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Computer and Mathematics-Related Occupations

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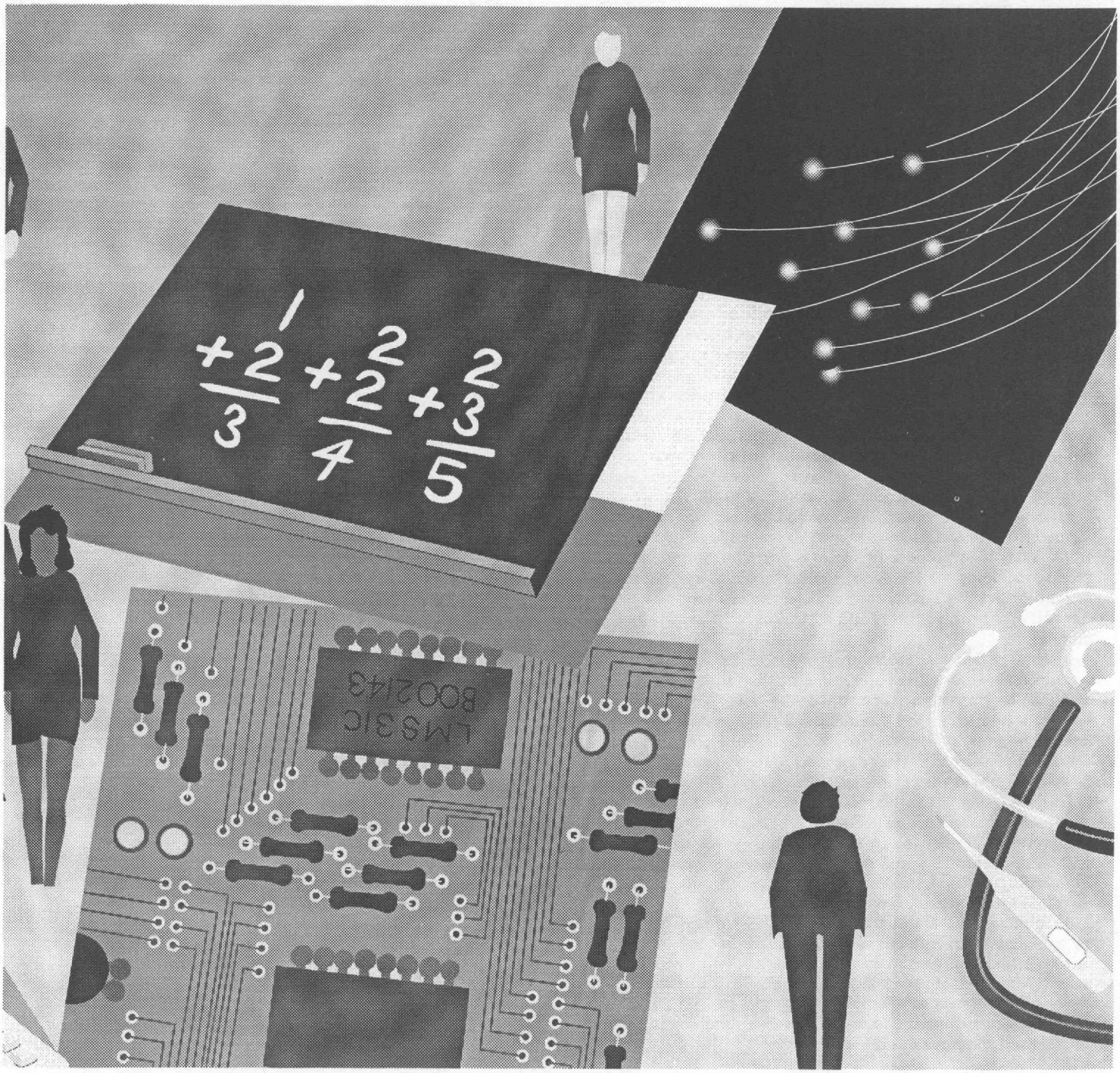

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Accountants and Auditors

(D.O.T. 160 through .167-042, -054, and .267-014)

Nature of the Work

Managers must have up-to-date financial information in order to make important decisions. Accountants and auditors prepare, analyze, and verify financial reports and taxes, and monitor information systems that furnish this information to managers in all business, industrial, and government organizations.

Four major fields of accounting are public, management, and government accounting, and internal auditing. Public accountants have their own businesses or work for public accounting firms. They perform a broad range of accounting, auditing, tax, and consulting activities for their clients, who may be corporations, governments, nonprofit organizations, or individuals. Management accountants, also called industrial, corporate, or private accountants, record and analyze the financial information of the companies for which they work. Internal auditors verify the accuracy of their organization's records and check for mismanagement, waste, or fraud. Government accountants and auditors maintain and examine the records of government agencies and audit private businesses and individuals whose activities are subject to government regulations or taxation.

Within each field, accountants often concentrate on one phase of accounting. For example, many public accountants concentrate on tax matters, such as preparing an individual's income tax returns and advising companies of the tax advantages and disadvantages of certain business decisions. Others concentrate on consulting and offer advice on matters such as employee health care benefits, and compensation; the design of companies' accounting and data processing systems; and controls to safeguard assets. Some specialize in forensic accounting—investigating and interpreting bankruptcies and other complex financial transactions. Still others work primarily in auditing—examining a client's financial statements and reporting to investors and authorities that they have been prepared and reported correctly. However, fewer accounting firms are performing this type of work because of potential liability.

Management accountants analyze and interpret the financial information corporate executives need to make sound business decisions. They also prepare financial reports for nonmanagement groups, including stock holders, creditors, regulatory agencies, and tax authorities. Within accounting departments, they may work in financial analysis, planning and budgeting, cost accounting, and other areas.

Internal auditing is rapidly growing in importance. As computer systems make information more timely and available, top management can base its decisions on actual data rather than personal observation. Internal auditors examine and evaluate their firms' financial and information systems, management procedures, and internal controls to ensure that records are accurate and controls are adequate to protect against fraud and waste. They also review company operations—evaluating their efficiency, effectiveness, and compliance with corporate policies and procedures, laws, and government regulations. There are many types of highly specialized auditors, such as electronic data processing auditors, environmental auditors, engineering auditors, legal auditors, insurance premium auditors, bank auditors, and health care auditors.

Accountants and auditors also work for Federal, State, and local governments. Government accountants see that revenues are received and expenditures are made in accordance with laws and regulations. Many persons with an accounting background work for the Federal Government as Internal Revenue Service agents or in financial management, financial institution examination, and budget analysis and administration.

In addition, a small number of persons trained as accountants teach and conduct research at business and professional schools. Some work part time as accountants or consultants.

Computers are widely used in accounting and auditing. With the aid of special computer software packages, accountants summarize transactions in standard formats for financial records or organize data in special formats for financial analysis. These accounting packages are easily learned and require few specialized computer skills, and greatly reduce the amount of tedious manual work associated with figures and records. Personal and laptop computers enable accountants and auditors in all fields—even those who work independently—to use their clients' computer system and to extract information from large mainframe computers. Internal auditors may recommend controls for their organization's computer system to ensure the reliability of the system and the integrity of the data. A growing number of accountants and auditors have extensive computer skills and specialize in correcting problems with software or developing software to meet unique data needs.

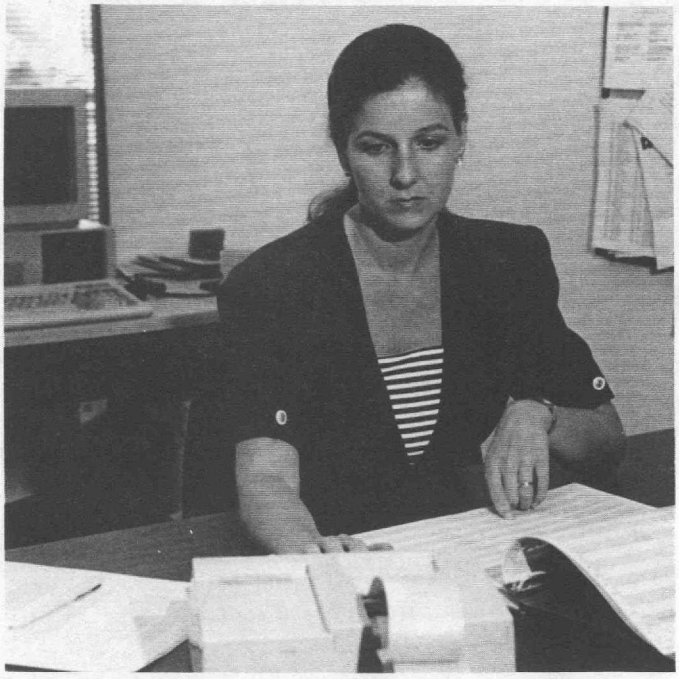
Working Conditions

Accountants and auditors work in offices, but public accountants may frequently visit the offices of clients while conducting audits. Self-employed accountants may be able to do part of their work at home. Accountants and auditors employed by large firms and government agencies may travel frequently to perform audits at clients' places of business, branches of their firm, or government facilities.

The majority of accountants and auditors generally work a standard 40-hour week, but many work longer, particularly if they are self-employed and free to take on the work of as many clients as they choose. For example, about 4 out of 10 self-employed accountants and auditors work more than 50 hours per week, compared to 1 out of 4 wage and salary accountants and auditors. Tax specialists often work long hours during the tax season.

Employment

Accountants and auditors held about 939,000 jobs in 1992. They worked throughout all types of firms and industries, but nearly one-



CPA's have the widest range of job opportunities.

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third worked for accounting, auditing, and bookkeeping firms, or were self-employed.

The majority of accountants and auditors were unlicensed management accountants, internal auditors, or government accountants and auditors. However, in 1992 there were on record over 475,000 State-licensed Certified Public Accountants (CPA's), Public Accountants (PA's), Registered Public Accountants (RPA's), and Accounting Practitioners (AP's). The vast majority of these—over 400,000—were CPA's, but there may have been far fewer practicing CPA's in the country; many CPA's hold licenses in several States at once.

Most accountants and auditors work in urban areas where public accounting firms and central or regional offices of businesses are concentrated. Roughly 10 percent of all accountants were self-employed, and less than 10 percent worked part time.

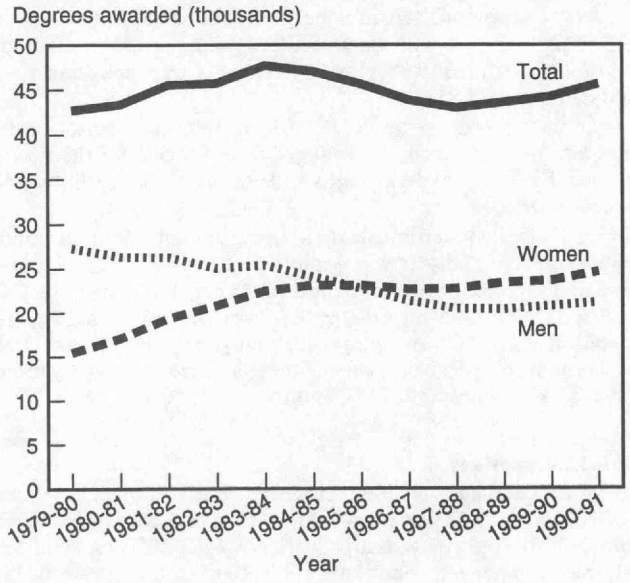
Some accountants and auditors teach full time in junior colleges and colleges and universities; others teach part time while working for private industry or government or as self-employed accountants.

Training, Other Qualifications, and Advancement

Most public accounting and business firms require applicants for accountant and internal auditor positions to have at least a bachelor's degree in accounting or a related field. Those wishing to pursue a bachelor's degree in accounting should carefully research accounting curricula before enrolling. Many States will soon require CPA candidates to complete 150 semester hours of coursework prior to taking the CPA exam, and many schools have altered their curricula accordingly. Some employers prefer those with a master's degree in accounting or a master's degree in business administration with a concentration in accounting. Most employers also prefer applicants who are familiar with computers and their applications in accounting and internal auditing.

For beginning accounting and auditing positions in the Federal Government, 4 years of college (including 24 semester hours in accounting or auditing) or an equivalent combination of education and experience is required.

The number of accounting graduates remained stable between 1986 and 1991, but more women than men obtained bachelor's degrees in accounting.



Source: National Center for Education Statistics

Previous experience in accounting or auditing can help an applicant get a job. Many colleges offer students an opportunity to gain experience through summer or part-time internship programs conducted by public accounting or business firms. Such training is invaluable in gaining permanent employment in the field.

Professional recognition through certification or licensure also is helpful. In the majority of States, CPA's are the only accountants who are licensed and regulated. Anyone working as a CPA must have a certificate and a license issued by a State board of accountancy. The vast majority of States require CPA candidates to be college graduates, but a few States substitute a certain number of years of public accounting experience for the educational requirement. Based on recommendations made by the American Institute of Certified Public Accountants and the National Association of State Boards of Accountancy, some States currently require that CPA candidates complete 150 semester hours of college coursework, and many other States are working toward adopting this law. This 150-hour rule requires an additional 30 hours of coursework beyond the usual 4-year bachelor's degree in accounting.

All States use the four-part Uniform CPA Examination prepared by the American Institute of Certified Public Accountants. The 2-day CPA examination is rigorous, and only about one-quarter of those who take it each year pass each part they attempt. Candidates are not required to pass all four parts at once, although most States require candidates to pass at least two parts for partial credit. Many States require all sections of the test to be passed within a certain period of time. Most States also require applicants for a CPA certificate to have some accounting experience.

