DUBLIN
CITY SCHOOLS

K-12 SCIENCE
Graded Course of Study
2025

A K-12 Dublin City Schools science education aims to create lifelong learners who are curious, critical thinkers, and effective collaborators, equipped with the scientific knowledge and skills necessary to navigate and shape a complex and ever-changing world.

Our vision is to inspire students to develop a deep appreciation for science and its applications, empowering them to:

- Ask questions, seek answers, and explore the natural world with a sense of wonder and curiosity.
- Think critically and creatively to solve problems and make informed decisions as a scientifically literate citizen.
- Communicate and collaborate effectively in our diverse community and beyond to address common challenges and create innovative solutions.
- Build their own identity as a scientist in order to apply scientific concepts and methods to understand and address real-world issues competently and confidently.
- Develop the resilience, adaptability, and perseverance needed to succeed in a rapidly evolving world.

Instructional Agreements for Science Learning within the Dublin City Schools

- Teachers will provide opportunities for students to engage in hands-on experiences, projects, and real-world simulations to provide context and relevance to science concepts.
- Teachers will create an environment that emphasizes the importance of effort, perseverance, and reflection in order to learn and grow from both success and failure.
- Content standards will be learned in conjunction with best practices regarding science education.

Together, we will cultivate resourceful, adaptable, and collaborative individuals with the ability to tackle real-world challenges with resilience and innovation.

Nature of Science	
One goal of science education is to help students become scientifically literate citizens able to use science as a way of knowing about the natural and material world. All students should have sufficient understanding of scientific knowledge and scientific processes to enable them to distinguish what is science from what is not science and to make informed decisions about career choices, health maintenance, quality of life, community and other decisions that impact both themselves and others.	
Scientific Inquiry, Practice and Applications	All students must use these scientific processes with appropriate laboratory safety techniques to construct their knowledge and understanding in all science content areas.
Science is a Way of Knowing	Science assumes the universe is a vast single system in which basic laws are consistent. Natural laws operate today as they did in the past and they will continue to do so in the future. Science is both a body of knowledge that represents a current understanding of natural systems and the processes used to refine, elaborate, revise and extend this knowledge.
Science is a Human Endeavor	Science has been, and continues to be, advanced by individuals of various races, genders, ethnicities, languages, abilities, family backgrounds and incomes.
Scientific Knowledge is Open to Revision in Light of New Evidence	Science is not static. Science is constantly changing as we acquire more knowledge.

Scientific and Engineering Practices:
1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

Ohio's Cognitive Demands for Science	
Educators will refer to "Ohio's Cognitive Demands for Science" to create experiences for students to engage in science content and demonstrate understanding of scientific concepts in ways that align with current research about how people learn.	
DESIGNING TECHNOLOGICAL/ ENGINEERING SOLUTIONS USING SCIENCE CONCEPTS	Requires students to solve science-based engineering or technological problems through application of scientific inquiry. Within given scientific constraints, propose or critique solutions, analyze and interpret technological and engineering problems, use science principles to anticipate effects of technological or engineering design, find solutions using science and engineering or technology, consider consequences and alternatives, and/or integrate and synthesize scientific information.
DEMONSTRATING SCIENCE KNOWLEDGE	Requires students to use scientific practices and develop the ability to think and act in ways associated with inquiry, including asking questions, planning and conducting investigations, using appropriate tools and techniques to gather and organize data, thinking critically and logically about relationships between evidence and explanations, constructing and analyzing alternative explanations, and communicating scientific arguments. (Slightly altered from National Science Education Standards)
INTERPRETING AND COMMUNICATING SCIENCE CONCEPTS	Requires students to use subject-specific conceptual knowledge to interpret and explain events, phenomena, concepts and experiences using grade-appropriate scientific terminology, technological knowledge and mathematical knowledge. Communicate with clarity, focus and organization using rich, investigative scenarios, real-world data and valid scientific information.
RECALLING ACCURATE SCIENCE	Requires students to provide accurate statements about scientifically valid facts, concepts and relationships. Recall only requires students to provide a rote response, declarative knowledge or perform routine mathematical tasks. This cognitive demand refers to students' knowledge of science fact, information, concepts, tools, procedures (being able to describe how) and basic principles.

