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The field of computing has expanded rapidly over the past ten years, and after surveying thousands of students from Canada, the USA, and Africa, we realized that students need more information about this field and its related careers.

This Guide is designed to outline the five computing disciplines, and show how they relate to specific job titles and tasks.

Information about additional training and specializations are also provided along with links to Canadian occupational information resources. For more information on how to design your career, we recommend resources available on the CERIC website (www.ceric.ca).
Many career-counselling web resources do not list all the computing disciplines as identified by the ACM (Association of Computing Machinery), but instead treat computing as a single discipline, typically computer science. But in reality there is not a single computing discipline but at least five. Including different sub-specialities, there are dozens of possible computing educational paths for prospective students.

The ACM has outlined five distinct computing disciplines: computer science, computer engineering, information systems, information technology, and software engineering. While ACM curricula is oriented towards degree programs, many computing certificates and diplomas borrow from or blend these disciplines together.

Students, advisors, and career counsellors need more information to better understand what each one of these computing disciplines does and which best suits their interests, talents, skills and abilities. This guide is designed to support prospective students, career practitioners, academic advisors and career counsellors by outlining these five areas of practice and providing information you can use to guide interested students.
The ACM has identified five computing disciplines, as well as mixed majors combining computing with other areas of expertise.

This Guide provides an overview of each of these disciplines, and their related careers, core courses, key tasks and sample jobs.
TO HELP EXPLAIN THE DIFFERENCES IN THE COMPUTING DISCIPLINES, THIS GUIDE USES A CITY METAPHOR. EACH DISCIPLINE HAS ITS OWN CITY DISTRICT THAT PROVIDES AN OVERVIEW OF THE DISCIPLINE AND THEN STEPS INSIDE THAT DISCIPLINE TO DESCRIBE TYPICAL JOB TASKS.

**COMPUTER ENGINEERING (CE)**
is concerned with the design and construction of computers and computer-based systems.

**INFORMATION SYSTEMS (IS)**
is focused on integrating information technology solutions and business processes.

**SOFTWARE ENGINEERING (SE)**
is the discipline of developing and maintaining large software systems.

**COMPUTER SCIENCE (CS)**
covers the widest range of computing topics from its theoretical foundations to the development of new computing technologies and techniques.

**INFORMATION TECHNOLOGY (IT)**
programs prepare students to meet the computer technology needs of business and other organizations.
Computer Engineers are focused on the connection between hardware and software. A dominant area within computing engineering is embedded systems: the development of devices that have software and hardware embedded in them. Devices such as cell phones, digital audio players, digital video recorders, alarm systems, x-ray machines, and laser surgical tools all require integration of hardware and embedded software.

The emphasis here is more on hardware than on software, but CEs use both for integrated devices. CEs apply engineering theories to the problems of designing computers and computer-based devices. This is a theory-driven practice which incorporates traditional engineering and mathematics.
Computer Engineering (CE) is concerned with the design and construction of computers and computer-based systems.

It involves the study of hardware, software, communications, and the interaction among them.

Its curriculum focuses on the theories, principles, and practices of traditional electrical engineering and mathematics ...

... and applies them to the problems of designing computers and computer-based devices.

Let’s look more closely at what a computer engineer learns and does ...
In Computer Engineering (CE), we are especially interested in the interaction between hardware and software.

We develop embedded systems, that is, devices with software and hardware in them.

We are also engineers, which means we also have traditional engineering skills and training.

We study project management, testing, process control, mathematics, signal processing, and other topics.

We help design 3D printers, cell phones, robots, control systems, and many other digital devices.

We develop software as well, typically with a focus on the hardware-software interface.

Interesting ... we do some of these same tasks over in Computer Science but are more focused on the software aspects.

In Information Technology, we are also interested in hardware but in a more applied way.

We develop embedded systems, that is, devices with software and hardware in them.
**COMPUTER ENGINEERING**

**Summary**

Computer Engineering is focused on computer architecture and infrastructure, from the applied to the theoretical aspects. It also has an interest in software methods (programming) insofar as it applies to the hardware side of computing.

**On the Job**

Designs hardware to implement communication systems.

Develops hardware devices that are software-controlled, such as iPods, smart phones and gaming devices.

