

# FOUNDATIONS OF SCIENCE (CCSC-SHU)

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## CCSC-SHU 100 Mathematics for the Sciences (2 Credits)

*Typically offered occasionally*

This course is designed for students who would like to develop a better grounding of the specific mathematical methods used in the basic natural science courses, mainly in physics and chemistry. It is intended for students who would like to strengthen their mathematical skills so that they can better focus on the principles of the basic sciences. The course will review, as well as teach, how the concepts of algebra, trigonometry, vectors, calculus, differential equations, statistics as they are used in the sciences using specific examples from physics, chemistry, and applications in studies of classical mechanics, quantum mechanics, thermodynamics, electrostatics, theory of atoms and molecules, etc. The pre-requisites are basic high school mathematics.

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

## CCSC-SHU 101 Foundations of Science 1 Physics (2 Credits)

*Typically offered Fall*

Foundations of Science 1: Energy and Matter provides a comprehensive introduction to these two fundamental concepts that are so famously unified in the equality  $E=mc^2$ . Following an introduction to the physical sciences, the course focuses on velocity, acceleration, forces, and energy, while simultaneously introducing students to atoms and molecules. Chemical reactions are examined, and the energy changes associated with them are investigated via a thorough analysis of the three laws of thermodynamics. Laboratory exercises focus on the guiding principles of the scientific method and an introduction to experimental design, data analysis, and scientific presentation, including technical writing. Focused disciplinary tutorials in biology, chemistry, and physics provide an opportunity for in-depth analysis and discussion of classic papers, enhanced understanding of fundamental concepts, and development of practical skill sets. Weekly discussion sections are designed to hone proficiency at solving problems in a collaborative, team environment.

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

## CCSC-SHU 102 Foundations of Science 1 Chemistry (2 Credits)

*Typically offered Fall*

Foundations of Science 1. "Energy and Matter," provides a comprehensive introduction to these two fundamental concepts, which are so famously unified in the equality  $E=mc^2$ . Following an introduction to the physical sciences, it focuses on velocity, acceleration, forces, and energy, while simultaneously introducing students to atoms and molecules. Chemical reactions are examined, and the energy changes associated with them are investigated via a thorough analysis of the three laws of thermodynamics. Laboratory exercises focus on the guiding principles of the scientific method and an introduction to experimental design, data analysis, and scientific presentation, including technical writing.

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

## CCSC-SHU 103 Foundations of Science 2 Physics (2 Credits)

*Typically offered Fall*

Foundations of Science 2, "Forces and Interactions," introduces students to fundamental forces, including gravity and electromagnetic forces. Concurrently, atomic theory, the theory of molecular bonding, and atomic and molecular structures and shapes, in which forces and energy play a role, are investigated. Students apply these concepts to understanding molecules related to the life sciences. Laboratory exercises focus on acquisition of computer skills and modeling with a continued emphasis on technical presentation. Focused disciplinary tutorials in biology, chemistry, and physics provide an opportunity for in-depth analysis and discussion of classic papers, enhanced understanding of fundamental concepts, and development of practical skill sets. Weekly discussion sections are designed to hone proficiency at solving problems in a collaborative, team environment. Co-requisite: MATH-121

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

## CCSC-SHU 104 Foundations of Science 2 Chemistry (2 Credits)

*Typically offered Fall*

Foundations of Science 2, "Forces and Interactions," introduces students to fundamental forces, including gravity and electromagnetic forces. Concurrently, atomic theory, the theory of molecular bonding, and atomic and molecular structures and shapes, in which forces and energy play a role, are investigated. Students apply these concepts to understanding molecules related to the life sciences. Laboratory exercises focus on acquisition of computer skills and modeling with a continued emphasis on technical presentation. Focused disciplinary tutorials in biology, chemistry, and physics provide an opportunity for in-depth analysis and discussion of classic papers, enhanced understanding of fundamental concepts, and development of practical skill sets. Weekly discussion sections are designed to hone proficiency at solving problems in a collaborative, team environment. Co-requisite: MATH-121