Sports Science Academy

Academy Description

The Sports Science Academy (SSA) provides hands-on opportunities for students to gain exposure to careers in sports and health-related fields. Coursework will include anatomy and physiology as it pertains to sports and fitness, evaluating performance through data collection and analysis, and how performance in physical activities can be maximized. Students will have access to technologies similar to those used in research and rehabilitation settings, opportunities to learn from individuals in sports and health-related fields, and author research projects that illustrate their understanding of the concepts learned in the academy.

Courses Included

- IB Sports, Exercise and Health Science (SL)
- Advanced Research in Science
- Statistical Analysis in Science

The content standards addressed in this academy will be learned in partnership with the state of Ohio's focus on the Nature of Science, Science and Engineering Practices, and the Cognitive Demands for Science.

Nature of Science	
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IB Sports, Exercise and Health Science (SL)

Course Description

IB Sports, Exercise and Health science (SEHS) is primarily concerned with the scientific study of human physiology, biomechanics and psychology. Scientists working in these fields attempt to make sense of human physical and mental health and performance through a variety of approaches and techniques, controlled experimentation, and collaboration with other researchers. Students examine scientific knowledge claims in a real-world context, fostering interest and curiosity. By exploring the subject, they develop understandings, skills and techniques which can be applied across their studies and beyond. The course is organized under three main themes: exercise physiology and nutrition of the human body; biomechanics; sports psychology and motor learning. These themes are distinct, but also share many overlapping features; studying the similarities and connections between them is a central component of the course.

EXERCISE PHYSIOLOGY AND NUTRITION OF THE HUMAN BODY	
Content Statement	**Content Elaboration**
The nervous system senses both internal and external conditions to coordinate the responses of the body's physiological systems effectively.	• Components of the nervous system (central, peripheral, efferent, autonomic, sympathetic and parasympathetic) and their functions should be known.
The endocrine system, made up of the body's glands and hormones, regulates all biological processes in the body.	• The function of some hormones (epinephrine, norepinephrine, insulin, glucagon, ADH, progesterone, oestrogen, testosterone) should be known.
The cardiovascular system transports nutrients, hormones, gases, heat and waste to perform necessary bodily functions.	• Variations in heart rate, stroke volume, cardiac output, blood pressure and blood redistribution • Impact of age, sex, body size, fitness, type and intensity of activity
The respiratory system enables the exchange of gases between the external	• Variations in minute ventilation, tidal volume and respiration rate • Impact of age, sex, body size, fitness, type and intensity of activity

environment and the body, to facilitate cellular respiration.	
Water and electrolyte balance is necessary for effective functioning of the body and is influenced by the environment.	• Water and electrolyte intake via the large intestine • Loss via evaporation at skin, respiratory tract and excretion via osmosis • Imbalances occur through dehydration, hypernatremia and hyponatremia that affect health and performance • Water and electrolyte balance can be measured through body weight, urine color and osmolarity • Regulation of electrolyte balance by hypothalamus, pituitary gland and kidneys (nephron function and kidney structure are NOT assessed) • Circumstances that can cause cardiovascular drift
Macronutrients (carbohydrates, proteins and lipids) provide sources of energy to maintain bodily functions during growth, rest and physical activity.	• Macronutrient needs vary based on body composition, age, sex and activity level • Macronutrient availability and metabolization influences health and performance • Effect of nutritional strategies regarding macronutrients prior to and during exercise on gastrointestinal comfort and sporting performance, can be adopted to suit specific activities, age, sex and activity level • Low energy availability (LEA) is insufficient energy to support physiological functions needed for optimal health • Relative energy deficiency in sport (RED-S) is a consequence of LEA
The body relies on the phosphagen, glycolytic and oxidative systems for energy production to sustain life and physical activity.	• Energy systems have different fuel sources for ATP, recovery, benefits and limitations during activity • Energy continuum helps describe relative contribution of each system based on activity • Oxidative system is the dominant supplier of ATP at rest and during extended sub-max activity • Short high intensity periods and sudden increases in intensity rely on anaerobic systems for ATP production (no assessment of details of Kreb's and electron transport)
Maximal oxygen consumption (VO2 max) is influenced by an individual's age, sex differences, body composition, lifestyle factors and level of fitness.	• Effect on performance in endurance activities of VO_2 max and efficiency of movement (running economy)
Homeostasis is any self-regulating biological	• Reliance on negative feedback mechanisms for homeostasis

