High School Robotics Curriculum Essentials Document

Boulder Valley School District
Department of CTEC
March 2012
Introduction

During this class students will explore the field of robotic design using a variety of hands on activities. Students begin the semester with an introduction to the tools used to create robotic devices. Students work in teams to create simple drive trains capable of movement through tele-operated interaction. Programming is an essential and vital element. Students program the onboard micro-processor using the C programming language. CAD application is introduced as a tool used for mechanical design. Students then move onto autonomous navigation where the robot is controlled entirely through programming. Mechanical concepts such as gearing/torque/speed/power are introduced. These topics are explored through the use of hands on labs. Students must use this knowledge to design and build custom drive trains capable of meeting a variety of criteria including climbing, pushing, attaining maximum speed, etc. Sensors are introduced to allow robotic devices to interact with the environment. Actuator design is discussed and different manipulator designs are introduced.

The final three weeks of class will be comprised of a capstone design project.
## Robotics Overview

### Course Description
Students will develop skills in mechanical design (CAD), and construction as they work in teams to build simple and complex robotic devices. We will explore usage of robotics in modern business and industry and examine how robotic devices are affecting our lives and shaping our culture. Students will apply concepts learned in physical science and physics classes to mechanical devices.

### Topics at a Glance
- Speed, Power, Torque and DC Motors.
- Gears, Chains and Sprockets
- Friction and Traction
- Drive Train Design
- Object manipulation and rotating joints
- Control Systems and teleoperated operations
- Autonomous programming
- Competition preparation
- Introduction of FIRST Robotics Team

### Assessments
- Quizzes
- Projects
- Student Reflections
- Competitions
Prepared Graduates

The preschool through twelfth-grade concepts and skills that all students who complete the Colorado education system must master to ensure their success in a postsecondary and workforce setting.

1. CTE Essential Skills: Academic Foundations

ESSK.01: Achieve additional academic knowledge and skills required to pursue the full range of career and postsecondary education opportunities within a career cluster.

Prepared Graduate Competencies in the CTE Essential Skills standard:

- Complete required training, education, and certification to prepare for employment in a particular career field
- Demonstrate language arts, mathematics, and scientific knowledge and skills required to pursue the full range of post-secondary and career opportunities

2. CTE Essential Skills: Communications Standards

ESSK.02: Use oral and written communication skills in creating, expressing, and interrupting information and ideas, including technical terminology and information

Prepared Graduate Competencies in the CTE Essential Skills standard:

- Select and employ appropriate reading and communication strategies to learn and use technical concepts and vocabulary in practice
- Demonstrate use of concepts, strategies, and systems for obtaining and conveying ideas and information to enhance communication in the workplace

3. CTE Essential Skills: Problem Solving and Critical Thinking

ESSK.03: Solve problems using critical thinking skills (analyze, synthesize, and evaluate) independently and in teams using creativity and innovation.
Prepared Graduate Competencies in the CTE Essential Skills standard:

- Employ critical thinking skills independently and in teams to solve problems and make decisions
- Employ critical thinking and interpersonal skills to resolve conflicts with staff and/or customers
- Conduct technical research to gather information necessary for decision-making

4. CTE Essential Skills: Safety, Health, and Environmental

ESSK.06: Understand the importance of health, safety, and environmental management systems in organizations and their importance to organizational performance and regulatory compliance

Prepared Graduate Competencies in the CTE Essential Skills standard:

- Implement personal and jobsite safety rules and regulations to maintain safe and helpful working conditions and environment
- Complete work tasks in accordance with employee rights and responsibilities and employers obligations to maintain workplace safety and health

5. CTE Essential Skills: Leadership and Teamwork

ESSK.07: Use leadership and teamwork skills in collaborating with others to accomplish organizational goals and objectives

Prepared Graduate Competencies in the CTE Essential Skills standard:

- Employ leadership skills to accomplish organizational skills and objectives
6. CTE Essential Skills: Employability and Career Development

ESSK.09: Know and understand the importance of employability skills; explore, plan, and effectively manage careers; know and understand the importance of entrepreneurship skills

Prepared Graduate Competencies in the CTE Essential Skills standard:

- Identify and demonstrate positive work behaviors and personal qualities needed to be employable
- Develop skills related to seeking and applying for employment to find and obtain a desired job
COLORADO COMMUNITY COLLEGE SYSTEM CAREER & TECHNICAL EDUCATION TECHNICAL STANDARDS REVISION & ACADEMIC ALIGNMENT PROCESS

Colorado’s 21st Century Career & Technical Education Programs have evolved beyond the historic perception of vocational education. They are Colorado’s best kept secret for:

• Relevant & rigorous learning
• Raising achievement among all students
• Strengthening Colorado’s workforce & economy

Colorado Career & Technical Education serves more than 116,000 Colorado secondary students annually through 1,200 programs in 160 school districts, 270 High Schools, 8 Technical Centers, 16 Community Colleges & 3 Technical Colleges. One of every three Colorado high school students gains valuable experiences by their enrollment in these programs.

ALIGNMENT REQUIRED BY SB 08-212

22-7-1005. Preschool through elementary and secondary education - aligned standards - adoption - revisions.

2(b): In developing the preschool through elementary and secondary education standards, the State Board shall also take into account any Career & Technical Education standards adopted by the State Board for Community Colleges and Occupational Education, created in Section 23-60-104, C.R.S., and, to the extent practicable, shall align the appropriate portions of the preschool through elementary and secondary education standards with the Career and Technical standards.