The designations PA or RPA are also recognized by most States, and several States continue to issue these licenses. With the growth in the number of CPA's, however, the majority of States are phasing out the PA, RPA, and other non-CPA designations by not issuing any more new licenses. Accountants who hold PA or RPA designations have similar legal rights, duties, and obligations as CPA's, but their qualifications for licensure are less stringent. The designation Accounting Practitioner is also awarded by several States. It requires less formal training than a CPA license and covers a more limited scope of practice.

Nearly all States require both CPA's and PA's to complete a certain number of hours of continuing professional education before their licenses can be renewed. The professional associations representing accountants sponsor numerous courses, seminars, group study programs, and other forms of continuing education.

Professional societies bestow other forms of credentials on a voluntary basis. Voluntary certification can attest to professional competence in a specialized field of accounting and auditing. It also can certify that a recognized level of professional competence has been achieved by accountants and auditors who acquired some skills on the job, without the amount of formal education or public accounting work experience needed to meet the rigorous standards required to take the CPA examination. Increasingly, employers seek applicants with these credentials.

The Institute of Internal Auditors confers the designation Certified Internal Auditor (CIA) upon graduates from accredited colleges and universities who have completed 2 years' work in internal auditing and who have passed a four-part examination. The EDP Auditors Association confers the designation Certified Information Systems Auditor (CISA) upon candidates who pass an examination and who have 5 years of experience in auditing electronic data processing systems. However, auditing or data processing experience and college education may be substituted for up to 3 years. Other organizations, such as the National Association of Certified Fraud Examiners and the Bank Administration Institute, confer other specialized auditing designations.

The Institute of Management Accountants (IMA), formerly the National Association of Accountants, confers the Certified Management Accountant (CMA) designation upon college graduates who pass a four-part examination, agree to meet continuing education requirements, comply with standards of professional conduct, and have at least 2 years' work in management accounting. The

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CMA program is administered through an affiliate of the IMA, the Institute of Certified Management Accountants. The Accreditation Council for Accountancy and Taxation, a satellite organization of the National Society of Public Accountants, awards a Certificate of Accreditation in Accountancy to those who pass a comprehensive examination, and a Certificate of Accreditation in Taxation to those with appropriate experience and education. It is not uncommon for a practitioner to hold multiple licenses and designations. For instance, one internal auditor might be a CPA, CIA, and CISA.

Persons planning a career in accounting should have an aptitude for mathematics, be able to analyze, compare, and interpret facts and figures quickly, and make sound judgments based on this knowledge. They must be able to clearly communicate the results of their work, orally and in writing, to clients and management.

Accountants and auditors must be good at working with people as well as with business systems and computers. Accuracy and the ability to handle responsibility with limited supervision are important. Perhaps most important, because millions of financial statement users rely on their services, accountants and auditors should have high standards of integrity.

Capable accountants and auditors should advance rapidly; those having inadequate academic preparation may be assigned routine jobs and find promotion difficult. Many graduates of junior colleges and business and correspondence schools, as well as bookkeepers and accounting clerks who meet the education and experience requirements set by their employers, can obtain junior accounting positions and advance to more responsible positions by demonstrating their accounting skills on the job.

Beginning public accountants usually start by assisting with work for several clients. They may advance to positions with more responsibility in 1 or 2 years and to senior positions within another few years. Those who excel may become supervisors, managers, or partners, open their own public accounting firms, or transfer to executive positions in management accounting or internal auditing in private firms.

Beginning management accountants often start as cost accountants, junior internal auditors, or as trainees for other accounting positions. As they rise through the organization, they may advance to accounting manager, chief cost accountant, budget director, or manager of internal auditing. Some become controllers, treasurers, financial vice presidents, chief financial officers, or corporation presidents. Many senior corporation executives have a background in accounting, internal auditing, or finance.

There is a large degree of mobility among public accountants, management accountants, and internal auditors. Practitioners often shift into management accounting or internal auditing from public accounting, or between internal auditing and management accounting. However, it is less common for accountants and auditors to move from either management accounting or internal auditing into public accounting.

Job Outlook

Employment of accountants and auditors is expected to grow faster than the average for all occupations through the year 2005. Qualified accountants and auditors should have good job opportunities. Although the profession is characterized by a relatively low rate of turnover, because the occupation is so large many openings also will arise as accountants and auditors retire, die, or move into other occupations. CPA's should have the widest range of opportunities, especially as more States enact the 150-hour rule and it becomes more difficult to become a CPA.

As the economy grows, the number of business establishments increases, requiring more accountants and auditors to set up their books, prepare their taxes, and provide management advice. As these businesses grow, the volume and complexity of information developed by accountants and auditors on costs, expenditures, and taxes will increase as well. More complex requirements for accountants and auditors also arise from changes in legislation related to taxes, financial reporting standards, business investments, mergers, and other financial matters. In addition, businesses will increasingly need quick, accurate, and individually tailored financial information due to the demands of growing international competition.

The changing role of public accountants, management accountants, and internal auditors also will spur job growth. Public accountants will perform less auditing work due to potential liability, and less tax work due to growing competition from tax preparation firms, but they will assume an even greater management advisory role and expand their consulting services. These rapidly growing services will lead to increased demand for public accountants in the coming years. Management accountants also will take on a greater advisory role as they develop more sophisticated and flexible accounting systems, and focus more on analyzing operations rather than just providing financial data. Similarly, management will increasingly need internal auditors to develop new ways to discover and eliminate waste and fraud.

Despite growing opportunities for qualified accountants and auditors, competition for the most prestigious jobs—such as those with major accounting and business firms—will remain keen. Applicants with a master's degree in accounting, a master's degree in business administration with a concentration in accounting, or a broad base of computer experience will have an advantage. Moreover, computers now perform many simple accounting functions, allowing accountants and auditors to incorporate and analyze more information. This increasingly complex work requires greater knowledge of more specialized areas such as international business and current legislation, and expertise in specific industries.

Earnings

According to a College Placement Council Salary Survey in 1993, bachelor's degree candidates in accounting received starting salary offers averaging nearly $28,000 a year; master's degree candidates in accounting, over $30,000.

According to a survey of workplaces in 160 metropolitan areas, accountants with limited experience had median earnings of $24,700 in 1992, with the middle half earning between $22,200 and $27,500. The most experienced accountants had median earnings of $76,000, with the middle half earning between $68,500 and $84,600. Public accountants—employed by public accounting firms—with limited experience had median earnings of $28,000 in 1992, with the middle half earning between $26,500 and $29,400. The most experienced public accountants had median earnings of $42,400, with the middle half earning between $36,900 and $50,400. Many owners and partners of firms earned considerably more.

Based on a survey by the Institute of Management Accountants, the average salary of IMA members was about $55,100 a year in 1992. IMA members who were certified public accountants averaged $61,900, while members who were certified management accountants averaged $58,700.

According to a survey by the Institute of Internal Auditors, salaries of internal auditors in 1992 ranged from $26,500 for those with less than 2 years of experience to $60,700 for those with over 10 years of experience.

In the Federal Government, the starting annual salary for junior accountants and auditors was about $18,300 in 1993. Candidates who had a superior academic record could begin at about $22,700. Applicants with a master's degree or 2 years' professional experience began at $27,800. Accountants employed by the Federal Government in nonsupervisory, supervisory, and managerial positions averaged $46,300 a year in 1993; auditors, $48,200.

Related Occupations

Accountants and auditors design internal control systems and analyze financial data. Others for whom training in accounting is invaluable include appraisers, budget officers, loan officers, financial analysts and managers, bank officers, actuaries, underwriters, tax collectors and revenue agents, FBI special agents, securities sales workers, and purchasing agents.

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Sources of Additional Information

Information about different accounting licenses and the standards for licensure in your State may be obtained from your State board of accountancy. A list of the addresses and chief executives of all State boards of accountancy is available from:

☞ National Association of State Boards of Accountancy, 380 Lexington Ave., Suite 200, New York, NY 10168-0002.

Information about careers in certified public accounting and about CPA standards and examinations may be obtained from:

☞ American Institute of Certified Public Accountants, 1211 Avenue of the Americas, New York, NY 10036-8775, or call 1-800-862-4272.

Information on management and other specialized fields of accounting and auditing and on the Certified Management Accountant program is available from:

☞ Institute of Management Accountants, 10 Paragon Dr., Montvale, NJ 07645-1760.

☞ National Society of Public Accountants and the Accreditation Council for Accountancy and Taxation, 1010 North Fairfax St., Alexandria, VA 22314.

☞ The Institute of Internal Auditors, 249 Maitland Ave., Altamonte Springs, FL 32701-4201.

☞ The EDP Auditors Association, 455 Kehoe Blvd., Suite 106, Carol Stream, IL 60188-0180.

For information on accredited accounting programs and educational institutions offering a specialization in accounting or business management, contact:

☞ American Assembly of Collegiate Schools of Business, 605 Old Ballas Rd., Suite 220, St. Louis, MO 63141.

Actuaries

(D.O.T. 020.167-010)

Nature of the Work

Why do young drivers pay more for automobile insurance than older drivers? How much should an insurance policy cost? How much should an organization contribute each year to its pension fund? Answers to these and similar questions are provided by actuaries, who design insurance and pension plans and ensure that they are maintained on a sound financial basis.

Actuaries assemble and analyze statistics to calculate probabilities of death, sickness, injury, disability, unemployment, retirement, and property loss. They use this information to determine the expected insured loss. For example, they may calculate the probability of claims due to automobile accidents, which can vary depending on the insured's driving history, type of car, and many other factors. They must make sure that the price charged for the insurance will enable the company to pay all claims and expenses as they occur. Finally, this price must be profitable and yet be competitive with other insurance companies. In a similar manner, the actuary calculates premium rates and determines policy contract provisions for each type of insurance offered. Most actuaries specialize in either life, health, or property and casualty insurance; others specialize in pension plans or in financial planning and investment.

To perform their duties effectively, actuaries must keep informed about general economic and social trends and legislative, health, and other developments that may affect insurance practices. Because of their broad knowledge of insurance, company actuaries may work in investment, underwriting, or pension planning departments. Actuaries in executive positions help determine company policy. In that role, they may be called upon to explain complex technical matters to other company executives, government officials, policyholders, and the public. They may testify before public agencies on proposed legislation affecting the insurance business, for example, or explain changes in premium rates or contract provisions. They also may help companies develop plans to enter new lines of business, such as environmental risk, or long-term health care.

The small number of actuaries who work for the Federal Government usually deal with a particular insurance or pension program, such as Social Security or life insurance for veterans and members of the Armed Forces. Actuaries in State government are usually employed by State insurance departments that regulate insurance companies, oversee the operations of State retirement or pension systems, handle unemployment insurance or workers' compensation problems, and assess the impact of proposed legislation. They might determine whether the rates charged by an insurance company are proper or whether an employee benefit plan is financially sound.

Consulting actuaries provide advice for a fee to various clients including insurance companies, corporations, hospitals, labor unions, government agencies, and attorneys. Some consulting actuaries set up pension and welfare plans, calculate future benefits, and determine the amount of employer contributions. They also provide advice to health care and financial services firms. Consultants may be called upon to testify in court regarding the value of potential lifetime earnings lost by a person who has been disabled or killed in an accident, the current value of future pension benefits in divorce cases, or the calculation of automobile insurance rates. Actuaries who are enrolled under the provisions of the Employee Retirement Income Security Act of 1974 (ERISA) evaluate the pension plans covered by that act and report on their financial soundness.

Working Conditions

Actuaries have desk jobs that require no unusual physical activity; their offices generally are comfortable and pleasant. They usually work at least 40 hours a week. Some actuaries, particularly consulting actuaries, often travel to meet with clients. Consulting actuaries may also be expected to work more than 40 hours per week.

Employment

Actuaries held about 15,000 jobs in 1992. Some actuaries were self-employed.

Well over one-half of wage and salary actuaries worked in the insurance industry. Most worked for life insurance companies; others worked for property, casualty, and health insurance companies, and insurance agents and brokers. Most of the remaining actuaries worked for firms providing services, especially consulting actuarial services. A small number of actuaries worked for government agencies.

Although few in number, actuaries provide essential services to insurance companies.

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Training, Other Qualifications, and Advancement

A good educational background for a beginning job in a large life or casualty company is a bachelor's degree in a mathematics- or business-related discipline, such as actuarial science, mathematics, statistics, economics, finance, or accounting. Some companies hire applicants with a liberal arts major, provided the applicant has a working knowledge of mathematics, including calculus, probability, and statistics, and has demonstrated this ability by passing at least the beginning actuarial exams required for professional designation. Courses in accounting, computer science, and insurance also are useful. Companies increasingly prefer well-rounded individuals who, in addition to a strong technical background, have some training in liberal arts and business. Good communication and interpersonal skills are important, particularly for prospective consulting actuaries. Although only about 55 colleges and universities offer an actuarial science program, hundreds of schools offer a degree in mathematics or statistics.

A strong background in mathematics is essential for persons interested in a career as an actuary. It is an advantage to pass, while still in school, two or more of the examinations offered by professional actuarial societies. Three societies sponsor programs leading to full professional status in their specialty. The Society of Actuaries gives a series of actuarial examinations for the life and health insurance, pension, and finance and investment fields and the Casualty Actuarial Society gives a series of examinations for the property and casualty field. Because the first parts of the examination series of each society are jointly sponsored and cover the same material, students need not commit themselves to a specialty until they have taken the initial examinations. These examinations test competence in subjects such as linear algebra, probability, calculus, statistics, risk theory, and actuarial mathematics. The first few examinations help students evaluate their potential as actuaries. Those who pass usually have better opportunities for employment and higher starting salaries.