process aiming to produce a relatively stable, constant internal environment for optimal functioning of the body. In response to changing internal and external conditions, various mechanisms work constantly towards homeostasis.	• Maintenance of blood pH based on CO_2 concentration through respiratory control center and chemoreceptors • Intrinsic and extrinsic control of heart • Integration of cardiovascular, muscular, nervous and integumentary systems for thermoregulation at 37° C • Thermoregulation through sweating, vasodilation/constriction, shivering and nonshivering thermogenesis • Effects on thermoregulation of training, body composition, environment and sex (including hormones) • Regulation of blood glucose through insulin/glucagon, effects of exercise
An active lifestyle supports physical well-being.	• Benefits of physical activity • Variations with age/sex • Effects on muscular and immune function • Impact on risk of hypokinetic diseases
The quality of training design and programme design are essential elements in developing a safe and effective programme for improving health or performance.	• Characteristics of program design - specificity, progressive overload, recovery, variety, reversibility and periodization (macrocycle, mesocycle, microcycle) • Adaptive responses are based on types of training (anaerobic and aerobic) and individual differences

GENERATING MOVEMENT IN THE BODY	
Content Statement	**Content Elaboration**
The human skeleton is divided into an axial component and an appendicular component. These have different primary functions.	• Using positional terminology
Movements occur in one or more planes, and rotations occur along one or more axes.	• Use of specific terms to describe anatomical planes and joint movements
The structure of connective tissues and joints are related to their function in enabling	• Structure of joints (various connective tissues) • Types of joints

movement.	• Classes of synovial joints
The body uses different types of muscular contractions to create movement and stability.	• Organization of muscle tissue and motor units (all-or-none principle) • Muscle fiber types and recruitment • Use of ATP in contraction • Hypotrophy/hypertrophy • Types of contractions • Reciprocal inhibition
Three different classes of levers, both within and outside the human body, work to create movements.	• Organization of each class of lever • Mechanical advantage/disadvantage • Use of levers inside the body to project outside objects or as implements • Levers outside the body can enhance functionality of movement or enhance performance

FORCES, MOTION AND MOVEMENT	
Content Statement	**Content Elaboration**

Linear and angular motion can be analyzed using Newton's laws of motion.	• Describe motion using speed, velocity, acceleration
	• Motion results from the sum of forces on an object
	• Principles related to Newton's Laws - Stability
	  ○ Summing joint forces
	  ○ Linear motion, impulse and momentum
	  ○ Impulse direction
	  ○ Angular motion as eccentric force related to center of mass
	  ○ Conservation of angular momentum
	  ○ Use of equations for speed, linear velocity, angular velocity, acceleration, linear momentum, force and weight

The path of a projectile through air is determined by different factors and forces.	• Impact of launch velocity and angle • Impact on desired flight path launch height • Influence on flight of weight • Air resistance ratio
A phases-of-movement approach is used to	• Phases are preparatory, force-production and critical-instant

break down and describe movements.	• Follow through included for discrete skills • Recovery for continuous skills • Movement analysis can identify areas for improvement related to health, safety and performance ○ including but not limited to rehabilitation and accessibility

INJURY	
Content Statement	**Content Elaboration**
The complex interaction of internal and external risk factors can predispose and make an individual susceptible to injury.	• Internal factors - age, sex, pregnancy, effects of training, congenital factors, previous injuries. • External factors - personal protective equipment
An acute trauma is caused by a sudden or excessive application of force, or by a force from an unexpected direction. A cumulative trauma is caused by the repeated application of force.	• Trauma can lead to injuries of connective tissue, muscle, bone, skin and the brain.
Methods of lowering the risk of injury attempt to minimize the abnormal application of forces and maximize the ability of the body to absorb any such application of force.	• Protective equipment, proper warm-up, training, prehabilitation, learning correct techniques
The initial stages of injury treatment often involve mitigation of inflammation.	• Therapeutic modalities are used to promote healing. • Methods to treat inflammation (RICE, NSAIDs) • Serious injuries sometimes require surgery
Treatment of concussion varies based on the specifics of the injury. The pace of recovery is not always linear.	• A return to normal daily activities, learning or sport is generally a staged process involving increasing levels of cognitive and physical demand.

