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## Computer science and mathematics

### Computer science

A discipline that deals with the theoretical and practical aspects of computers, including their design, programming, operation and use.

### **Algorithmics**

The study of the application of algorithms (a step-by-step procedure for accomplishing some end) to computer science.

#### Project ideas

Designing an automaton to control the lighting in a house

“I love you”—a self-modifying algorithm

Compressing files: data, images, video clips

Designing a software program that enables a two-legged robot to move forward

Designing a software program that helps determine where a serial criminal lives

Designing a software program that helps protect voice transmission (by code)

Is computer security completely secure?

Calculating moves in games using the algorithm A\*

Creating algorithms that visualize fractals, geometric shapes of a variety of complex 2-D, 3-D or 4-D structures

Comparing the effectiveness of sorting algorithms

### **Bioinformatics**

A discipline that involves the use of computers in different fields of biology.

#### Project ideas

Studying the evolution of a piece of wild land bordering a forest

Dendrochronology

Studying the effects of spruce budworm infestation on the growth of the balsam fir

Managing all the data generated by projects in genomics or proteomics

High throughput screening in drug manufacturing

Telemedicine

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### **Application design**

Methods used to develop computer programs designed to perform various tasks.

#### Project ideas

- The evolution of Linux
- The use of computers in the performing arts
- IRC (Internet Relay Chat)—a more accessible and safer party line
- Using computers to control the environmental parameters in a house

### **Interactive computer terminal design**

A field that specializes in the production of multimedia content on touch-screen terminals at public venues.

#### Project ideas

- Creating a science terminal for the Science Fair public
- Creating a terminal to help with career choices

### **CD-ROM or DVD-ROM design**

A field that specializes in the production of a wide range of content on CD.

#### Project ideas

- Technologies for storing past, present and future information
- Systems for encoding and decoding CDs
- Detection and correction of errors
- Compression with or without loss of information

### **Interactive content design**

Non-linear structuring of content and design of an effective means of navigating through the available content.

#### Project ideas

- Designing a software program to help learn about science
- A tutorial program to understand the periodic table
- A computer game to discover the cosmos
- A PC software program that explains about PCs
- A software program to help learn about mathematics
- Designing software programs to help students with learning difficulties

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### **Detection and elimination of computer viruses**

Developing means of detecting and eliminating dangerous viruses.

#### Project ideas

Inventing a computer system that is immune from viruses, without the use of anti-virus software, through the intelligent recognition of attacking viruses

An effective antidote for computer viruses

Can a computer virus spread on its own?

A computer virus that behaves like a human virus

A virus for eliminating viruses

### **Database management**

A practical structural approach to creating databases (a collection of organized data that can be accessed by means of specialized software).

#### Project ideas

How will we deal with long-term data storage given the limited operational life of a hard disk?

Understanding and designing a redundant security system for data management

Modelling object-based databases

Is it possible to respond to a request even if information is missing in a database?

### **Software engineering**

The application of engineering principles and techniques for designing large-scale integrated software systems.

#### Project ideas

Can a factory be entirely robotized?

### **Distributed computing**

A computer system that uses computers situated in different places and connected by means of a network to input, control, record, process or generate data.

#### Project ideas

The file system of the different police forces

The RISQ network

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### **Artificial intelligence**

The subfield of computer science concerned with knowledge processing and human reasoning with a view to developing intelligent computer programs that can perform functions that would be considered intelligent if observed in a human (e.g. reasoning, comprehension, adaptation).

#### Project ideas

- Developing software that can perform calculations
- Developing software that can prescribe medication
- What are the possible applications of artificial intelligence?
- Is the future of artificial intelligence close at hand?
- Constancy in Tarot reading
- Constancy in celestial charting
- Can a computer participate in a conversation?
- Neuron networks and expert systems applied to simulation games
- Developing software that will enable a robotized car to drive to a specific location in a minimum amount of time

### **Web content integration**

Adaptation to clients' Internet technology needs (e.g. network flow, security, e-commerce, content updates).

#### Project ideas

- The management of open-source code projects on the Internet
- Web-based distance learning

### **Microcomputing**

Computing based on the use of microcomputers, which are characterized by the application of microelectronics and microprocessors.

#### Project ideas

- Developing an optical microprocessor
- Can we expect another bug like Y2K?
- What are the different processor design technologies?
- Can processors become even more miniaturized?

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### **Multimedia**

Information technology that simultaneously uses several types of digital data (textual, graphic or sound form) within a given application or medium, and integrates an interactive component.

#### Project ideas

- Creating an interactive game to teach children to read
- Creating an interactive game that integrates all types of media (video, images, sound, text, writer and players)
- Digital television: cable or satellite?
- Designing a house plan
- The 3-D configuration of a protein
- A representation of the human body
- Computer-generated special effects for film
- Creating the perfect 3-D image
- Studying leg motion
- The grasping motion of an artificial hand
- Creating a full-length or short film that is entirely computer animated

### **Programming and programming languages**

Formulation of instructions in a language that computers can understand.