Actuaries are encouraged to complete the entire series of examinations as soon as possible; completion generally takes from 5 to 10 years. Examinations are given twice each year. Extensive home study is required to pass the advanced examinations; many actuaries study for several months to prepare for an examination. Actuaries who complete approximately half of the total examinations in either the life insurance series or the pension series or seven examinations in the casualty series are awarded "associate" membership in their society. Those who pass an entire series receive the title "fellow."

The American Society of Pension Actuaries confers several designations, both actuarial and nonactuarial, for which requirements vary. However, membership status generally requires the passage of some actuarial exams, as well as some pension experience.

Pension actuaries who attest to the Federal Government as to the financial status of defined benefit plans must be enrolled by the Joint Board for the Enrollment of Actuaries. Applicants for enrollment must meet certain experience, education, and examination requirements as stipulated by the Joint Board.

Beginning actuaries often rotate among jobs to learn various actuarial operations and different phases of insurance work, such as marketing, underwriting, or product development. At first, they prepare data for actuarial tables or perform other simple tasks. As they gain experience, they may supervise clerks, prepare correspondence and reports, and do research.

Advancement to more responsible work as assistant, associate, and chief actuary depends largely on job performance and the number of actuarial examinations passed. Actuaries with a broad knowledge of the insurance, pension, and employee benefits fields often advance to administrative and executive positions in underwriting, accounting, or data processing departments. Actuaries with a business background and supervisory ability may advance to management positions in other areas, such as marketing, advertising, or planning.

Job Outlook

Employment of actuaries is expected to grow faster than the average for all occupations through the year 2005. College graduates who have passed at least two actuarial examinations while still in school, have a strong mathematical and statistical background and strong communication and problem-solving skills, and have gained some practical experience by completing an internship should have the best prospects.

Employment growth of consulting actuaries is expected to be faster than growth in life insurance companies, traditionally the major employer of actuaries. As companies seek to boost profitability by streamlining operations, some actuarial departments may be cut back or eliminated completely. Insurance companies may increasingly turn to consultants to provide actuarial services formerly performed in-house.

The need to assess the financial effects of prospective changes in the health care system and health problems such as AIDS or heart disease on insurance companies or government will result in continued overall employment growth. Also, shifts in the age distribution of the population will result in a large increase in the number of people with established careers and family responsibilities. This is the group that traditionally has accounted for the bulk of private insurance sales. As people live and work longer, they draw health and pension benefits for a longer period, and actuaries are needed to re-estimate the probabilities of such events as death, sickness, and length of retirement.

The liability of companies for damage resulting from their products has received much attention in recent years. Casualty actuaries will continue to be involved in the development of product liability insurance, medical malpractice and workers' compensation coverage, and self-insurance, which may involve internal reserve funds established by some large corporations. The growing need to evaluate environmental risks and calculate prices for insuring facilities which carry such risks, such as underground storage tanks, will contribute to the demand for actuaries.

Despite expected employment growth, actuaries may face competition for jobs. Due to favorable publicity about the actuarial profession, the number of workers entering this small occupation has increased substantially in recent years, while at the same time, demand is expected to slow due to slower growth in the insurance industry.

Earnings

In 1992, starting salaries for actuaries averaged about $31,800 for those with a bachelor's degree, according to the College Placement Council. New college graduates entering the actuarial field without having passed any actuarial exams averaged slightly lower salaries.

Insurance companies and consulting firms give merit increases to actuaries as they gain experience and pass examinations. Some companies also offer cash bonuses for each exam passed. A 1992 salary survey of insurance and financial services companies, conducted by the Life Office Management Association, Inc., indicated that actuarial students who have been designated Associate, Society of Actuaries, received an average salary of about $46,000. Newly designated Fellows, Society of Actuaries, received an average salary of nearly $65,500. Fellows with additional years of experience can earn substantially more.

Actuaries typically receive other benefits including vacation and sick leave, health and life insurance, and pension plans.

Related Occupations

Actuaries determine the probability of income or loss from various risk factors. Other workers whose jobs involve related skills include accountants, economists, financial analysts, mathematicians, rate analysts, rate engineers, risk managers, statisticians, and value engineers.

Sources of Additional Information

For facts about actuarial careers, contact:

☞ American Academy of Actuaries, 1720 I St. NW., 7th Floor, Washington, DC 20006.

For information about actuarial careers in life and health insurance, contact:

☞ Society of Actuaries, 475 N. Martingale Rd., Suite 800, Schaumburg, IL 60173-2226.

For information about actuarial careers in property and casualty insurance, contact:

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☞ Casualty Actuarial Society, 1100 N. Glebe Rd., Suite 600, Arlington, VA 22201.

Career information on actuaries specializing in pensions is available from:

☞ American Society of Pension Actuaries, 4350 N. Fairfax Dr., Suite 820, Arlington, VA 22203.

Computer Programmers

(D.O.T. 030.162-010, -018, -022, and .167-010)

Nature of the Work

Computers increasingly affect our daily lives. They control the temperature and air quality in office buildings, expand dramatically the capabilities of our telephones, control manufacturing and other business processes, and even control the scoreboards at major athletic events. Computer programmers write, update, and maintain the detailed instructions (called programs or software) that list in a logical order the steps that computers must execute to perform these and other functions.

In many large organizations, programmers follow descriptions prepared by systems analysts who have carefully studied the task that the computer system is going to perform. These descriptions list the input required, the steps the computer must follow to process data, and the desired arrangement of the output. (A more detailed description of the work of systems analysts is presented in the statement on computer scientists and systems analysts elsewhere in the *Handbook*.) Some organizations, particularly smaller ones, do not employ systems analysts. Instead, workers called programmer-analysts are responsible for both systems analysis and programming. Programmers in software development companies often work without the contribution of systems analysts. Instead, they may work directly with experts from various fields to create software—either programs designed for specific clients or packaged software for general use ranging from games and education software to programs for desktop publishing, financial planning, and spreadsheets.

The transition from a mainframe environment to primarily a PC-based environment has brought about a blurring of the once rigid distinction between the programmer and the user. Increasingly adept users are taking over many of the programming tasks previously performed by programmers. For example, the growing use of packaged software, like spreadsheet and data base management software packages, allows users to write simple programs to calculate or access data.

Regardless of setting, programmers write specific programs by breaking down each step into a logical series of instructions the computer can follow. They then code these instructions in a conventional programming language, such as C and FORTRAN, or one of the more advanced artificial intelligence or object oriented languages, such as LISP, Prolog, C++, or Ada.

Much of the programming being done today is the preparation of packaged software, one of the most rapidly growing segments of the computer industry. Despite the prevalence of packaged software, many programmers are involved in updating, repairing, and modifying code for existing programs. When making changes to a section of code, called a routine, programmers need to make other users aware of the task that the routine is to perform. They do this by inserting comments in the coded instructions so others can understand the program. Programmers using computer-aided software engineering (CASE) can concentrate on writing the unique parts of the program because the computer automates some of the more basic processes. This also yields more reliable and consistent programs and increases programmers' productivity by eliminating some of the routine steps.

When a program is ready to be tested, programmers run the program to ensure that the instructions are correct and will produce the desired information. They prepare sample data that test every part of the program and, after trial runs, review the results to see if any errors were made. If errors do occur, the programmer must change and recheck the program until it produces the correct results. This is called "debugging" the program.

Finally, programmers working in a mainframe environment prepare instructions for the computer operator who will run the program. (The work of computer operators is described in the statement on computer and peripheral equipment operators elsewhere in the *Handbook*.) They may also contribute to a user's manual for the program.

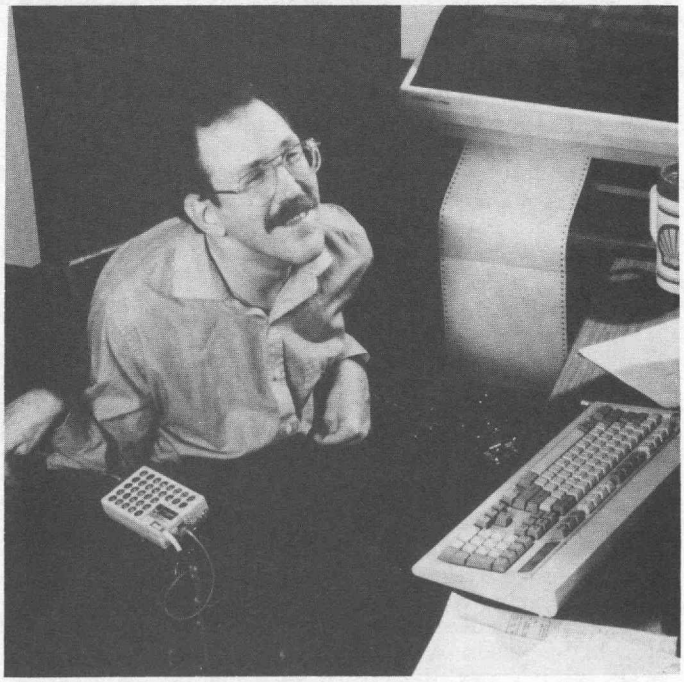
Programs vary with the type of information to be accessed or generated. For example, the data involved in updating financial records are different from those required to simulate a flight on a pilot trainee's monitor. Although simple programs can be written in a few hours, programs that use complex mathematical formulas or many data files may require more than a year of work. In most cases, several programmers may work together as a team under a senior programmer's supervision.

Programmers often are grouped into two broad types: applications programmers and systems programmers. Applications programmers usually are oriented toward business, engineering, or science. They write software to handle specific jobs, such as a program used in an inventory control system or one to guide a missile after it has been fired. They also may work alone to revise existing packaged software. Systems programmers, on the other hand, maintain the software that controls the operation of an entire computer system. These workers make changes in the sets of instructions that determine how the central processing unit of the system handles the various jobs it has been given and communicates with peripheral equipment, such as terminals, printers, and disk drives. Because of their knowledge of the entire computer system, systems programmers often help applications programmers determine the source of problems that may occur with their programs.

Working Conditions

Programmers work in offices in comfortable surroundings. They usually work about 40 hours a week, but their hours are not always from 9 to 5. Programmers may report early or work late to use the computer when it is available; occasionally, they work longer hours in order to meet deadlines or fix critical problems that occur during off hours.

Because programmers spend long periods of time in front of a computer monitor typing at a keyboard, they are susceptible to eyestrain and back discomfort and hand and wrist problems.



Many programmers develop packaged software.

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Employment

Computer programmers held about 555,000 jobs in 1992. Programmers are employed in most industries, but the largest concentrations are in data processing service organizations, including firms that write and sell software; firms that provide engineering and management services; manufacturers of office, computing, and accounting machines; banks; educational institutions, and government agencies.

Applications programmers work for all types of firms that use computer systems. Systems programmers, on the other hand, usually work for organizations with large computer centers and for firms that manufacture computers or develop software.

A small but growing number of programmers are employed on a temporary basis. A marketing firm, for example, may need the services of several extra programmers to write and "debug" the software necessary to get a new data base management system running. Once the software is functioning, however, their services are no longer needed. Rather than hiring these programmers as permanent employees and then laying them off after the job is done, employers increasingly are contracting with temporary help agencies, consulting firms, or directly with programmers themselves. Such temporary jobs usually last several months but some last a year or longer.

Training, Other Qualifications, and Advancement

There are no universal training requirements for programmers because employers' needs vary so much that computer applications have become so widespread and varied. Computer programming is taught at public and private vocational schools, community and junior colleges, and universities. High schools in many parts of the country also offer introductory courses in data processing. Many programmers obtain 2-year degrees or certificates. Two-year colleges are targeted toward producing graduates for entry level jobs and may have strong ties to the local job market.

The majority of programmers hold a 4-year degree. Of these, some hold a B.A. or B.S. in computer science or information systems while others have taken special courses in computer programming to supplement their study in fields such as accounting, inventory control, or other business areas. College graduates who are interested in changing careers or developing an area of expertise may return to a junior college for more training.

The level of education and quality of training that employers seek have been rising due to the growth in the number of qualified applicants and the increasing complexity of some programming tasks. Bachelor's degrees are now commonly required; in the absence of a degree, substantial specialized experience may be needed.

Employers using computers for scientific or engineering applications prefer college graduates who have degrees in computer or information science, mathematics, engineering, or the physical sciences. Graduate degrees are required for some jobs. Knowledge of C and FORTRAN programming languages is desirable since these are the most common languages used in this area.

Employers who use computers for business applications prefer to hire people who have had college courses in management information systems (MIS), programming, and business. Knowledge of Cobol, C, Fourth Generation Languages (4GL), CASE tools, C++ and other object oriented programming languages is highly desirable. General business skills and experience related to the operations of the firm generally are preferred by employers. In the future, it may be common for applications programmers to obtain a multidisciplinary degree to provide adequate knowledge of the application area along with programming skills. A relatively small number of employers promote workers such as computer operators who have taken courses in programming to programmer jobs because of their knowledge of and particular work experience with computer systems.

Most systems programmers hold a 4-year degree in computer science. Extensive knowledge of operating systems is essential. This includes being able to configure the operating system to work with different types of hardware and adapting the operating system to best meet the needs of the particular company.

The Institute for Certification of Computer Professionals offers the Certificate in Computer Programming (CCP) to those who pass a core examination plus exams in two specialty areas. College graduates with little or no experience may be tested for certification as an Associate Computer Professional (ACP). Certification is not mandatory but it may give a jobseeker a competitive advantage.