INDIVIDUAL DIFFERENCES AND MOTOR LEARNING	
Content Statement	**Content Elaboration**
Personality refers to individual differences in characteristic patterns of thinking, feeling and behaving. Personality is typically understood to be an interaction between genetic traits and the environment.	• Traits are considered stable. • Personality traits can be assessed using the "big five": openness, conscientiousness, extraversion, agreeableness, neuroticism
Mental toughness is an aspect of personality that partly explains how individuals manage challenging and pressurized situations.	• Mental toughness encompasses appraisal of challenges, commitment, confidence, perceived control and resilience. • Mental toughness is a malleable personality trait.
Learning, including motor learning, is a relatively permanent change in behavior brought about by experience, whereas performance is a temporary occurrence, fluctuating over time.	• Characteristics of the information processing model and ecological dynamics theory. • Motor learning theory includes non-linear pedagogy and traditional linear pedagogy.
The psychological refractory period is the time in which response to a second stimulus is significantly slowed because a first stimulus is still being processed.	• Application of the PRP in relation to sports ("false" moves).
Transfer of learning refers to the influence of previous experience performing a skill on the learning of a new skill.	• Skill to skill, practice to performance, abilities to skills, bilateral, stage to stage and principles to skills
The proficient execution of specific skills requires the correct attentional focus.	• Attention, concentration, distractions, and attentional narrowing

MOTIVATION, STRESS AND COPING	
Content Statement	**Content Elaboration**
Need achievement theory c that personality and situational factors interact to produce resultant factors, which create emotional factors, which drive behavioral factors.	• Other individuals can change situational factors to encourage individuals to approach achievement situations.
Goal orientation theory assumes that individuals strive to feel successful.	• The perception of success (task-oriented and ego-oriented)
Self-determination theory hypothesizes that humans strive to satisfy needs of autonomy, competence and relatedness.	
Motivation can be placed along a continuum from a motivation to controlled motivation to autonomous motivation.	• Amotivation, controlled motivation, autonomous motivation and intrinsic motivation.
Motivational climate describes the psychological environment that the coach creates by designing sessions that provide instructions and feedback, which will help to motivate the athletes in training or competition.	• Mastery and ego motivational climates • TARGET approach to foster mastery motivational climate
Arousal refers to the level of physical and psychological activation. This impacts on sport performance in the way that individuals attempt to manage their levels of intensity.	• Drive theory and inverted U theory
When anxiety is low, individuals experience positive emotions, such as excitement, desire and elation. High levels of anxiety induce	• Catastrophe theory and methods to measure anxiety.

negative emotions such as fear, worry and despondency.	
A stressor causes psychological strain. This can be positive, such as looking forward to an opportunity, or negative, such as fearing an outcome.	• Methods to cope include problem focused, emotion focused, avoidance focus, self-talk and relaxation.
Goal setting directs attention to a specific task. It is regularly used to enhance motivation in sport, exercise and health.	• Types of goals (outcome, learning-focused, performance, process) and factors that impact achievement.

Advanced Research in Science

Course Description:
This course will facilitate advanced learning of the philosophy of science, research methods, science writing and reporting, statistical analysis of results, lab and/or fieldwork methods, and ethical concerns. This is an individual research course in which students will develop and complete an experimental research project.

ADVANCED RESEARCH TOPICS	
Content Statement	**Content Elaboration**
Select sufficient and relevant sources of information.	• The reliability of the source must be considered.
Formulate research questions and hypotheses.	• The research question must be specific to identify relevant variables and systems being investigated. • Null and alternative hypothesis.
State and explain predictions using scientific understanding.	• Background knowledge of scientific principles and their relation to hypotheses.
Demonstrate creativity in the designing, implementation and presentation of the investigation.	• Research questions demonstrate personal interests or relevance.
Develop investigations that involve hands-on laboratory experiments, databases, simulations and modelling.	• Research can be performed using a variety of methods.
Identify and justify the choice of dependent, independent and control variables.	
Justify the range and quantity of measurements.	• Reasoning for the selection of the range of the independent variable should be provided.