Focuses exclusively on hardware design, including digital electronics, with less involvement in software design.

Evaluates and improves the usability (user experience) of computing systems.

Take existing equipment and adapt it for specialized use.

**Core Courses**

- Computer Architecture and Organization
- Circuits and Electronics
- Data Structure and Algorithms
- Digital Design
- Embedded Systems
- Computer Networks
- Signal Processing
- Software Design
- Information Security

**Sample Programs**

- University of Western Ontario, Bachelor of Engineering Science in Computer Engineering
- University of British Columbia, Bachelor of Applied Science in Computer Engineering
- University of Alberta, Bachelor of Engineering in Computer Engineering
- McGill University, Bachelor of Engineering in Computer Engineering
- University of New Brunswick, Bachelor of Science in Computer Engineering
- Seneca College, Computer Engineering Technology Diploma
Computer Scientists develop a strong foundation based on mathematics and algorithms. They are trained to discover the best solutions for new problems, generate new technologies and come up with innovative cutting-edge ideas. They design and test software that applies theory to practice, creating innovations in fields like robotics, computer vision, intelligent systems and bio-informatics.

Computer Scientists think up new ways to use computers, explore applications and develop effective ways to solve complex computing problems. They are involved in computer programming, and may supervise programmer teams. Computer Scientists may also develop encryption and other data protection schemes. They are involved in large software development projects.
Computer Science (CS) covers the widest range of computing topics ...

... from its theoretical and algorithmic foundations to the development of new computing technologies and techniques.

The work of computer scientists falls into three categories:

They design and implement software.

They devise new ways to use computers.

They develop effective new ways to solve computing problems.

Let's take a closer look at Computer Science ...
Computer Science (CS) professionals can perform many different tasks. We use mathematical approaches to invent and improve new algorithms. We can supervise other programmers. We take on challenging programming jobs.

Progress in CS enables innovation in other fields, such as...

... bio-informatics
... robotics
... data visualization

Our skills are often an essential foundation for games development.

In Software Engineering, we do some of these things, but more focused on the process of improving how software is created.

In Information Technology, we are also generalists but are more engaged on the practical applied side.

Computer Engineering has some similarities, but we are more focused on the connection between software and hardware.
Summary

Computer science has the widest range of computing topics. It focuses especially on the theoretical aspects of computing, leaving the more applied topics (and organizational and architecture issues) to other disciplines.

On the Job

Use new theories to create cutting edge software.
Focus on the theoretical aspects of technology.
Utilize theory to research and design software solutions.
Use a wide range of foundational knowledge to adapt to new technologies and ideas.
Apply mathematical and theoretical knowledge in order to compare and produce computational solutions and choose the best one.

Core Courses

Programming and programming languages
Data structures and algorithms
Graphics and visualization
Human-computer interaction
Software development fundamentals
Artificial intelligence
Networking and communications
Operating systems
Parallel and distributed computing

Sample Programs

University of Saskatchewan, Bachelor of Science in Computer Science
University of British Columbia, Bachelor of Computer Science
University of Manitoba, Bachelor of Computer Science
Memorial University of Newfoundland, Bachelor of Arts in Computer Science
University of Prince Edward Island, Bachelor of Science in Computer Science
Dawson College, Computer Science Technology DEC
Information Systems specialists integrate information technology with business processes. They focus on the processing of information, and must have an understanding of how organizations and technology work.

Their studies combine business and computing coursework, and may have a computing focus or a management focus. They work closely with clients to determine how information and technology can provide a competitive advantage.
Information Systems (IS) is focused on integrating information technology solutions and business processes.

IS professionals require a sound understanding of business practices.

They can serve as an effective bridge between the management and technical communities within an organization.

IS programs are often located within business faculties.

IS programs can exist under different labels.

For example, Computer Information Systems (CIS) programs have a larger technology focus ...

... while programs in Management Information Systems (MIS) emphasize more the business and organizational aspects of IS.

Let's take a closer look at what one does in Information Systems ...
In Information Technology, we are also interested in the applied side of computing.

In Software Engineering, we manage large software projects.

We are interested in the information that computer systems can provide to aid an enterprise in achieving its goals.

We view technology as an instrument for generating, processing, and distributing information.

We are often the interface between the end users and the technical experts.