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

## CCSC-SHU 105 Foundations of Science 3 Physics (1 Credit)

*Typically offered Spring*

Foundations of Science 3, "Systems in Flux," focuses on changes in systems in the physical and living worlds. Capacitors, current, and basic circuits are explored with an eye toward understanding their applications to chemical reactions and the behavior of living cells. The rates and directions of chemical reactions are explored as chemical kinetics and chemical equilibrium are investigated with a special focus on acid-base chemistry. These fundamental physical and chemical principles are used to describe basic cellular monomers and polymers including DNA, RNA, and protein, and the sequence of events that leads to information flow and its regulation in the cell nucleus. They are also applied to macroscopic systems found in the biosphere. Laboratory exercises focus on classic scientific experiments that are designed to sharpen basic laboratory skills. Prerequisite: CCSC-104; Prerequisite: MATH 121 OR 201

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

**CCSC-SHU 106 Foundations of Science 3 Chemistry (2 Credits)***Typically offered Spring*

Mathematics is the language of physics. In this course, students will understand the advanced mathematical methods most widely used in physics and extend their skills by practice. On completion, successful students will be able to understand and proficiently use (1) vector and matrix algebra, (2) ordinary and partial differential equations, and (3) functions of complex variables. The lectures serve as an introduction, and the real work of learning starts when you do the homework. The lectures will be most useful to you if you ask questions when there is something you do not understand. Do not imagine that you are the only person in the room who does not understand something. The most important part of the class is the homework you do. You learn more physics by doing the homework than from the lecture. I encourage you to work together with one or more friends on the homework assignments. It is more enjoyable that way, and you learn by explaining things to each other. Textbooks: Mary L. Boas, *Mathematical Methods in the Physical Sciences*, (Wiley, 2005).

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 107 Foundations of Science 3 Biology (2 Credits)***Typically offered Spring*

Foundations of Science 3, "Systems in Flux," focuses on changes in systems in the physical and living worlds. Capacitors, current, and basic circuits are explored with an eye toward understanding their applications to chemical reactions and the behavior of living cells. The rates and directions of chemical reactions are explored as chemical kinetics and chemical equilibrium are investigated with a special focus on acid-base chemistry. These fundamental physical and chemical principles are used to describe basic cellular monomers and polymers including DNA, RNA, and protein, and the sequence of events that leads to information flow and its regulation in the cell nucleus. They are also applied to macroscopic systems found in the biosphere. Laboratory exercises focus on classic scientific experiments that are designed to sharpen basic laboratory skills. Prerequisite: CCSC-104 AND MATH 121 OR 201

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 108 Foundations of Science 4 Physics (1 Credit)***Typically offered Spring*

Foundations of Science 4, "Form and Function," explores a question applicable to all branches of science: How does the form or shape of a physical entity set its function? This leads to another question: If a specific function is desired, can a form or shape be engineered or modified to execute or improve that function? The course examines the form/function concept in magnetic and electrical fields, the behavior and design of small molecules, and the activity of proteins as the workhorse in biological systems. Laboratory exercises require students to design experiments related to crystals and crystallography, and to examine chemical forms at the macroscopic and microscopic levels. Focused disciplinary tutorials in biology, chemistry, and physics provide an opportunity for in-depth analysis and discussion of classic papers, enhanced understanding of fundamental concepts, and development of practical skill sets. Weekly discussion section are designed to hone proficiency at solving problems in a collaborative, team environment. Prerequisite: CCSC-105 AND MATH 121 OR 201

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 109 Foundations of Science 4 Chemistry (2 Credits)***Typically offered Spring*

Foundations of Science 4, "Form and Function," explores a question applicable to all branches of science: How does the form or shape of a physical entity set its function? This leads to another question: If a specific function is desired, can a form or shape be engineered or modified to execute or improve that function? The course examines the form/function concept in magnetic and electrical fields, the behavior and design of small molecules, and the activity of proteins as the workhorse in biological systems. Laboratory exercises require students to design experiments related to crystals and crystallography, and to examine chemical forms at the macroscopic and microscopic levels. Focused disciplinary tutorials in biology, chemistry, and physics provide an opportunity for in-depth analysis and discussion of classic papers, enhanced understanding of fundamental concepts, and development of practical skill sets. Weekly discussion section are designed to hone proficiency at solving problems in a collaborative, team environment. Prerequisite: CCSC-104 AND MATH 121 OR 201

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 110 Foundations of Science 4 Biology (2 Credits)***Typically offered Spring*