When hiring programmers, employers look for people who can think logically and who are capable of exacting analytical work. The job calls for patience, persistence, and the ability to work with extreme accuracy even under pressure. Ingenuity and imagination are also particularly important when programmers test their work for potential failures. Increasingly, interpersonal skills are valued because of the use of programmer teams and user support centers. The ability to work with abstract concepts and do technical analysis is especially important for systems programmers because they work with the software that controls the computer's operation.

Beginning programmers may spend their first weeks on the job attending training classes. After this initial instruction, they may work alone on simple assignments, or on a team with more experienced programmers. Either way, they generally must spend at least several months working under close supervision. Because of rapidly changing technology, programmers must continuously update their training by taking courses sponsored by their employer or software vendors.

For skilled workers, the prospects for advancement are good. In large organizations, they may be promoted to lead programmer and be given supervisory responsibilities. Some applications programmers become systems programmers after they gain experience and take courses in systems software. With general business experience, both applications programmers and systems programmers may become systems analysts or be promoted to a managerial position. Other programmers, with specialized knowledge and experience with a language or operating system, may work in research and development areas such as artificial intelligence or CASE.

Job Outlook

Employment of programmers is expected to grow faster than the average for all occupations through the year 2005 as computer usage expands. The demand for programmers will increase as organizations seek new applications for computers and improvements to the software already in use. The rising demand for information, further automation of offices and factories, advances in health and medicine, and continuing scientific research will stimulate the demand for skilled programmers.

One important area of progress will be data communications. Networking computers so they can communicate with each other is necessary to achieve the greater efficiency that organizations require to remain competitive. Expert systems and other artificial intelligence principles and languages will increasingly be used in the years ahead, becoming productivity-enhancing tools available to programmers. Programmers will be creating and maintaining expert systems and embedding these technologies in more and more products. As this trend continues, knowledge of C++ and other object-oriented languages will become increasingly important.

Employment, however, is not expected to grow as rapidly as in the past as improved software and programming techniques, including CASE and 4GL, simplify or eliminate some programming tasks. Someone who can apply CASE tool programming along with design and systems analysis is able to produce applications quickly and more cheaply. Employers are increasingly interested in workers who can combine both of these skills.

In addition, the introduction of data base management systems is allowing users to take over many of the tasks previously performed by the programmer. Greater use of packaged software such as word processing and spreadsheet packages also may moderate the growth in demand for applications programmers.

Although the proportion of programmers leaving the occupation each year is smaller than in most occupations, most of the job openings for programmers will result from replacement needs. Most of the programmers who leave the occupation transfer to other occupations, such as manager or systems analyst. Opportunities will exist throughout the economy, but jobs for both systems and applications programmers should be particularly plentiful in data processing service firms, software houses, and computer consulting businesses.

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Because the number and quality of applicants have increased, employers have become more selective. Competition has increased for entry level positions, affecting even applicants with a bachelor's degree. Graduates of 2-year programs in data processing and people with less than a 2-year degree or its equivalent in work experience are facing especially strong competition for programming jobs. Many observers expect opportunities for people without college degrees to diminish in coming years as programming tasks become more complex. Prospects should be good for college graduates who are familiar with a variety of programming languages, particularly newer languages that apply to computer networking, data base management, and artificial intelligence.

Many employers prefer to hire applicants with previous experience in the field. Firms also desire programmers who develop a technical specialization in areas such as structured methodology programming, multimedia programming, graphic user interface, or 4th and 5th generation programming tools. Therefore, people who want to become programmers can enhance their chances by combining work experience with the appropriate formal training. Students have various options: Holding a summer or part-time job in a data processing department, participating in a college work-study program, or undertaking an internship. Students can greatly improve their employment prospects by also taking courses such as accounting, management, engineering, or science—allied fields in which applications programmers are in demand.

Earnings

Median earnings of programmers who worked full time in 1992 were about $35,600 a year. The lowest 10 percent earned less than $19,700, and the highest 10 percent, more than $58,000. On average, systems programmers earn more than applications programmers.

In the Federal Government, the entrance salary for programmers with a college degree or qualifying experience was about $18,300 a year in 1993; for those with a superior academic record, $22,700.

Related Occupations

Programmers must pay great attention to detail as they write and "debug" programs. Other professional workers who must be detail-oriented include statisticians, engineers, financial analysts, accountants, auditors, actuaries, and operations research analysts.

Sources of Additional Information

State employment service offices can provide information about job openings for computer programmers. Also check with your city's chamber of commerce for information on the area's largest employers.

For information about certification as a computer professional, contact:

☞ Institute for the Certification of Computer Professionals, 2200 East Devon Ave., Suite 268, Des Plaines, IL 60018.

Further information about computer careers is available from:

☞ The Association for Computing Machinery, 1515 Broadway, New York, NY 10036.

Computer Scientists and Systems Analysts

(D.O.T. 030.062-010, .162-014, .167-014; 033.167-010, .262-010; and 109.067-010)

Nature of the Work

The rapid spread of computers amd computer-based technologies over the past two decades has generated a need for skilled, highly trained workers to design and develop the hardware and software systems and to determine how to incorporate these advances into new or existing systems. Although many narrow specializations have developed and no uniform job titles exist, this professional specialty group is widely referred to as computer scientists and systems analysts.

Computer scientists, including computer engineers conduct research, design computers, and discover and use principles of applying computers. Computer scientists and engineers may perform many of the same duties as other computer professionals throughout a normal workday, but their jobs are distinguished by the higher level of theoretical expertise they apply to complex problems and innovative ideas for the application or creation of new technology. Computer scientists employed by academic institutions work in areas from theory to hardware to language design, or on multi-discipline projects, for example, developing and advancing uses for artificial intelligence (AI). Their counterparts in private industry work in areas such as applying theory, developing specialized languages, or designing programming tools, knowledge-based systems, or computer games. Computer engineers often work as part of a team that designs new computing devices or computer-related equipment.

Far more numerous than scientists and engineers, systems analysts define business, scientific, or engineering problems and design their solutions using computers. This process may include planning and developing new computer systems or devising ways to apply existing systems to operations still completed manually or by some less efficient method. Systems analysts may design entirely new systems, including hardware and software, or add a single new software application to harness more of the computer's power.

Analysts begin an assignment by discussing the data processing problem with managers and users to determine its exact nature. Much time is devoted to clearly defining the goals of the system so that it can be broken down into separate programmable procedures. Analysts then use techniques such as structured analysis, data modeling, information engineering, mathematical model building, sampling, and cost accounting to plan the system. Once the design has been developed, systems analysts prepare charts and diagrams that describe it in terms that managers and other users can understand. They may prepare a cost-benefit and return-on-investment analysis to help management decide whether the proposed system will be satisfactory and financially feasible.

Analysts must specify the files and records to be accessed by the system, design the processing steps, and design the format for the output that will meet the users' needs. They must be sure that the system they design is user-friendly, so that it can be easily learned by the user and any problems encountered can be overcome quickly. Analysts also ensure security of the data by making it inaccessible to those who are not authorized to use it.

When the system is accepted, systems analysts may determine what computer hardware and software will be needed to set up the system or implement changes to it. They coordinate tests and observe initial use of the system to ensure it performs as planned. They prepare specifications, work diagrams, and structure charts for computer programmers to follow and then work with them to "debug," or eliminate errors from the system. Some organizations do not employ programmers; instead, a single worker called a programmer-analyst is responsible for both systems analysis and programming. This is becoming more common with the development of Computer Assisted Software Engineering (CASE) tools which automate much of the coding process, making programming functions easier to learn. (The work of programmers is described elsewhere in the *Handbook*.)

One of the biggest obstacles to wider computer use is the inability of different computers to communicate with each other. Many systems analysts are involved with connecting all the computers in an individual office, department, or establishment. This "networking" has many variations; it may be called local area network, wide area network, or multiuser system, for example. A primary goal of networking is to allow users of microcomputers (also known as personal computers or PC's) to retrieve data from a mainframe computer and use it on their machine. This connection also allows data to be entered into the mainframe from the PC.

Because up-to-date information—accounting records, sales figures, or budget projections, for example—is so important in modern organizations, systems analysts may be instructed to make the computer systems in each department compatible with each other so facts and figures can be shared. Similarly, electronic mail requires open pathways to send messages, documents, and data from one computer "mailbox" to another across different equipment and program lines. Analysts must design the gates in the hardware and

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software to allow free exchange of data, custom applications, and the computer power to process it all. They study the seemingly incompatible pieces and create ways to link them so that users can access information from any part of the system.

Because the possible uses of computers are so varied and complex, analysts usually specialize in either business, scientific, engineering, or microcomputer applications. Previous experience or training in a particular area usually dictates the field in which they are most qualified to develop computer systems.

Working Conditions

Computer scientists and systems analysts work in offices or laboratories in comfortable surroundings. They usually work about 40 hours a week—the same as other professional and office workers. Occasionally, however, evening or weekend work may be necessary to meet deadlines.

Because computer scientists and systems analysts spend long periods of time in front of a computer terminal typing on a keyboard, they are susceptible to eye strain and back discomfort and hand and wrist problems.

Employment

Computer scientists and systems analysts held about 666,000 jobs in 1992. Although they are found in most industries, the greatest concentration is in computer and data processing service firms. Many others work for government agencies, manufacturers of computer and related electronic equipment, insurance companies, and universities.

A small but growing number of these workers are employed on a temporary basis. For example, a company installing a new computer system may need the services of several systems analysts just to get the system running. Because not all of them would be needed once the system is functioning, the company might contract directly with the systems analysts themselves or with a temporary help agency or consulting firm. The company would contract for their services on a temporary basis; temporary jobs usually are for several months at least, and some last up to 2 years or more.

Training, Other Qualifications, and Advancement

There is no universally accepted way to prepare for a job as a computer professional because employers' preferences depend on the work being done. Prior work experience is very important. Many persons develop an area of expertise in their jobs which tends to make them more marketable to employers. For example, people move into systems analyst jobs after working as computer programmers. Another example is the auditor in an accounting department who becomes a systems analyst specializing in accounting systems development.

College graduates almost always are sought for computer professional positions, and, for some of the more complex jobs, persons with graduate degrees are preferred. Generally, a computer scientist working in a research lab or academic institution will hold a Ph.D. or master's degree in computer science or engineering. Some computer scientists are able to gain sufficient experience for this type of position with only a bachelor's degree, but this is more difficult. Computer engineers generally have a bachelor's degree in computer engineering, electrical engineering, or math.

Employers usually want systems analysts to have a background in business management or a closely related field for work in a business environment, while a background in the physical sciences, applied mathematics, or engineering is preferred for work in scientifically oriented organizations. Many employers seek applicants who have a bachelor's degree in computer science, information science, computer information systems, or data processing. Regardless of college major, employers look for people who are familiar with programming languages and have a broad knowledge of computer systems and technologies. Courses in computer programming or systems design offer good preparation for a job in this field.

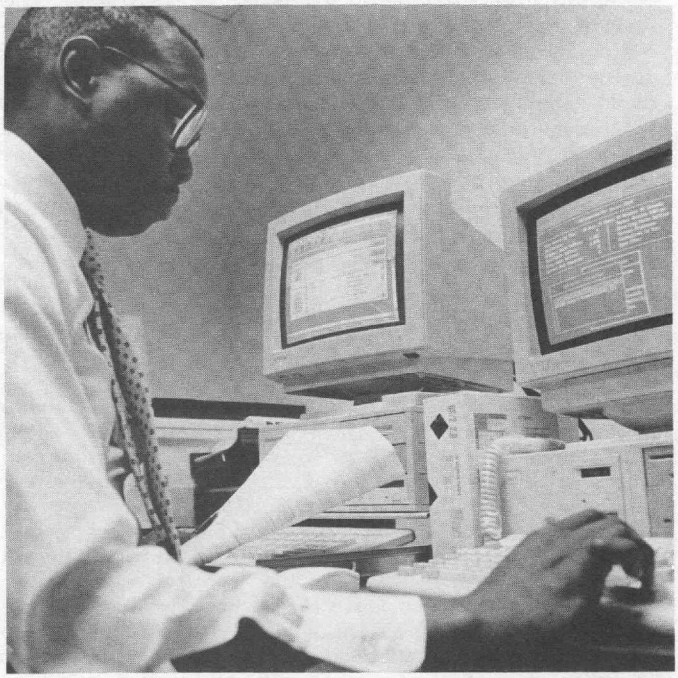
Systems analysts must be able to think logically, have good communication skills, and like working with ideas and people. They often deal with a number of tasks simultaneously. The ability to concentrate and pay close attention to detail also is important. Although systems analysts often work independently, they also work in teams on large projects. They must be able to communicate effectively with technical personnel, such as programmers and managers, as well as with other staff who have no technical computer background.

Technological advances come so rapidly in the computer field that continuous study is necessary to keep skills up to date. Continuing education is usually offered by employers, hardware and software vendors, colleges and universities, or private training institutions. Additional training may come from professional development seminars offered by professional computing societies.

The Institute for Certification of Computer Professionals offers the designation Certified Systems Professional (CSP) to those who have 4 years of experience and who pass a core examination plus exams in two specialty areas. The Quality Assurance Institute awards the designation Certified Quality Analyst (CQA) to those who meet education and experience requirements, pass an exam, and endorse a code of ethics. Neither designation is mandatory, but either may provide a jobseeker a competitive advantage.

Systems analysts may be promoted to senior or lead systems analysts after several years of experience. Those who show leadership ability also can advance to management positions such as manager of information systems or chief information officer. Systems analysts with several years of experience may start their own computer consulting firms.