We can be involved in system deployment and the training of users.

We tailor application technologies (especially databases) to the needs of the organization.

Information Systems (IS) professionals combine business and technical knowledge.

Later in our career, we may manage a team of developers on a software project.

In Information Technology, we are also interested in the applied side of computing.

In Software Engineering, we manage large software projects.

Information Systems (IS) professionals combine business and technical knowledge.
**On the Job**

Combines knowledge of business with knowledge of technology.

Selects computer systems to improve business processes.

Focuses on information, and views technology as a tool for generating, processing and distributing it.

Uses technology to give a business a competitive advantage.

Manages projects, teams of software developers or a computing department.

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**Core Courses**

- Foundations of Information Systems
- Data and Information Management
- Enterprise Architecture
- IS Project Management
- Systems Analysis and Design
- Knowledge Management and Business Intelligence Systems
- IS Security, Privacy and Ethics
- IS Strategy, Management & Acquisition
- IT Infrastructure

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**Sample Programs**

- University of Windsor, Bachelor of Science in Computer Information Systems
- Queen’s University, Bachelor of Commerce in Information Systems
- Mount Royal University, Bachelor of Science in Computer Information Systems
- Concordia University, Bachelor of Computer Science in Information Systems
- St. Francis Xavier University, Bachelor of Information Systems
- Okanagan College, Computer Information Systems Diploma
Information Technology professionals provide customer service with a focus on technology. They work to meet the computer technology needs of business, government, healthcare, schools, and other kinds of organizations. Their emphasis is on the technology itself more than the content or information it conveys.

IT professionals select appropriate hardware and software products for the organization, and integrate these with existing hardware. Their responsibilities may include installation of networks, security, design of web pages, multimedia resource development, and the installation of communication components such as email systems. They are responsible for planning and managing the entire technology lifecycle.
Information Technology (IT) programs prepare students to meet the computer technology needs of business and other organizations.

IT specialists select hardware and software products and ...

... install, customize, and maintain those products for the organization's computer users.

IT is a new field and its programs exist under different labels (that is, they may not use the IT label in their name).

Let's take a closer look at Information Technology tasks ...
We understand computer systems and their software and help to solve computer-related problems.

We install, customize, and maintain both applications and devices for an organization and its users.

We can help configure and improve an organization's data infrastructure.

We also do software development, especially in applied areas such as web sites and mobile apps.

We possess a combination of theoretical knowledge and practical, hands-on expertise.

In Information Technology (IT) we are principally focused on how to configure, use, and support technology infrastructures within organizations.

In Information Systems, we are mainly interested in the business aspects of information technology.

This means we can take care of an organization's information technology infrastructure.

Organizations are dependent upon information technology and IT professionals help support it.

In Computer Engineering, we are also interested in hardware, but we focus on designing and creating it.

We install, customize, and maintain both applications and devices for an organization and its users.

In Information Technology, we are principally focused on how to configure, use, and support technology infrastructures within organizations.

We can help configure and improve an organization's data infrastructure.

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In Information Systems, we are mainly interested in the business aspects of information technology.

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Organizations are dependent upon information technology and IT professionals help support it.

In Computer Engineering, we are also interested in hardware, but we focus on designing and creating it.
**Summary**

Information Technology is focused on the applied side of computing. It covers all aspects of technology infrastructure, including hardware, operating systems, applications, data storage and communication systems.

**On the Job**

Integrates hardware and software.
Applies technology to solve practical problems.
Provides a support role, within an organization, to help others make the best use of its technical and information resources.
Uses a wide range of foundational knowledge to adapt to new technologies and ideas.
Understands both technology and business, but with a focus more on the technical side.

**Core Courses**

IT Fundamentals
Programming Fundamentals
Fundamentals of Networking
Information Assurance and Security
System Administration and Maintenance
IT infrastructure and Project Management
Fundamentals of Web Systems
Database Systems

**Sample Programs**

York University, Bachelor of Arts in Information Technology
Algoma University, Bachelor of Arts in Information Technology
Concordia University College of Alberta, Bachelor of Science in Information Technology
Bishop’s University, Bachelor of Arts in Information Technology
Mount Saint Vincent University, Bachelor of Applied Arts in Information Technology
Nova Scotia Community College, Information Technology Diploma
Software Engineers develop and maintain large-scale software systems. Using the principles of mathematics and computer science, and the practices of engineering, software engineers learn how to develop software that meets customer needs.

