra for budgeting, and algorithms when troubleshooting.

Although successful network technicians rely on their understanding of mathematics, they also rely on one another. Because of the complexity of today's computer systems, companies increasingly are asking their network technicians not only to be the last line of defense when it comes to maintaining the network, but also to serve on the front lines of customer service and employee support. Competition from the global marketplace puts ever-increasing demands on companies to hire employees who have not only the academic knowledge and know-how to succeed in business but also the communication and teamwork skills to put that knowledge to use.

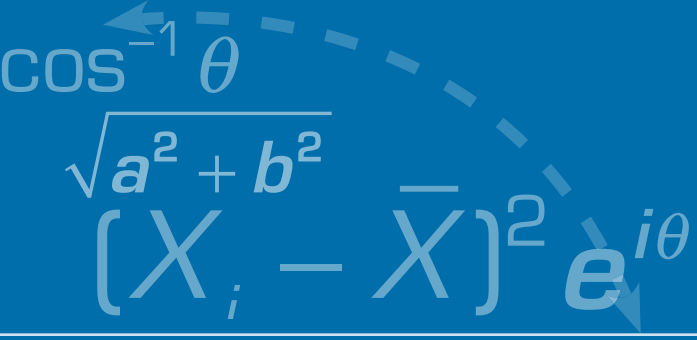
> *"The skills needed to be productive in today's IT workplace, especially problem-solving skills, are best developed through first having a strong foundation in mathematics. Many, if not all, IT troubleshooting and design skills are ultimately dependent on these analytical skills. Training for an IT career realistically begins with mathematics — the more advanced, the better."*

Tim Maxwell, U.S. Training Program Manager
Infrastructure Solutions Global Training Team
Perot Systems

Network technicians of today require the mathematical skill set for building and maintaining sophisticated computer networks, but they also must be articulate and creative problem solvers — skills that permeate the college- and career-ready ADP benchmarks. Accordingly, as every sector of business increasingly relies on computer network technology, communication and teamwork skills are emerging as central talents for employees to possess.

> *"Network technicians and engineers are essentially troubleshooters. The better the mathematics background, the better the troubleshooter. These skills go hand-in-hand in fixing problems and career success."*

Glenn Wintrich
Director, Service Line Management
Perot Systems



About Achieve

Achieve, Inc., created by the nation's governors and business leaders, is a bipartisan, non-profit organization that helps states raise academic standards, improve assessments and strengthen accountability to prepare all young people for postsecondary education, careers and citizenship.

About the American Diploma Project (ADP) Network

In 2005, Achieve launched the ADP Network — a collaboration of states working together to improve their academic standards and provide all students with a high school education that meets the needs of today's workplaces and universities. The ADP Network members — responsible for educating 80 percent of all our nation's public high school students — are committed to taking four college and career readiness action steps:

1. Align high school standards with the demands of college and careers.
2. Require all students to complete a college- and career-ready curriculum to earn a high school diploma.
3. Build college- and career-ready measures into statewide high school assessment systems.
4. Hold high schools and postsecondary institutions accountable for student success.

The world has changed, and high schools must change with it. The ADP Network is leading the charge in ensuring that all high school students graduate with a degree that works.

Visit our Web site for more information about the ADP Network and the ADP benchmarks (www.achieve.org/ADPbenchmarks) and to view additional "Mathematics at Work" brochures (www.achieve.org/mathatwork).

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