Computer engineers and scientists employed in industry can eventually move into managerial or project leader positions. Those employed in academic institutions can advance to become heads of research departments or published authorities in their field. Some start their own consulting firms.



Systems analysts design ways to link computers through networks.

Job Outlook

Computer scientists and systems analysts will be among the fastest growing occupations through the year 2005. In addition, tens of thousands of job openings will result annually from the need to replace workers who move into managerial positions or other occupations or leave the labor force.

The demand for computer scientists and engineers is expected to rise as organizations attempt to maximize the efficiency of their computer systems. As international and domestic competition increases, organizations will face growing pressure to use technological advances in areas such as office and factory automation, telecommunications technology, and scientific research. Computer

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scientists and engineers will be needed to develop this new technology. In addition, the complexity associated with designing new applications is growing. More computer scientists will be needed to develop innovative and increasingly sophisticated systems.

As users develop more sophisticated knowledge of computers, they become more aware of the machine's potential and are better able to suggest operations that will increase their own productivity and that of the organization. The need to design computer networks that will facilitate the sharing of information will be a major factor in the rising demand for systems analysts. A greater emphasis on problem definition, analysis, and implementation also will guarantee a higher demand for systems analysts. In addition, falling prices of computer hardware and software are inducing more small businesses to computerize their operations, further stimulating demand for these workers.

Individuals with an advanced degree in computer science should enjoy very favorable employment prospects because the number of these degrees has not kept pace with the needs of employers. College graduates with a bachelor's degree in computer science, computer engineering, information science, or information systems should also experience good prospects for employment. College graduates with non-computer science majors who have had courses in computer programming, systems analysis, and other data processing areas as well as training or experience in an applied field should be able to find jobs as systems analysts. Those who are familiar with CASE and other programming tools will have an even greater advantage. Employers will be more willing to hire someone who can combine programming skills with traditional systems analysis skills.

Earnings

Median annual earnings of systems analysts who worked full time in 1992 were about $42,100. The middle 50 percent earned between $32,000 and $52,200. The lowest 10 percent earned less than $25,200 and the highest tenth, more than $65,500. Computer scientists with advanced degrees generally earn more than systems analysts.

In the Federal Government, the entrance salary for recent college graduates with a bachelor's degree was about $18,300 a year in 1993; for those with a superior academic record, $22,700.

Related Occupations

Other workers who use research, logic, and creativity to solve business problems are computer programmers, financial analysts, urban planners, engineers, operations research analysts, management analysts, and actuaries.

Sources of Additional Information

Further information about computer careers is available from:

☞ Association for Computing Machinery, 1515 Broadway, New York, NY 10036.

Information about certification as a computer professional is available from:

☞ Institute for the Certification of Computer Professionals, 2200 East Devon Ave., Suite 268, Des Plaines, IL 60018.

Information about certification as a Certified Quality Analyst is available from:

☞ Quality Assurance Institute, 7575 Dr. Phillips Blvd., Suite 350, Orlando, FL 32819.

Economists and Marketing Research Analysts

(D.O.T. 050.067)

Nature of the Work

Economists. Economists study the ways a society uses scarce resources such as land, labor, raw materials, and machinery to produce goods and services. They analyze the costs and benefits of distributing and consuming these goods and services. Economists conduct research, collect and analyze data, monitor economic trends, and develop forecasts. Their research might focus on topics such as energy costs, inflation, interest rates, farm prices, rents, imports, or employment.

Most economists are concerned with practical applications of economic policy in a particular area, such as finance, labor, agriculture, transportation, real estate, environment, natural resources, energy, or health. They use their understanding of economic relationships to advise business firms, insurance companies, banks, securities firms, industry and trade associations, labor unions, government agencies, and others. On the other hand, economists who are primarily theoreticians may use mathematical models to develop theories on the causes of business cycles and inflation, or the effects of unemployment and tax legislation.

Depending on the topic under study, economists devise methods and procedures for obtaining the data they need. For example, sampling techniques may be used to conduct a survey, and econometric modeling techniques may be used to develop forecasts. Preparing reports usually is an important part of the economist's job. He or she may be called upon to review and analyze all the relevant data, prepare tables and charts, and write up the results in clear, concise language. Being able to present economic and statistical concepts in a meaningful way is particularly important for economists whose research is policy directed.

Economists who work for government agencies assess economic conditions in the United States and abroad and estimate the economic effects of specific changes in legislation or public policy. For example, they may study how the dollar's fluctuation against foreign currencies affects import and export markets. Most government economists are in the fields of agriculture, business, finance, labor, transportation, utilities, urban economics, or international trade. Economists in the U.S. Department of Commerce study domestic production, distribution, and consumption of commodities or services; those in the Federal Trade Commission prepare industry analyses to assist in enforcing Federal statutes designed to eliminate unfair, deceptive, or monopolistic practices in interstate commerce; and those in the Bureau of Labor Statistics analyze data on prices, wages, employment, productivity, and safety and health. An economist working for a State or local government might analyze regional or local data on trade and commerce, industrial and commercial growth, and employment and unemployment, and project labor force trends.

Marketing Research Analysts. Marketing research analysts are concerned with the design, promotion, price, and distribution of a product or service. They provide information which is used to identify and define marketing opportunities; generate, refine, and evaluate marketing actions; and monitor marketing performance. Like economists, marketing research analysts devise methods and procedures for obtaining data they need. Marketing research analysts often design surveys and questionnaires; conduct telephone, personal, or mail interviews; and sometimes offer product samples to assess consumer preferences and indicate current trends. Once the data are compiled, marketing research analysts code, tabulate, and evaluate the data. They then make recommendations to management based upon their findings and suggest a course of action. They may provide management with information to make decisions on the promotion, distribution, design, and pricing of company products or services; or to determine the advisability of adding new lines of merchandise, opening new branches, or diversifying the company's operations. Analysts also conduct public opinion research to familiarize the media, government, lobbyists, and others with the needs and attitudes of the public. This can help political leaders and others assess public support for new taxes or spending on health, education, welfare, or defense, for example.

Marketing research analysts employed by large organizations may have a strong background in statistics or they may work with statisticians to select a group of people to be interviewed who accurately represent prospective customers of a product or service. Under an experienced marketing research analyst's direction, trained interviewers conduct surveys and office workers tabulate the results. The researchers must maintain confidentiality, accuracy, and good scientific methods in order to obtain useful results.

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Economists and marketing research analysts use computers to prepare reports, develop surveys, and analyze data.

Working Conditions

Economists and marketing research analysts working for government agencies and private firms have structured work schedules. They may work alone writing reports, preparing statistical charts, and using computers and calculators. Or they may be an integral part of a research team. Most work under pressure of deadlines and tight schedules, and sometimes must work overtime. Their routine may be interrupted by special requests for data, letters, meetings, or conferences. Travel may be necessary to collect data or attend conferences.

Economics and marketing faculty have flexible work schedules, and may divide their time among teaching, research, consulting, and administration.

Employment

Economists and marketing research analysts held about 51,000 jobs in 1992. Private industry—particularly economic and marketing research firms, management consulting firms, banks, securities and commodities brokers, and computer and data processing companies—employed 7 out of 10 salaried workers. The remainder, primarily economists, were employed by a wide range of government agencies, primarily in the Federal Government. The Departments of State, Labor, Agriculture, and Commerce are the largest Federal employers of economists. A number of economists and marketing research analysts combine a full-time job in government or business with part-time or consulting work in academia or another setting.

Employment of economists and marketing research analysts is concentrated in large cities—for example, New York City, Washington, D.C., and Chicago. Some economists work abroad for companies with major international operations; for the Department of State and other U.S. Government agencies; and for international organizations, including the World Bank and the United Nations.

Besides the jobs described above, many economists and marketing research analysts held economics and marketing faculty positions in colleges and universities. (See the statement on college and university faculty elsewhere in the *Handbook*.)

Training, Other Qualifications, and Advancement

A bachelor's degree with a major in economics or marketing is sufficient for many entry-level research, administrative, management trainee, and sales jobs. Economics majors can choose from a variety of courses, ranging from those which are intensly mathematical like microeconomics, macroeconomics, and econometrics, to more philosophical courses like the history of economic thought. In addition to courses in business, marketing, and consumer behavior, marketing majors should take courses in related disciplines, including economics, political science, psychology, organizational behavior, sociology, finance, business law, and international relations. Because of the importance of quantitative skills to economists and marketing researchers, courses in mathematics, statistics, econometrics, sampling theory and survey design, and computer science are highly recommended.

Aspiring economists and marketing research analysts can gain experience gathering and analyzing data, conducting interviews or surveys, and writing reports on their findings while in college. This experience can prove invaluable later in obtaining a full-time position in the field, since much of their work in the beginning centers around these duties. Beginning workers also may do considerable clerical work, such as copying data, editing and coding questions, and tabulating survey results. With further experience, economists and marketing research analysts eventually are assigned their own research projects.

Graduate training increasingly is required for many economist and marketing research analyst jobs, and for advancement to more responsible positions. Economics includes many specialties at the graduate level, such as advanced economic theory, mathematical economics, econometrics, history of economic thought, international economics, and labor economics. Students should select graduate schools strong in specialties in which they are interested. Marketing research analysts may earn a master's degree in business administration, marketing, statistics, or some related discipline. Some schools help graduate students find internships or part-time employment in government agencies, economic consulting firms, financial institutions, or marketing research firms. Like undergraduate students, work experience and contacts can be useful in testing career preferences and learning about the job market for economists and marketing research analysts.

In the Federal Government, candidates for beginning economist positions generally need a college degree with a minimum of 21 semester hours of economics and 3 hours of statistics, accounting, or calculus. Competition is keen, however, and additional education or experience may be required for some jobs.

For a job as a college instructor in many junior colleges and some 4-year schools, a master's degree is the minimum requirement. In most colleges and universities, however, a Ph.D. is necessary for appointment as an instructor. Similar to other disciplines, a Ph.D. and extensive publication are required for a professorship and for tenure.

In government, industry, research organizations, and consulting firms, economists and marketing research analysts who have a graduate degree usually can qualify for more responsible research and administrative positions. A Ph.D. is necessary for top positions in many organizations. Many corporation and government executives have a strong background in economics or marketing.

Persons considering careers as economists or marketing research analysts should be able to work accurately with detail since much time is spent on data analysis. Patience and persistence are necessary qualities since economists and marketing research analysts may spend long hours on independent study and problem solving. At the same time, they must be able to work well with others, especially marketing research analysts, who often interview a wide variety of people. Economists and marketing research analysts must be objective and systematic in their work and be able to present their findings, both orally and in writing, in a clear, meaningful way. Creativity and intellectual curiosity are essential for success in these fields, just as they are in other areas of scientific endeavor.

Job Outlook

Employment of economists and marketing research analysts is expected to grow about as fast as the average for all occupations through the year 2005. Most job openings, however, are likely to result from the need to replace experienced workers who transfer to other occupations, or retire or leave the labor force for other reasons.

Opportunities for economists should be best in private industry and in research and consulting firms, as some companies contract out for economic research services rather than support a staff of full-time economists. The growing complexity of the global economy

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and increased reliance on quantitative methods of analyzing business trends, forecasting sales, and planning purchasing and production should spur demand for economists. The continued need for economic analyses by lawyers, accountants, engineers, health services administrators, education administrators, urban and regional planners, environmental scientists, and others also should result in additional jobs for economists. Other organizations, including trade associations, unions, and nonprofit organizations, may offer job opportunities for economists. Employment of economists in the Federal Government should decline in line with the rate of growth projected for the Federal workforce as a whole. Slower than average employment growth is expected among economists in State and local government.

A strong background in economic theory, mathematics, statistics, and econometrics provides the tools for acquiring any specialty within the field. Those skilled in quantitative techniques and their application to economic modeling and forecasting and marketing research, including the use of computers, should have the best job opportunities.

Persons who graduate with a bachelor's degree in economics through the year 2005 should face keen competition for the limited number of economist positions for which they qualify. Related work experience—conducting research, developing surveys, or analyzing data, for example—while in school is a major asset in this competitive job market. Many graduates will find employment in government, industry, and business as management or sales trainees, or as research or administrative assistants. Economists with good quantitative skills are qualified for research analyst positions in a broad range of fields. Those with strong backgrounds in mathematics, statistics, survey design, and computer science may be hired by private firms for marketing research work. Those who meet State certification requirements may become high school economics teachers. The demand for secondary school economics teachers is expected to grow as economics becomes an increasingly important and popular course. (See the statement on kindergarten, elementary, and secondary school teachers elsewhere in the *Handbook*.)

Candidates who hold a master's degree in economics have better employment prospects than bachelor's degree holders. Some businesses and research and consulting firms seek master's degree holders who have strong computer and quantitative skills and can perform complex research, but do not command the high salary of a Ph.D. Master's degree holders are likely to face competition for teaching positions in colleges and universities; however, some may gain positions in junior and community colleges.

Opportunities will be best for Ph.D.'s. Ph.D. graduates should have opportunities to work as economists in private industry, research and consulting firms, and government. In addition, employment prospects for economists in colleges and universities should improve due to an expected wave of retirements among college faculty.

Demand for marketing research analysts should be strong due to an increasingly competitive global economy. Marketing research provides organizations valuable feedback from purchasers, allowing companies to evaluate consumer satisfaction and more effectively plan for the future. As companies seek to expand their market and consumers become better informed, the need for marketing professionals is increasing. Opportunities for marketing research analysts should be good in a wide range of employment settings, particularly in marketing research firms, as companies find it more profitable to contract out for marketing research services rather than supporting their own marketing department. Other organizations, including financial services organizations, health care institutions, advertising firms, manufacturing firms that produce consumer goods, and insurance companies may offer job opportunities for marketing research analysts. Like economists, graduates with related work experience or an advanced degree in marketing or a closely related business field should have the best job opportunities.