Their focus is on software reliability, and they focus on techniques for developing and maintaining appropriate software solutions.

Software engineers work closely with customers, they learn how to assess customer needs and they often manage large, complex and/or safety-critical software projects.
Let’s take a closer look at what a software engineer can do ...

Degree programs in computer science and in software engineering have many courses in common.

Software Engineering (SE) is the discipline of developing and maintaining large software systems.

SE students learn about software reliability and maintenance and focus more on the best techniques for engineering software applications.

Some SE programs are within Engineering programs while others are specialities within computer science.

Let’s take a closer look at what a software engineer can do ...
Computer Engineering has some similarities, but we are more focused on the connection between software and hardware. We use special design techniques so that software is more likely to be reliable and correct.

We are interested in learning and improving software design principles. We may supervise a team of developers.

We need to be able to assess user needs and develop usable software.

We are often engineers, which means we also have traditional engineering skills and training.

We sometimes do many of these same tasks over in Computer Science as well.

In Software Engineering (SE) we are focused on how to best develop large-scale, reliable software systems.

We also develop new testing techniques to create safer software.

Computer Engineering has some similarities, but we are more focused on the connection between software and hardware.

We are often engineers, which means we also have traditional engineering skills and training.
Software Engineering is focused on everything (from applied to theoretical) related to software methods, that is, writing software. Infrastructure and application technologies are also part of software engineering.

**Summary**

**On the Job**

- Focuses on large-scale systems development.
- Designs testing procedures for large-scale systems.
- Utilizes theory to research and design software solutions.
- Develops software systems that are maintainable, reliable, efficient, and satisfy customer requirements.
- Utilizes sound engineering practices to create computer applications.
- Manages a team of software developers.

**Core Courses**

- Mathematical and Engineering Fundamentals
- Programming Fundamentals
- Software Modeling and Analysis
- Software Design and Processes
- Software Quality Assurance
- Software Security
- Software Project Management
- Data Structures and Algorithms

**Sample Programs**

- University of Guelph, Bachelor of Computing in Software Engineering
- University of Victoria, Bachelor of Engineering in Software Engineering
- University of Calgary, Bachelor of Science in Software Engineering
- University of Manitoba, Bachelor of Science in Software Engineering
- Concordia University, Bachelor of Engineering in Software Engineering
- University of New Brunswick, Bachelor of Science in Software Engineering
- Sheridan College, Computer Systems Technician – Software Engineering Diploma
Not every computing program that you find in a college or university will have one of these five ACM discipline titles. For example, we now see undergraduate degrees in Game Design, Cyber-Security, and Computer Applications. Many universities also offer mixed majors that combine computing with a variety of other disciplines, including Computational Science, BioInformatics, Computational Arts, and Computing and Health Sciences.

One-year certificates, two-year diplomas, and three-year applied or associate degrees provide dozens of other options, either as stand-alone training or post-degree specialization. These programs often use a variety of titles which don’t always map to the five ACM discipline areas.

To make it more confusing, the job title you have in a company might not sound like the program you took. For example, Network Administrators could have backgrounds in Computer Science, Information Systems, or Information Technology.
WHAT ASPECT OF COMPUTING WILL I FOCUS ON?

Most computing jobs fall into one of the general categories shown in the below diagram and which are explained in more detail on the following page. Notice the people on the stairs: they represent the fact that people working within development can often find themselves moving to other types of jobs.
THERE ARE MANY, MANY, MANY DIFFERENT TYPES OF COMPUTING JOBS. IF THERE IS ONE THING WE HOPE THAT THIS GUIDE TEACHES YOU IS THAT COMPUTING IS MUCH MORE THAN JUST PROGRAMMING!

APPLICATION DEVELOPMENT
Manager
Chief Information Officer
ITS Manager
Project Manager
Software Engineer
Front-End Developer
Programmer
Web Developer
Game Developer

INFRASTRUCTURE
Automation Engineer
Computer Hardware Engineer
Computer System Manager
Network Engineer
Systems Administrator

DEVELOPMENT
These are the jobs most often identified with computing. The focus here is on software development, often referred to simply as programming. As you can see, there are many different labels for developers, each with a different focus.