Foundations of Science 4, "Form and Function," explores a question applicable to all branches of science: How does the form or shape of a physical entity set its function? This leads to another question: If a specific function is desired, can a form or shape be engineered or modified to execute or improve that function? The course examines the form/function concept in magnetic and electrical fields, the behavior and design of small molecules, and the activity of proteins as the workhorse in biological systems. Laboratory exercises require students to design experiments related to crystals and crystallography, and to examine chemical forms at the macroscopic and microscopic levels. Focused disciplinary tutorials in biology, chemistry, and physics provide an opportunity for in-depth analysis and discussion of classic papers, enhanced understanding of fundamental concepts, and development of practical skill sets. Weekly discussion section are designed to hone proficiency at solving problems in a collaborative, team environment. Prerequisite: CCSC-107 AND MATH 121 OR 201

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 111 Foundations of Science 5 Biology (2 Credits)***Typically offered occasionally*

Foundations of Science 5, "Propagating Change," focuses on disturbances in physical and living systems that bring about change. In physics, disturbances generate waves that are associated with the transmission of light and sound. These same waves generate responses in living organisms as sensory systems detect them, including nerves in some species. Electromagnetic waves, interactions among light, matter, and living systems, and the responses of nerve cells are examined. Changes during the maturation of organisms are explored at the molecular level as well. In addition, evolution is introduced as the fundamental means of propagating change that gives rise to new species in the living world. Laboratory exercises fuse physics, chemistry and biology as students engage in projects related to recombinant DNA technology, gene cloning, and protein synthesis and characterization. Prerequisite: CCSC-110

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No

**CCSC-SHU 112 Foundations of Science 5 Physics (2 Credits)***Typically offered Fall*

Foundations of Science 5, "Propagating Change," focuses on disturbances in physical and living systems that bring about change. In physics, disturbances generate waves that are associated with the transmission of light and sound. These same waves generate responses in living organisms as sensory systems detect them, including nerves in some species. Electromagnetic waves, interactions among light, matter, and living systems, and the responses of nerve cells are examined. Changes during the maturation of organisms are explored at the molecular level as well. In addition, evolution is introduced as the fundamental means of propagating change that gives rise to new species in the living world. Laboratory exercises fuse physics, chemistry and biology as students engage in projects related to recombinant DNA technology, gene cloning, and protein synthesis and characterization.

Prerequisite: CCSC-110

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 113 Foundations of Science 6 Biology (1 Credit)***Typically offered occasionally*

Foundations of Science 6, "Oscillations," examines how repetitious or cyclical events, although presumably predictable, are associated with inherent uncertainty in their outcomes. This is embodied in physics and chemistry in quantum theory and the Heisenberg uncertainty principle. But living systems, especially when populations are studied, provide countless examples of oscillatory events that possess inherent uncertainty when scientists try to predict outcomes. Indeed, this final chapter in Foundations of Science challenges students to consider the very nature of studying complex problems and systems and assessing the uncertainty associated with the scientific method. The laboratory exercises involve collaborative projects in which teams of students must apply their acquired knowledge and skills to design experiments focused on answering a question or solving a problem, keeping uncertainty in mind as they report their results and discuss additional data that would be needed to provide a better answer or solution. Prerequisite: CCSC-111

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 114 Foundations of Science 6 Physics (1 Credit)***Typically offered occasionally*

Foundations of Science 6, "Oscillations," examines how repetitious or cyclical events, although presumably predictable, are associated with inherent uncertainty in their outcomes. This is embodied in physics and chemistry in quantum theory and the Heisenberg uncertainty principle. But living systems, especially when populations are studied, provide countless examples of oscillatory events that possess inherent uncertainty when scientists try to predict outcomes. Indeed, this final chapter in Foundations of Science challenges students to consider the very nature of studying complex problems and systems and assessing the uncertainty associated with the scientific method. The laboratory exercises involve collaborative projects in which teams of students must apply their acquired knowledge and skills to design experiments focused on answering a question or solving a problem, keeping uncertainty in mind as they report their results and discuss additional data that would be needed to provide a better answer or solution. Prerequisite: CCSC-112

**Grading:** Ugrd Abu Dhabi Graded**Repeatable for additional credit:** No**CCSC-SHU 130 Introduction to computer programming with Mathematica (2 Credits)***Typically offered occasionally*