Earnings

According to a 1993 salary survey by the College Placement Council, persons with a bachelor's degree in economics received offers averaging $25,200 a year; in marketing, $24,100.

The median base salary of business economists in 1992 was $65,000, according to a survey by the National Association of Business Economists. Ninety percent of the respondents held advanced degrees. The highest salaries were reported by those who had a Ph.D., with a median salary of $78,000. Master's degree holders earned a median salary of $58,000, while bachelor's degree holders earned $51,000. The highest paid business economists were in the nondurable manufacturing, securities and investment, mining, banking, and real estate industries. The lowest paid were in academia and government.

The Federal Government recognizes education and experience in certifying applicants for entry level positions. In general, the entrance salary for economists having a bachelor's degree averaged about $18,300 a year in 1993; however, those with superior academic records could begin at $22,700. Those having a master's degree could qualify for positions at an annual salary of $27,800. Those with a Ph.D. could begin at $33,600, while some individuals with experience and an advanced degree could start at $40,300. Economists in the Federal Government in nonsupervisory, supervisory, and managerial positions averaged around $53,500 a year in 1993.

Like other college faculty, economists and marketing research analysts entering careers in higher education may receive benefits such as summer research money, computer access, money for student research assistants, and secretarial support.

Related Occupations

Economists are concerned with understanding and interpreting financial matters, among other subjects. Others with jobs in this area include financial managers, financial analysts, accountants and auditors, underwriters, actuaries, securities and financial services sales workers, credit analysts, loan officers, and budget officers.

Marketing research analysts are involved in social research, including the planning, implementation, and analysis of surveys to determine people's needs and preferences. Other jobs using these skills include social welfare research workers, employment research and planning directors, sociologists, and urban and regional planners.

Sources of Additional Information

For information on careers in economics and business, contact:

☞ National Association of Business Economists, 28790 Chagrin Blvd., Suite 300, Cleveland, OH 44122.

☞ The Margin Magazine, University of Colorado, 1420 Austin Bluffs Pkwy., Colorado Springs, CO 80918.

For information about careers and salaries in marketing research, contact:

☞ American Marketing Association, 250 South Wacker Dr., Suite 200, Chicago, IL 60606.

☞ Marketing Research Association, 2189 Silas Deane Hwy., Suite 5, Rocky Hill, CT 06067.

☞ Council of American Survey Research Organizations, 3 Upper Devon, Port Jefferson, NY 11777.

Engineering, Science, and Data Processing Managers

(D.O.T. 002.167-018; 003.167-034 and -070; 005.167-010 and -022; 007.167-014; 008.167-010; 010.161-010, -014, and .167-018; 011.161-010; 012.167-058 and -062; 018.167-022; 019.167-014; 022.161-010; 024.167-010; 029.167-014; 162.117-030; 169.167-030 and -082; and 189.117-014)

Nature of the Work

Engineering, science, and data processing managers plan, coordinate, and direct research, development, design, production, and computer related activities. They supervise a staff which may include engineers, scientists, technicians, computer specialists, data processing workers, along with support personnel.

Engineering, science, and data processing managers determine scientific and technical goals within broad outlines provided by top management. These goals may include the redesign of an industrial

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machine, improvements in manufacturing processes, the development of a large computer program, or advances in basic scientific research. Managers make detailed plans for the accomplishment of these goals—for example, they may develop the overall concepts of new products or identify problems standing in the way of project completion. They forecast costs and equipment and personnel needs for projects and programs. They hire and assign scientists, engineers, technicians, computer specialists, data processing workers, and support personnel to carry out specific parts of the projects, supervise their work, and review their designs, programs, and reports.

Managers coordinate the activities of their unit with other units or organizations. They confer with higher levels of management; with financial, industrial production, marketing, and other managers; and with contractors and equipment suppliers. They also establish working and administrative procedures and policies.

Engineering managers direct and coordinate production, operations, quality assurance, testing, or maintenance in industrial plants; or plan and coordinate the design and development of machinery, products, systems, and processes. Many are plant engineers, who direct and coordinate the maintenance, operation, design, and installation of equipment and machinery in industrial plants. Others manage research and development activities that produce new products and processes or improve existing ones.

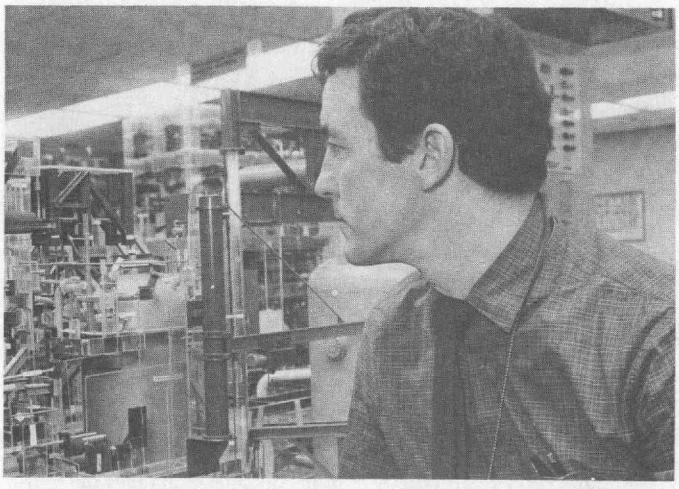
Natural science managers oversee activities in agricultural science, chemistry, biology, geology, meteorology, or physics. They manage research and development projects and direct and coordinate testing, quality control, and production activities in industrial plants.

Electronic data processing managers direct, plan, and coordinate data processing activities. Top level managers direct all computer-related activities in an organization. Others manage computer operations, software development, or data bases. They analyze the data processing requirements of their organization and assign, schedule, and review the work of systems analysts, computer programmers, and computer operators. They determine computer hardware requirements, evaluate equipment options, and make purchasing decisions.

Some engineering, science, and data processing managers head a section of perhaps 3 to 10 or more scientists, engineers, or computer professionals. Above them are heads of divisions composed of a number of sections, with as many as 15 to 50 scientists or engineers. A few are directors of large laboratories or directors of research.

Working Conditions

Engineering, science, and data processing managers spend most of their time in an office. Some managers, however, may also work in laboratories or industrial plants, where they normally are exposed to the same conditions as research scientists and may occasionally be exposed to the same conditions as production workers. Most work at least 40 hours a week and may work much longer on occasion to meet project deadlines. Some may experience considerable pressure to meet technical or scientific goals within a short time or within a tight budget.



Engineering managers direct the research, development, and manufacture of a product.

Employment

Engineering, science, and data processing managers held about 337,000 jobs in 1992. Although these managers are found in almost all industries, nearly two-fifths are employed in manufacturing, especially in the industrial machinery and equipment, electrical and electronic equipment, transportation equipment, instruments, and chemicals industries. They also work for engineering, management, and computer and data processing services companies. Others work for government, colleges and universities, and nonprofit research organizations. The majority are most likely engineering managers, often managing industrial research, development, and design projects.

Training, Other Qualifications, and Advancement

Experience as an engineer, mathematician, natural scientist, or computer professional is the usual requirement for becoming an engineering, science, or data processing manager. Consequently, educational requirements are similar to those for scientists, engineers, and data processing professionals.

Engineering managers start as engineers. A bachelor's degree in engineering from an accredited engineering program is acceptable for beginning engineering jobs, but many engineers increase their chances for promotion to manager by obtaining a master's degree in engineering or business administration. A degree in business administration or engineering management is especially useful for becoming a general manager.

Natural science managers usually start as a chemist, physicist, biologist, or other natural scientist. Most natural scientists engaged in basic research have a Ph.D. degree. Some in applied research and other activities may have lesser degrees. First-level science managers are usually specialists in the work they supervise. For example, the manager of a group of physicists doing optical research is almost always a physicist who is an expert in optics.

Most data processing managers have been systems analysts, although some may have experience as programmers, operators, or in other computer specialties. There is no universally accepted way of preparing for a job as a systems analyst. Many have degrees in computer or information science, computer information systems, or data processing and have experience as computer programmers. A bachelor's degree is usually required and a graduate degree often is preferred. A typical career advancement progression in a large organization would be from programmer to programmer/analyst, to systems analyst, and then to project leader or senior analyst. The first real managerial position might be as project manager, programming supervisor, systems supervisor, or software manager.

In addition to educational requirements, scientists, engineers, or computer specialists generally must have demonstrated above-average technical skills to be considered for promotion to manager. Superiors also look for leadership and communication skills, as well as managerial attributes such as the ability to make rational decisions, to manage time well, to organize and coordinate work effectively, to establish good working and personal relationships, and to motivate others. Also, a successful manager must have the desire to manage. Many scientists, engineers, and computer specialists want to be promoted but actually prefer doing technical work.

Some scientists and engineers become managers in marketing, personnel, purchasing, or other areas or become general managers.

Job Outlook

Employment of engineering and science managers is expected to increase faster than the average for all occupations through the year 2005. Opportunities for those who wish to become engineering, science, and data processing managers should be closely related to the growth of the occupations they supervise and the industries in which they are found. (See the statements on natural scientists, engineers, computer programmers, and computer scientists and systems analysts elsewhere in the *Handbook*.)

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Underlying much of the growth of managers in science and engineering are competitive pressures and advancing technologies which force companies to update and improve products more frequently. Research and investment in plants and equipment to expand output of goods and services and to raise productivity also will add to employment requirements for science and engineering managers involved in research and development, design, and the operation and maintenance of production facilities.

Many of the industries which employ engineers and scientists derive a large portion of their business from defense contracts. Because defense expenditures are being reduced, employment growth and job outlook for managers in these industries may not be as strong in the future as in the 1980's, when defense expenditures were increasing.

Employment of data processing managers will increase rapidly due to the fast paced expansion of the computer and data processing services industry and the increased employment of computer systems analysts. Large computer centers are consolidating or closing as small computers become more powerful, and more automated systems are resulting in fewer opportunities for data processing managers at computing centers. However, as the economy expands and as advances in technology lead to broader applications for computers, opportunities should increase and employment growth should be brisk.

Despite growth in employment, most job openings will result from the need to replace workers who leave the occupation. Because many engineers, natural scientists, and computer specialists are eligible for management and seek promotion, there can be substantial competition for these openings.

Earnings

Earnings for engineering, science, and data processing managers vary by specialty and level of management. Science and engineering managers had average salaries that ranged from $50,000 to well over $100,000 for the most senior managers in large organizations, according to the limited data available. Data processing managers had salaries that ranged from $35,000 to $80,000. Managers often earn about 15 to 25 percent more than those they directly supervise, although there are cases where some employees are paid more than the manager who supervises them, especially in research.

In addition, engineering, science, and data processing managers, especially those at higher levels, often are provided more benefits than non-managerial workers in their organizations. Higher level managers often are provided with expense accounts, stock option plans, and bonuses.

Related Occupations

The work of engineering, science, and data processing managers is closely related to that of engineers, natural scientists, computer personnel, and mathematicians. It is also related to the work of other managers, especially general managers and top executives.

Sources of Additional Information

Contact the sources of additional information on engineers, natural scientists, and systems analysts that are listed in statements on these occupations elsewhere in the *Handbook*.

Mathematicians

(D.O.T. 020.067-014, .167-030; 199.267-014)

Nature of the Work

Mathematics is one of the oldest and most basic sciences. Mathematicians today are engaged in a wide variety of activities, ranging from the creation of new mathematical theories and techniques involving the latest technology to the solving of economic, scientific, engineering, and business problems using mathematical knowledge and computational tools.

Mathematical work falls into two broad classes: Theoretical (pure) mathematics; and applied mathematics. However, these classes are not sharply defined and often overlap.

Theoretical mathematicians advance mathematical science by developing new principles and new relationships between existing principles of mathematics. Although they seek to increase basic knowledge without necessarily considering its practical use, this pure and abstract knowledge has been instrumental in producing or furthering many scientific and engineering achievements.

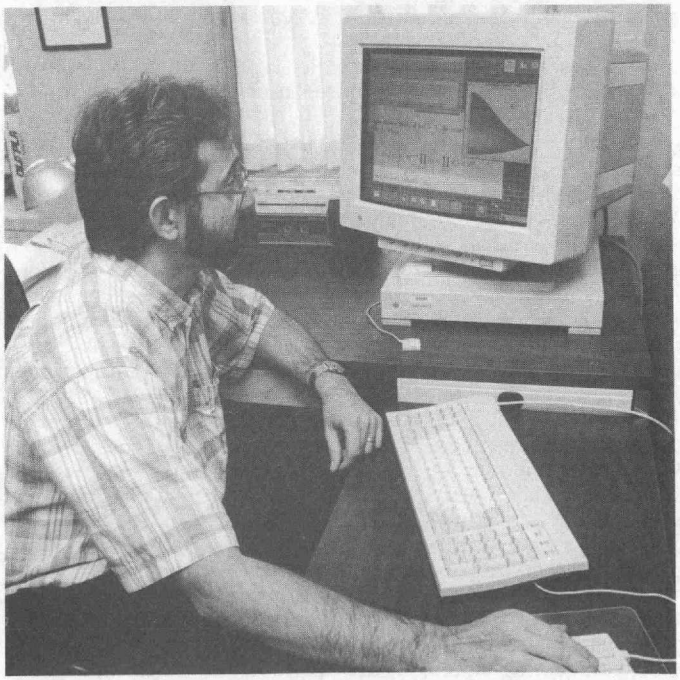
Applied mathematicians use theories and techniques, such as mathematical modeling and computational methods, to formulate and solve practical problems in business, government, engineering, and the physical, life, and social sciences. For example, they may analyze the mathematical aspects of computer and communications networks, the effects of new drugs on disease, the aerodynamic characteristics of aircraft, or the distribution costs or manufacturing processes of businesses. Applied mathematicians working in industrial research and development may develop or enhance mathematical methods when confronted with difficult problems. Some mathematicians, called cryptanalysts, analyze and decipher encryption systems designed to transmit national security-related information.