DATA
We live in a world that is over-flowing with digital data. Experts in this area help organize, analyze, and secure the data needs of organizations.

DESIGN
Most computing systems are used by humans, and as a result specialists are needed to make these systems attractive and usable as well as efficient and bug-free.

BUSINESS
Ultimately, computing systems are used by businesses and organizations. Specialists are needed to help optimize computing systems for business needs, as well as adopt business processes to new innovations.

MANAGEMENT
Like other business activities, computing requires managers. A manager might oversee a project, a development team, a computing department, or the information needs of an entire corporation.
As you can see, there is a lot of overlap. One of the amazing things about the computing industry is that over one’s career, one can potentially have a variety of different jobs.

The following table provides examples of how some sample job titles relate to the five ACM disciplines, and shows where additional training may be needed.

<table>
<thead>
<tr>
<th>Job Title</th>
<th>Computing Discipline</th>
<th>Possible Additional Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business System Analyst</td>
<td>CS</td>
<td>Business/Commerce</td>
</tr>
<tr>
<td>Computational Scientist</td>
<td>CS</td>
<td>Mathematics, Sciences</td>
</tr>
<tr>
<td>Computer Network Support Specialist</td>
<td>CS</td>
<td></td>
</tr>
<tr>
<td>Data Analyst</td>
<td>IS, CS</td>
<td>Statistics</td>
</tr>
<tr>
<td>Database Administrator</td>
<td>CS, IT</td>
<td></td>
</tr>
<tr>
<td>Gaming &amp; Multimedia Specialist</td>
<td>IS</td>
<td>Graphic Design, Creative Writing</td>
</tr>
<tr>
<td>Hardware Engineer</td>
<td>IS</td>
<td>Electrical/Electronic Engineering</td>
</tr>
<tr>
<td>Information Security Analyst</td>
<td>IS, IT</td>
<td></td>
</tr>
<tr>
<td>IT/IS Consultant</td>
<td>IS</td>
<td></td>
</tr>
<tr>
<td>Medical Computing / Bioinformatics</td>
<td>IS</td>
<td>Biology, Health Sciences, Statistics</td>
</tr>
<tr>
<td>Project Manager</td>
<td>IS, IT</td>
<td></td>
</tr>
<tr>
<td>Quality Assurance Specialist</td>
<td>IS</td>
<td></td>
</tr>
<tr>
<td>Software Developer</td>
<td>IS</td>
<td></td>
</tr>
<tr>
<td>Systems Administrator</td>
<td>IS</td>
<td></td>
</tr>
<tr>
<td>Systems Analyst and Designer</td>
<td>IS</td>
<td></td>
</tr>
<tr>
<td>Web Developer / Designer</td>
<td>IS, IT</td>
<td>Graphic Design</td>
</tr>
</tbody>
</table>
For more occupational information, consider these free Canadian resources.

Canada – explore careers, wages, etc: www.jobbank.gc.ca/explorecareers.do

Canadian Occupational Projection System: occupations.esdc.gc.ca/sppc-cops

Simply Hired (Canada) www.simplyhired.ca

Working in Canada: www.workingincanada.gc.ca/home-eng.do

Alberta – Occupational Information: www.alis.gov.ab.ca/occinfo


Manitoba – Career Development: www.manitobacareerdevelopment.ca

Nova Scotia – Explore Careers: careers.novascotia.ca/searchjobprofiles

New Brunswick – Explore Careers: www.nbjobs.ca/explore

Newfoundland and Labrador: www.aesl.gov.nl.ca/lmi.html

Ontario – Job Profiles: www.ontario.ca/page/labour-market

PEI – Career Development: www.cdspei.ca


For additional information about computing education and careers, consider these additional sites.

Careers in Computing: www.computerscienceonline.org

ACM Computing Curricula Recommendations: www.acm.org/education/curricula-recommendations

ACM Career and Job Center: jobs.acm.org

Career One Stop: www.careeronestop.org

Association for Women in Computing: www.awc-hq.org

For more information about disciplinary differences within computing, consider these readings.


ACM/IEEE (2013). Computer Science Curriculum 2013: Curriculum Guidelines for Undergraduate Degree Programs.