#### Project ideas

- Designing a compiler that directly translates human language into machine language
- The evolution of Linux
- How can data transfer be secured?
- Coding matrices

### **Virtual reality**

A surrogate environment created by communications and computing systems that enables users to interact with the computer-generated counterpart of a physical object.

#### Project ideas

- Immersion peripherals in computer-generated universes

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### **Networking**

A series of techniques and activities for designing, installing and using networks.

#### Project ideas

Past, present and future network protocols

Can today's Internet be modified?

### **Telematics**

Services available for both professional and home use that allow for the unilateral or interactive transmission of information in textual, graphic or sound form on a telecommunications network, using remote processing techniques.

#### Project ideas

How does the Internet work?

Telemedicine

ATM and SONET network telephone management systems

Designing software that would make it possible to take courses at home at the same time as colleagues

How would it be possible to communicate from Earth with a spaceship travelling at the speed of light?

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### **Mathematics**

A deductive science that deals with quantity and magnitude, as well as abstract elements (such as numbers, geometric figures and functions) and the relationships among them. Mathematics introduces unifying concepts and serves as a language for sciences.

### **Algebra**

A branch of mathematics in which arithmetic relations are generalized and explored by using letter symbols (a, b, x, N) to represent numbers, variable quantities, or other mathematical entities.

#### Project ideas

What does  $A + B$  signify if A and B each represents a group of numbers rather than a single number. In this case, how can we solve for X so that  $A + X = B$ ? Does every equation have a solution?

### **Analysis**

The study of functions and their properties, using mainly differential and integral calculus.

#### Project ideas

What are complex numbers? Where do they come from? Are they “real” or only “imaginary”?

### **Biomathematics**

The application of mathematics to biology and the biomedical field.

#### Project ideas

Modelling populations

Modelling heart and brain function

Medical imaging

The theory of knots and DNA chains

The Fibonacci series and its implications

Population growth

The pattern of spirals of sunflower seeds, on pineapples

The golden number according to which seashells grow, and leaves are arranged to get maximum sunlight

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### **Cryptology**

The applied science of encrypted communications and the methods of deciphering secret codes.

#### Project ideas

Quantum cryptography

The relationship between the flow of atoms and the flow of information

### **Geometry**

The study of the measurement and relationship of points, lines, angles, surfaces and solid figures in space.

#### Project ideas

Drawing an object in four dimensions

Drawing two lines that are both parallel and perpendicular

Is a line the shortest distance between two points?

Finding a surface that minimizes energy expenditure in an engine

Finding a way of cutting a tarp in order to minimize tension when it is in place, using calculations and simulations with soap bubbles.

Right angles and mathematics: demonstrations and the use of the Pythagorean theorem

What are the applications of geometry in land surveying, triangulation, etc.

### **Mathematical logic**

The study of formal relationships between various statements within a theoretical framework.

#### Project ideas

Solving paradoxes (e.g. the barber paradox)

Discussion on infinity (e.g. the infinite hotel)

Zenon's paradox

### **Discrete mathematics**

A branch of mathematics that includes combinatorics (counting problems) and graph theory.

#### Project ideas

The study of errors resulting from the representation of numbers in a computer or calculator.

Error correction codes



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### **Mathematical modelling**

The use of mathematics to describe and explain real-world phenomena.

#### Project ideas

Magic and mathematics—more closely related than you might think  
 The relationship between music and mathematics  
 Calculating a way of improving basketball shooting efficiency  
 What if the Earth were donut-shaped?  
 Is it possible to predict cactus shapes?  
 Is time linear or circular?  
 Is the cosmos infinite?  
 Simulations or imitating randomness (the Monte Carlo Method)  
 The myth of the golden section: it is wrong to claim that the great artists of antiquity used the symbolism of the golden section?

### **Probability**

The likelihood of occurrence of a particular event measured as the ratio of the outcomes that would produce that event to the total number of possible outcomes.

#### Project ideas

Estimating the number of times you will receive a chain letter  
 Estimating the number of times a bird will land on a given perch  
 Will I become a lottery millionaire?  
 Probabilities related to gambling  
 Law of large numbers

### **Statistics**

The body of principles and procedures based on the concept of probability, developed for the collection, classification, summarization and mathematical interpretation of numerical data related to phenomena for which an exhaustive study of all factors is impossible given their large numbers and complexity.

#### Project ideas

Are surveys accurate?

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### **Dynamic systems**

Study of systems that change with time. They include differential equations that refer to chaos or fractals.

#### Project ideas

Modelling the development of society

In an ecosystem of herbivores and carnivores, how many of each are needed to maintain the populations?

Chaos theory

Fractals—geometric shapes of a variety of complex structures

### **Number theory**

Study of the properties of numbers, especially integers.

#### Project ideas

Prime numbers and their use in encryption algorithms

The decimals of Pi