Mathematicians use computers extensively to analyze relationships among variables, solve complex problems, develop models, and process large amounts of data.

Much work in applied mathematics, however, is carried on by persons other than mathematicians. In fact, because mathematics is the foundation upon which many other academic disciplines are built, the number of workers using mathematical techniques is many times greater than the number actually designated as mathematicians. Engineers, computer scientists, and economists are among those who use mathematics extensively but have job titles other than mathematician. Some workers, such as statisticians, actuaries, and operations research analysts, actually are specialists in a particular branch of mathematics. (See statements on actuaries, operations research analysts, and statisticians elsewhere in the *Handbook*.)

Working Conditions

Mathematicians working for government agencies or private firms usually have structured work schedules. They may work alone, in a small group of mathematicians, or as an integral part of a team that includes engineers, computer scientists, physicists, technicians, and



Applied mathematicians often use their knowledge to solve practical problems in business, government, engineering, and science.

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others. Deadlines, overtime work, special requests for information or analysis, and travel to attend seminars or conferences may be part of their jobs.

Mathematics faculty have flexible work schedules, dividing their time among teaching, research, consulting, and administrative responsibilities.

Employment

Mathematicians held about 16,000 jobs in 1992. In addition, about 16,000 persons held mathematics faculty positions in colleges and universities, according to the American Mathematical Society. (See the statement on college and university faculty elsewhere in the *Handbook*.)

Most nonfaculty mathematicians work in the government and in service and manufacturing industries. The Department of Defense is the primary Federal employer of mathematicians; more than three-fourths of the mathematicians employed by the Federal Government work for the Navy, Army, or Air Force. A significant number of mathematicians also work in State governments. In the private sector, major employers within services industries include research and testing services, educational services, and computer and data processing services. Within manufacturing, the aircraft, chemicals, and computer and office equipment industries are key employers. Some mathematicians also work for banks, insurance companies, and public utilities.

Training, Other Qualifications, and Advancement

A bachelor's degree in mathematics is the minimum education needed for prospective mathematicians. A master's degree in mathematics is sufficient preparation for some research positions and for teaching jobs in many junior or community colleges and in some small 4-year colleges. However, in most 4-year colleges and universities, as well as in many research and development positions in private industry, a doctoral degree is necessary.

In the Federal Government, entry-level job candidates usually must have a 4-year degree with a major in mathematics or a 4-year degree with the equivalent of a mathematics major—24 semester hours of mathematics courses.

In private industry, job candidates generally need a master's degree to obtain jobs as mathematicians. The majority of bachelor's and master's degree holders in private industry work, not as mathematicians, but in related fields such as computer science, where they are called computer programmers, systems analysts, or systems engineers.

A bachelor's degree in mathematics is offered by most colleges and universities. Mathematics courses usually required for this degree are calculus, differential equations, and linear and abstract algebra. Additional coursework might include probability theory and statistics, mathematical analysis, numerical analysis, topology, modern algebra, discrete mathematics, and mathematical logic. Many colleges and universities urge or even require students majoring in mathematics to take several courses in a field that uses or is closely related to mathematics, such as computer science, engineering, operations research, a physical science, statistics, or economics. A double major in mathematics and either computer science, statistics, or one of the sciences is particularly desirable. A prospective college mathematics major should take as many mathematics courses as possible while in high school.

In 1992, 255 colleges and universities offered a master's degree as the highest degree in either pure or applied mathematics; 187 offered a Ph.D. in pure or applied mathematics. In graduate school, students conduct research and take advanced courses, usually specializing in a subfield of mathematics. Some areas of concentration are algebra, number theory, real or complex analysis, geometry, topology, logic, and applied mathematics.

For work in applied mathematics, training in the field in which the mathematics will be used is very important. Fields in which applied mathematics is used extensively include physics, actuarial science, engineering, and operations research; of increasing importance are computer and information science, business and industrial management, economics, statistics, chemistry, geology, life sciences, and the behavioral sciences.

Mathematicians should have substantial knowledge of computer programming because most complex mathematical computation and much mathematical modeling is done by computer.

Mathematicians need good reasoning ability and persistence in order to identify, analyze, and apply basic principles to technical problems. Communication skills are also important, as mathematicians must be able to interact with others, including nonmathematicians, and discuss proposed solutions to problems.

Job Outlook

Employment of mathematicians is expected to increase more slowly than the average for all occupations through the year 2005. The number of jobs available for workers whose educational background is solely mathematics is not expected to increase significantly. Many firms engaged in civilian research and development that use mathematicians are not planning to expand their research departments much, and, in some cases, may reduce them. Expected reductions in defense-related research and development will also affect mathematicians' employment, especially in the Federal Government. Those whose educational background includes the study of a related discipline will have better job opportunities. However, as advancements in technology lead to expanding applications of mathematics, more workers with a knowledge of mathematics will be required. An increasing number of these workers have job titles which reflect the end product of their work rather than the discipline of mathematics used in that work, which will contribute further to the slowdown in positions for mathematicians.

Bachelor's degree holders in mathematics are usually not qualified for jobs as mathematicians. However, those with a strong background in computer science, electrical or mechanical engineering, or operations research should have good opportunities in industry. Bachelor's degree holders who meet State certification requirements may become high school mathematics teachers. (For additional information, see the statement on kindergarten, elementary, and secondary school teachers elsewhere in the *Handbook*.)

Holders of a master's degree in mathematics will face very strong competition for jobs in college teaching or theoretical research. However, job opportunities in applied mathematics and related areas such as computer programming, operations research, and engineering design in industry and government will be more numerous.

Earnings

According to a 1992 College Placement Council Survey, starting salary offers for mathematics graduates with a bachelor's degree averaged about $28,400 a year; for those with a master's degree, $33,600; and for new doctoral graduates, $41,000. Starting salaries were generally higher in industry and government than in educational institutions. For example, the American Mathematical Society reported that, based on a 1992 survey, median annual earnings for new recipients of doctorates in research were $30,200; for those in teaching or teaching and research (9-10 month academic year), $34,000; for those in government, $53,000; and for those in business and industry, $53,000.

In the Federal Government in 1993, the average annual salary for mathematicians in supervisory, nonsupervisory, and managerial positions was $53,232; for mathematical statisticians, $54,109; and for cryptanalysts, $43,070.

Benefits for mathematicians tend to be similar to those offered to most professionals who work in office settings: Vacation and sick leave, health and life insurance, and a retirement plan, among others.

Related Occupations

Other occupations that require a degree in or extensive knowledge of mathematics include actuary, statistician, computer programmer, systems analyst, systems engineer, and operations research analyst. In addition, a strong background in mathematics facilitates employment in fields such as engineering, economics, finance, and physics.

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Sources of Additional Information

For more information about the field of mathematics, including career opportunities and professional training, contact:

☞ American Mathematical Society, P.O. Box 6248, Providence, RI 02940.

☞ Mathematical Association of America, 1529 18th St. NW., Washington, DC 20036.

For specific information on careers in applied mathematics, contact:

☞ Society for Industrial and Applied Mathematics, 3600 University City Science Center, Philadelphia, PA 19104-2688.

For information about careers in noncollegiate academic institutions, contact:

☞ National Council of Teachers of Mathematics, 1906 Association Dr., Reston, VA 22091.

Information on Federal job opportunities is available from area offices of the State employment service and the U.S. Office of Personnel Management's Federal Job Information Centers located in various large cities throughout the country.

Operations Research Analysts

(D.O.T. 020.067-018)

Nature of the Work

Efficiently running a complex organization or operation such as a large manufacturing plant, an airline, or a military deployment requires the precise coordination of materials, machines, and people. Operations research analysts help organizations coordinate and operate in the most efficient manner by applying scientific methods and mathematical principles to organizational problems. Managers can then evaluate alternatives and choose the course of action that best meets the organizational goals.

Operations research analysts, also called management science analysts, are problem solvers. The problems they tackle are for the most part those encountered in large business organizations: Strategy, forecasting, resource allocation, facilities layout, inventory control, personnel schedules, and distribution systems. The methods they use generally revolve about a mathematical model or set of equations that explains how things happen within the organization. Models are simplified representations that enable the analyst to break down systems into their component parts, assign numerical values to each component, and examine the mathematical relationships between them. These values can be altered to determine what will happen to the system under different sets of circumstances. Types of models include simulation, linear optimization, networks, waiting lines, and game theory.

Operations research analysts use computers extensively in their work. They are typically highly proficient in database management, programming, and in the development and use of sophisticated software programs. Most of the models built by operations research analysts are so complicated that only a computer can solve them efficiently.

The type of problem they usually handle varies by industry. For example, an analyst for an airline would coordinate flight and maintenance scheduling, passenger level estimates, and fuel consumption to produce a schedule that optimizes all of these factors to ensure safety and produce the most profits. An analyst employed by a hospital would concentrate on a different set of problems—scheduling admissions, managing patient flow, assigning shifts, monitoring use of pharmacy and laboratory services, or forecasting demand for new hospital services.

The role of the operations research analyst varies according to the structure and management philosophy of the firm. Some centralize operations research in one department; others disperse operations research personnel throughout all divisions. Some operations research analysts specialize in one type of application; others are generalists.

The degree of supervision varies by organizational structure and experience. In some organizations, analysts have a great deal of professional autonomy; in others, analysts are more closely supervised. Operations research analysts work closely with senior managers, who have a wide variety of support needs. Analysts must adapt their work to reflect these requirements.

Regardless of the industry or structure of the organization, operations research entails a similar set of procedures. Managers begin the process by describing the symptoms of a problem to the analyst. The analyst then defines the problem, which sometimes is general in nature and at other times specific. For example, an operations research analyst for an auto manufacturer may be asked to determine the best inventory level for each of the materials for a new production line or, more specifically, to determine how many windshields should be kept in inventory.

After analysts define the problem, they learn everything they can about it. They study the problem, then break it into its component parts. Then they gather information about each of these parts. Usually this involves consulting a wide variety of people. To determine the most efficient amount of steel to be kept on hand, for example, operations research analysts might talk with engineers about production levels; discuss purchasing arrangements with industrial buyers; and examine data on storage costs provided by the accounting department.

With this information in hand, the operations research analyst is ready to select the most appropriate analytical technique. There may be several techniques that could be used, or there may be one standard model or technique that is used in all instances. In a few cases, the analyst must construct an original model to examine and explain the system. In almost all cases, the selected model must be modified to reflect the specific circumstances of the situation.

A model for airline flight scheduling, for example, might include variables for the amount of fuel required to fly the routes, several projected levels of passenger demand, varying ticket prices, pilot scheduling, and maintenance costs. The analyst chooses the values for these variables, enters them into a computer, which has already been programmed to make the calculations required, and runs the program to produce the best flight schedule consistent with several sets of assumptions. The analyst would probably design a model that would take into account wide variations in the different variables.

At this point, the operations research analyst presents the final work to management along with recommendations based on the results of the analysis. Additional runs based on different assumptions may be needed to help in making the final decision. Once a decision has been reached, the analyst works with others in the organization to ensure its successful implementation.

Working Conditions

Operations research analysts generally work regular hours in an office environment. Because they work on projects that are of immediate interest to management, analysts often are under pressure to meet deadlines and may work more than a 40-hour week.

Employment

Operations research analysts held about 45,000 jobs in 1992. They are employed in most industries. Major employers include computer and data processing services, commercial banks and savings institutions, insurance agencies, engineering and management services firms, manufacturers of transportation equipment, airlines, and the Federal Government. Some analysts work for management consulting agencies that conduct operations research for firms that do not have an in-house operations research staff.

Most analysts in the Federal Government work for the Armed Forces. In addition, many operations research analysts who work in private industry do work directly or indirectly related to national defense.

Training, Other Qualifications, and Advancement

Employers strongly prefer applicants with at least a master's degree in operations research or management science, or other quantitative disciplines. A high level of computer skills is also required.

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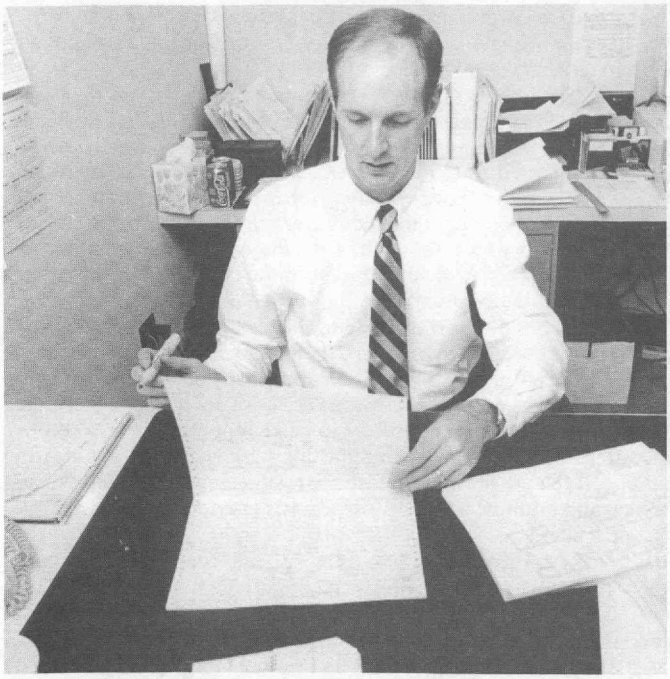

The field of operations research is growing rapidly due to the success of applying statistical techniques to business problems.