Design and explain a valid methodology.	• Developed methods should clearly demonstrate validity, reliability, specificity and accuracy. • Developed methods should be clearly written to allow for procedures to be repeated and verified by others. • All relevant variables that could impact the results are controlled.
Appreciate when and how to reduce bias in study design.	• Blind and double-blind studies • Placebo effec • Randomization of groups and selection of test subjects
Appreciate when and how to reduce the confounding effects of human factors on physiological performance.	• Various factors (age, sex, menstrual cycle, nutrition, motivation, etc.) can impact the results of human studies.
Appreciate when and how to calibrate measuring apparatus.	• Calibrating measuring devices increases the accuracy of the data.
Identify and record relevant qualitative observations.	• Qualitative data, although not analyzed using statistical methods, can provide important information related to the measurements.
Collect and record sufficient relevant quantitative data.	• Large sample sizes help strengthen the confidence that what is being measured is a true representation of the population.
Identify and address issues that arise during data collection.	• Both internal and external factors can influence measurements. • Many factors are confounding, while others can be controlled by performing experiments within lab settings.
Compare the outcomes of an investigation to the accepted scientific context.	• Relate outcomes to previously cited research that was also used to provide context for the investigation. • Agreement or disagreement with accepted scientific context, should be identified and explained.
Relate the outcomes of an investigation to the stated research question or hypothesis.	• The research question and the resulting hypotheses are the driving force for any investigation. • Collected data should address the question, and scientific principles should be applied to the data to explain the results of the investigation.

Discuss the impact of uncertainties on the conclusions.	• Uncertainties lead to variation within the measurements, impacting both the precision and accuracy of the data. • Decreasing uncertainties increases the reliability of the data.

Identify and discuss sources and impacts of random and systematic errors.	• Random errors are usually based upon the precision of the measuring device.
	  ○ For instance, hand timing has a random uncertainty of ± 0.2 seconds.
	  ○ Using a laser-timing system can increase the precision and reliability of the measurement.
	• Systematic errors are usually procedural issues with data collection or controlling variables.
	  ○ These can be corrected to increase the precision and accuracy of the measurements.

Evaluate the implications of methodological weaknesses, limitations and assumptions on conclusions.	• Identification of the major weaknesses, limitations and assumptions of the method that likely had an impact on the results of the investigation, and discussion of their impacts on the results.
Explain realistic and relevant improvements to an investigation.	• These should be explained from the perspective of a scientist who may seek to retry the investigation, and should suggest revisions to the method that would strengthen the investigation in light of the weaknesses, limitations and assumptions that were identified throughout the process.

Statistical Analysis in Science

Course Description:
This course introduces students to the major concepts and tools for collecting, analyzing, and drawing conclusions from data. Students are exposed to concepts of experimental design and bias, and the use of spreadsheets for collecting, organizing and analyzing data. The course will also present a number of different statistical and analytical tools, such as descriptive statistics, correlations, hypothesis testing and probability.

STATISTICAL ANALYSIS	
Content Statement	**Content Elaboration**
Applying technology to process data	• Using spreadsheets to organize and manipulate data • Represent data in graphical forms • Generate models and equations • Analyze images and videos
Applying general mathematics	• Use basic arithmetic and algebraic calculations to solve problems • Carry out calculations involving decimals, fractions, percentages, ratios and reciprocals • Calculate central tendencies • Apply measures of dispersion: range, st. dev., coeff. of var., st. error and interquartile range • Use and interpret scientific notation • Use approximation and estimation • Appreciate when some effects can be ignored and why this is useful • Compare and quote values to the nearest order of magnitude • Understand direct and inverse proportionality, as well as positive and negative correlations • Calculate and interpret percent: change, difference, error and uncertainty • Distinguish between continuous and discrete variables

Using units, symbols and numerical values	• Use SI units and prefixes • Use appropriate significant figures/decimal places
Processing uncertainties	• Understand the significance of uncertainties in raw and processed data • Record measurement uncertainties as a range (+/-) to an appropriate level of precision
Statistical Analysis of Data	• Apply coefficient of determination (R^2) to evaluate fit of trend lines/curves • Interpret correlation coefficient values (r) and identify correlations as positive/negative and compare to critical values • Apply and interpret appropriate tests of significance and understand p=0.05; apply the T-test
Graphing	• Sketch and label graphs to qualitatively describe trends • Construct and interpret tables, charts and graphs (bar, pie, histograms, scatter plots, lines and curves) • Plot linear and non-linear graphs to show relationships between variables (label appropriately) • Draw lines of best fit • Interpret graph features (gradients, intercepts, max/min, area) • Draw and interpret the following as uncertainty bars: range, degrees of precision, standard error, standard deviation; extrapolate and interpolate graphs