Mathematica is a powerful tool for technical computing. It provides a robust computing environment that is used in biology, chemistry, economics, engineering, finance, mathematics, physics, the arts, and a wide range of other fields. It is designed for symbolic as well as numerical calculations, and for visualization of technical information. Mathematica can change forever both what we teach and learn in the classroom, and how we teach and learn it. To provide students with the very best education possible, we need to bring it into our classrooms. The goal of this course is to empower students in the sciences, engineering, economics, finance, and even in the arts and humanities, to use symbolic and numeric computation, and thereby give them a tool (and a leg up) that they can use throughout their whole professional career. The course will include the following topics: A brief introduction to computer science and numerical methods, Mathematica as a sophisticated symbolic and numeric calculator, Wolfram Alpha – a computational database, programming in Mathematica and the concepts behind the language. Procedural programming, functional programming and rule based programming, parallel computing using multiple cores, dynamic interfaces (animation), precision and accuracy, working with units, vectors, matrices, calculus, differential equations, difference (recurrence) equations, optimization methods, image and video processing, audio processing, finance and economics applications, and software development. Students will complete a project that they will choose from within their own areas of interest. Textbooks: John W. Gray, Mastering Mathematica: Programming Methods and Applications, (Academic Press, 1997). Paul R. Wellin, Programming with Mathematica, An Introduction, (Cambridge U. Press, 2013). Handout notes. Prereq: Calculus or Honors Calculus

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No**CCSC-SHU 135 Topics in Modern Medicine for Non-Science Majors (2 Credits)***Typically offered occasionally*

This course, intended for Non-Science Majors, will consist of several guest speakers covering various topics related to modern medicine, such as: - The Cell, Proteins - DNA and RNA Structure - The Genetic code and Protein Synthesis, Antibiotics - Medical Diagnosis and Forensics - Serendipity in Molecular Medicine - Science and Intellectual Property - Pharmaceutical Patents - The Stress Reaction: a historical perspective - Smoking – The great evil

**Grading:** Ugrd Shanghai Graded**Repeatable for additional credit:** No

**CCSC-SHU 136A Topics in Human Genetics: Genes in Human Health and Disease I (2 Credits)**

*Typically offered occasionally*

Part I: The goal of Genes in Human Health and Disease I is to build a basic understanding of how information about traits is encoded in our genes, how this "blueprint" is interpreted by cellular machinery to build a complex human being, and how our heredity has resulted in our evolution. In Genes in Human Health and Disease II, we will continue the exploration of how environment, experience and random errors affect the process of building our traits, what happens when these processes fail, and the promise and possible peril of genetic technologies for human life. In Genes in Human Health and Disease I, student progress will be assessed through homework, exams, and in-class exercises. In addition to such assessments in Genes in Human Health and Disease II, students will have the opportunity to apply this understanding to current issues such as those affecting health, society, technology, policy and environment through in-class discussion and a term project. Prerequisites: None.

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

**CCSC-SHU 136B Topics in Human Genetics: Genes in Human Health and Disease II (2 Credits)**

*Typically offered occasionally*

Part II: The goal of Genes in Human Health and Disease I is to build a basic understanding of how information about traits is encoded in our genes, how this "blueprint" is interpreted by cellular machinery to build a complex human being, and how our heredity has resulted in our evolution. In Genes in Human Health and Disease II, we will continue the exploration of how environment, experience and random errors affect the process of building our traits, what happens when these processes fail, and the promise and possible peril of genetic technologies for human life. In Genes in Human Health and Disease I, student progress will be assessed through homework, exams, and in-class exercises. In addition to such assessments in Genes in Human Health and Disease II, students will have the opportunity to apply this understanding to current issues such as those affecting health, society, technology, policy and environment through in-class discussion and a term project. Prerequisites: CCSC-SHU 136A OR BIOL-SHU 21 OR Permission of the Instructor.

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No

**CCSC-SHU 155 Biology and Biotechnology: Essential, Commercial Aspects, Ethical Considerations (2 Credits)**

*Typically offered occasionally*

The course presents the essential elements of biology and biotechnology in order to enable non-scientists to have a basic understanding and an ability to read non-technical material. The techniques of genetic engineering and antibody production and the use of stem cells for medical pursuits will be covered in a manner amenable to all educated persons. Included in the biology part are both evolution and simple genetics with examples mostly from humans. Topics such as cancer and the ebola virus are currently of great interest. Students with a wide range of backgrounds should benefit. Pre-requisites: None.

**Grading:** Ugrd Shanghai Graded

**Repeatable for additional credit:** No