Employers often sponsor skill-improvement training for experienced workers, helping them keep up with new developments in operations research techniques as well as advances in computer science. Some analysts attend advanced university classes on these subjects.

Operations research analysts must be able to think logically and work well with people, so employers prefer workers with good oral and written communication skills. The computer is the most important tool for quantitative analysis, and training or experience in programming is a must.

Beginning analysts usually do routine work under the supervision of experienced analysts. As they gain knowledge and experience, they are assigned more complex tasks, with greater autonomy to design models and solve problems. Operations research analysts advance by assuming positions as technical specialists or supervisors. The skills acquired by operations research analysts are useful for higher level jobs, and experienced analysts with leadership potential often leave the field altogether to assume nontechnical managerial or administrative positions.

Job Outlook

Organizations are increasingly using operations research and management science techniques to improve productivity and quality and to reduce costs. This reflects growing acceptance of a systematic approach to decisionmaking as well as more affordable computers, which give even small firms access to operations research applications. The interplay of these two trends should greatly stimulate demand for these workers in the years ahead.

Those seeking employment as operations research or management science analysts who hold a master's or Ph.D. degree should find good opportunities through the year 2005. The number of openings generated each year as a result of employment growth and the need to replace those leaving the occupation, is expected to exceed the number of persons graduating with master's and Ph.D. degrees from management science or operations research programs.

Graduates with only a bachelors degrees in operations research or management science should find good opportunities as research assistants or analyst assistants in a variety of related fields; only the most highly qualified are likely to find employment as operations research or management science analysts.

Employment of operations research analysts is expected to grow much faster than the average for all occupations through the year 2005 due to the increasing importance of quantitative analysis in decisionmaking and the increasing availability of computing resources. Much of the job growth is expected to occur in the transportation, manufacturing, finance, and services sectors. Firms in these sectors recognize that quantitative analysis can achieve dramatic improvements in operating efficiency and profitability. More airlines, for example, are using operations research to determine the best flight and maintenance schedules, select the best routes to service, analyze customer characteristics, and control fuel consumption, among other things. Motel chains are beginning to use operations research to improve their efficiency by, for example, analyzing automobile traffic patterns and customer attitudes to determine location, size, and style of new motels. Like other management support functions, operations research grows by its own success. When one firm in an industry increases productivity by adopting a new procedure, its competitors usually follow. This competitive pressure will contribute to demand for operations research analysts.

Demand also should be strong in the manufacturing sector as firms expand existing operations research staffs in the face of growing domestic and foreign competition. More manufacturers are using mathematical models to study the operations of the organization for the first time. For example, analysts will be needed to determine the best way to control product inventory, distribute finished products, and to decide where sales offices should be based. In addition, increasing factory automation will require more operations research analysts to alter existing models or develop new ones for production layout, robotics installation, work schedules, and inventory control.

The Department of Defense and defense contractors employ many operations research analysts. For example, operations researchers helped plan the 1990 military deployment to Saudi Arabia. Not only did they determine the best air and water transport schedules to move the maximum number of personnel and amount of equipment in the shortest time, making optimal use of people, ships, aircraft, and fuel, but they were also central to the planning and command decisions made during combat. Because defense expenditures will be cut in the future, there will be fewer jobs available in the military and defense-related industries for these workers. However, high demand outside the military should more than offset reductions in defense-related demand.

Earnings

According to recruiters and national operations research associations, operations research analysts with a master's degree generally earned starting salaries of about $30,000 to $35,000 a year in 1992. Experienced operations research analysts earned about $50,000 a year in 1992, with top salaries exceeding $90,000.

The average annual salary for operations research analysts in the Federal Government in nonsupervisory, supervisory, and managerial positions was $57,419 in 1993.

Related Occupations

Operations research analysts apply mathematical principles to organizational problems. Workers in other occupations that stress quantitative analysis include computer scientists, applied mathematicians, statisticians, and economists. Operations research is closely allied to managerial occupations in that its goal is improved organizational efficiency.

Sources of Additional Information

Information on career opportunities for operations research analysts is available from:

☞ The Operations Research Society of America, 1314 Guilford Ave., Baltimore, MD 21202.

☞ The Institute of Management Sciences, 290 Westminster St., Providence, RI 02903.

For information on careers in the Armed Forces and Department of Defense, contact:

☞ Military Operations Research Society, 101 South Whiting St., Suite 202, Alexandria, VA 22304.

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Statisticians

(D.O.T. 020.067-022, .167-026)

Nature of the Work

Statistics is the collection, analysis, and presentation of numerical data. Statisticians design, implement, compile, and interpret the numerical results of surveys and experiments. In doing so, they often apply their knowledge of statistical methods to a particular subject area, such as biology, economics, engineering, medicine, or psychology. They may use statistical techniques to predict population growth or economic conditions, develop quality control tests for manufactured products, assess the nature of environmental problems, analyze legal and social problems, or help business managers and government officials make decisions and evaluate the results of new programs.

Often statisticians are able to obtain information about a group of people or things by surveying a small portion, called a sample, of the group. For example, to determine the size of the total audience for particular programs, television rating services ask only a few thousand families, rather than all viewers, which programs they watch. Statisticians decide where and how to gather the data, determine the type and size of the sample group, and develop the survey questionnaire or reporting form. They also prepare instructions for workers who will collect and tabulate the data. Statisticians use computers extensively to process large amounts of data for statistical modeling and graphic analysis.

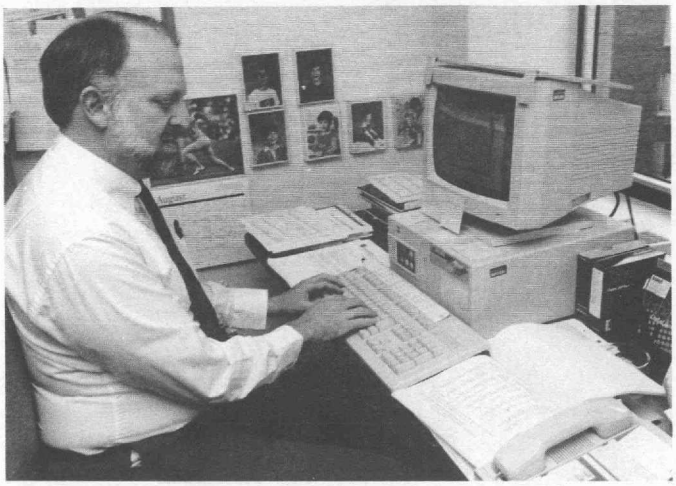
Because statistics are used in so many areas, it sometimes is difficult to distinguish statisticians from specialists in other fields who use statistics. For example, a statistician working with data on economic conditions may have the title of economist.

Working Conditions

Statisticians usually work regular hours in offices. Some statisticians may travel occasionally to supervise or set up a survey, or to gather statistical data. Some may have fairly repetitive tasks, while others may have a variety of tasks, such as in designing experiments.

Employment

Statisticians held about 16,000 jobs in 1992. About one-fourth of these jobs were in the Federal Government, where statisticians were concentrated in the Departments of Commerce (especially the Bureau of the Census); Agriculture; and Health and Human Services. Most of the remaining jobs were in private industry, especially in the insurance, transportation equipment, research and testing services, management and public relations, and computer and data processing services industries. Others worked in colleges and universities, and business and professional organizations.



A statistician compiles and analyzes large amounts of data with the aid of a personal computer.

Training, Other Qualifications, and Advancement

A bachelor's degree with a major in statistics or mathematics is the minimum educational requirement for many beginning jobs in statistics. The training required for employment as an entry level statistician in the Federal Government is a college degree including at least 15 semester hours of statistics—or a combination of 15 hours of mathematics and statistics if at least 6 semester hours are in statistics. An additional 9 semester hours in another academic discipline, such as economics, physical or biological science, medicine, education, engineering, or social science, are also required. To qualify as a mathematical statistician in the Federal Government requires 24 semester hours of mathematics and statistics with a minimum of 6 semester hours in statistics and 12 semester hours in mathematics at the calculus level or higher. Teaching and research positions in institutions of higher education and many positions in private industry require a graduate degree, often a doctorate, in statistics.

Over 80 colleges and universities offered bachelor's degrees in statistics in 1992. Many other schools also offered degrees in mathematics, operations research, and other fields which included a sufficient number of courses in statistics to qualify graduates for some beginning positions, particularly in the Federal Government. Required subjects for statistics majors include mathematics through differential and integral calculus, statistical methods, mathematical modeling, and probability theory. Additional courses that undergraduates should take include linear algebra, design and analysis of experiments, applied multivariate analysis, and mathematical statistics. Because computers are used extensively for statistical applications, a strong background in computer science is highly recommended. For positions involving quality and productivity improvement, training in engineering or physical science is useful. A background in biological or health science is important for positions involving the preparation and testing of pharmaceutical or agricultural products. For many jobs in market research, business analysis, and forecasting, courses in economics and business administration are helpful.

In 1992, approximately 110 universities offered a master's degree program in statistics, and about 70 had statistics departments which offered a doctoral degree program. Many other schools also offered graduate level courses in applied statistics for students majoring in biology, business, economics, education, engineering, psychology, and other fields. Acceptance into graduate statistics programs does not require an undergraduate degree in statistics although a good mathematics background is essential.

Good communications skills are important for prospective statisticians, not only for those who plan to teach, but also to qualify for many positions in industry, where the need to explain statistical processes to nonstatisticians is common. A solid understanding of business and management is also important for those who plan to work in private industry.

Beginning statisticians who have only the bachelor's degree often spend much of their time doing routine work supervised by an experienced statistician. With experience, they may advance to positions of greater technical and supervisory responsibility. However, opportunities for promotion are best for those with advanced degrees. Master's and Ph.D. degree holders enjoy greater independence in their work and are qualified to engage in research, to develop statistical methodology, or, after several years of experience in a particular area of technological application, to become statistical consultants.

Job Outlook

Although employment of statisticians is expected to grow more slowly than the average for all occupations through the year 2005, job opportunities should remain favorable. Many statistics majors, particularly at the bachelor's degree level, but also at the master's degree level, may find positions in which they do not have the title of statistician. This is especially true for those involved in analyzing and interpreting data from other disciplines such as economics, biological science, psychology, or engineering.

Among graduates with a bachelor's degree in statistics, those with a strong background in mathematics, engineering, or physical or

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computer science should have the best prospects of finding jobs related to their field of study in private industry or government. Federal Government agencies will need statisticians in fields such as agriculture, demography, consumer and producer surveys, transportation, Social Security, health, education, energy conservation, and environmental quality control. However, competition for entry level positions in the Federal Government is expected to be strong for those just meeting the minimum qualification standards for statisticians. Those who meet State certification requirements may become high school statistics teachers, a newly emerging field. (For additional information, see the statement on kindergarten, elementary, and secondary school teachers elsewhere in the *Handbook*.)

Private industry, in the face of increasing competition and strong government regulation, will continue to require statisticians, especially at the master's and Ph.D. degree levels, to not only monitor but improve productivity and quality in the manufacture of various products including pharmaceuticals, motor vehicles, chemicals, and food products. For example, pharmaceutical firms will need more statisticians to assess the safety and effectiveness of the rapidly expanding number of drugs. To meet growing competition, motor vehicle manufacturers will need statisticians to monitor the quality of automobiles, trucks, and their components. Statisticians with knowledge of engineering and the physical sciences will find jobs in research and development, working with scientists and engineers to help improve design and production processes in order to ensure consistent quality of newly developed products. Business firms will rely more heavily than in the past on workers with a background in statistics to forecast sales, analyze business conditions, and help solve management problems. In addition, sophisticated statistical services will increasingly be contracted out to consulting firms.

Earnings

The average annual salary for statisticians in the Federal Government in nonsupervisory, supervisory, and managerial positions was $51,893 in 1993; mathematical statisticians averaged $54,109.

According to a 1992 American Statistical Association salary survey of statisticians in departments with statistics programs, the median starting salary for assistant professors was $40,000; for associate professors, $43,500; and for professors, $54,500.

Statisticians who hold advanced degrees and work in private industry generally earn higher starting salaries than their counterparts in academic settings and in government.

Benefits for statisticians tend to resemble those offered most professionals who work in an office setting: Vacation and sick leave, health and life insurance, and a retirement plan, among others.

Related Occupations

People in numerous occupations work with statistics. Among them are actuaries, mathematicians, operations research analysts, computer programmers, computer systems analysts, engineers, economists, financial analysts, information scientists, life scientists, mathematicians, operations research analysts, physical scientists, and social scientists.

Sources of Additional Information

For information about career opportunities in statistics, contact:

☞ American Statistical Association, 1429 Duke St., Alexandria, VA 22314.

For information on a career as a mathematical statistician, contact:

☞ Institute of Mathematical Statistics, 3401 Investment Blvd., No. 7, Hayward, CA 94545.

Information on Federal job opportunities is available from area offices of the State employment service and the U.S. Office of Personnel Management or from Federal Job Information Centers located in various large cities throughout the country.

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