STANDARDS REVIEW AND ALIGNMENT PROCESS

Beginning in the fall of 2008, the Colorado Community College System conducted an intensive standards review and alignment process that involved:

NATIONAL BENCHMARK REVIEW

Colorado Career & Technical Education recently adopted the Career Cluster and Pathway Model endorsed by the United State Department of Education, Division of Adult and Technical Education. This model provided access to a national set of business and industry validated knowledge and skill statements for 16 of the 17 cluster areas. California and Ohio provided the comparative standards for the Energy cluster

• Based on this review Colorado CTE has moved from program-specific to Cluster & Pathway based standards and outcomes
• In addition, we arrived at fewer, higher, clearer and more transferrable standards, expectations and outcomes.

COLORADO CONTENT TEAMS REVIEW

The review, benchmarking and adjusting of the Colorado Cluster and Pathway standards, expectations and outcomes was through the dedicated work of Content Teams comprised of secondary and postsecondary faculty from across the state. Participation by instructors from each level ensured competency alignment between secondary and postsecondary programs. These individuals also proposed the draft academic
alignments for math, science reading, writing and communication, social studies (including Personal Financial Literacy) and post secondary and workforce readiness (PWR.)
ACADEMIC ALIGNMENT REVIEW

In order to validate the alignment of the academic standards to the Career & Technical Education standards, subject matter experts in math, science, reading, writing and communication, and social studies were partnered with career & technical educators to determine if and when a true alignment existed.

CURRENT STATUS

• One set of aligned Essential skills to drive Postsecondary and Workforce Readiness inclusion in all Career & Technical Education programs.

• 52 pathways with validated academic alignments

• 12 pathways with revised standards ready for alignment (currently there are no approved programs in these pathways)

• 21 pathways where no secondary programming currently exists. Standards and alignments will be developed as programs emerge.

• Available for review at: www.coloradostateplan.com/content_standards.htm
The Career & Technical Education standards have been organized by Career Cluster (17) and Pathway (81). In addition, a set of “Essential Skills” was developed to ensure the Postsecondary and Workforce Readiness within any cluster or pathway. These workforce readiness skills are applicable to all career clusters and should form the basis of each CTE program.

**Organization**

**Essential Skills**
There exists a common set of knowledge and skills that are applicable to all students regardless of which cluster or pathway they choose. This set of standards, is meant for inclusion in each program to enhance the development of postsecondary and workforce readiness skills.

**Career Cluster**
A Career Cluster is a grouping of occupations and broad industries based on commonalities. The 17 Career Clusters organize academic and occupational knowledge and skills into a coherent course sequence and identify pathways from secondary schools to two- and four-year colleges, graduate schools, and the workplace. Students learn in school about what they can do in the future. This connection to future goals motivates students to work harder and enroll in more rigorous courses.

**Career Pathway**
Pathways are sub-groupings of occupations/career specialties used as an organizing tool for curriculum design and instruction. Occupations/career specialties are grouped into Pathways based on the fact that they require a set of common knowledge and skills for career success.

**Prepared Completer Competency**
This level targets the “big ideas” in each pathway. These are the competencies that all students who complete a CTE pathway must master to ensure their success in a postsecondary and workforce setting. Prepared Completer Competencies will not usually be “course” specific but grow with the student’s progression through the sequence of courses.

**Concept/Skill**
The articulation of the concepts and skills that indicates a student is making progress toward being a prepared completer. They answer the question: *What do students need to know and be able to do?*

**Evidence Outcome**
The indication that a student is meeting an expectation at the mastery level. *How do we know that a student can do it?*
Academic Alignments

Academic alignments, where appropriate in Math, Reading, Writing and Communication, Science and Social Studies (including Personal Financial Literacy) were defined by CTE and academic subject matter experts using the following criteria:

- It was a point where technical and academic content naturally collided;
- The student must demonstrate adequate proficiency with the academic standard to perform the technical skill; and
- It could be assessed for both academic and technical understanding.

Colorado’s CTE programs have had academic alignments dating back to the early 1990’s. While these alignments resulted in an increase in academic focus in CTE programs, the reality is that a true transformation in intentional teaching toward the academic standard was limited.

With these alignments comes a new expectation: If a CTE instructor is teaching a CTE concept that has an identified alignment, they must also be intentional about their instruction of the academic standard. CCCS will be providing professional development and instructional resources to assist with the successful implementation of this new expectation. In addition, this expanded expectation will require increased collaboration between CTE and academic instructors to transform teaching and learning throughout each school.

For each set of Cluster and Pathway standards, the academic alignments have been included and are separated by academic area. CCCS chose to align at the “Evidence Outcome” level. The aligned academic evidence outcome follows the CTE evidence outcome to which it has been aligned. For a sample, see Illustration A.
AGBS.01 The student will describe agribusinesses, the relationship of agribusiness to the industry of agriculture and will identify opportunities in the agribusiness systems pathway  
AGBS.01.a The student will understand the history and global significance of agribusinesses  
AGBS.01.a.b Define the major trends and relationship of agribusiness to global agriculture production  
MAa2 GR.HS.S.1 GLE.1 EO.a Reason quantitatively and use units to solve problems (CCSS. N-Q)

The academic standard number used in the alignments matches the Colorado Department of Education standards numbering convention.
## Career Pathway Abbreviations

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Robotic

STCO.05 Develop and demonstrate an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.

STCO.05.01 Understand and apply tools, materials and processes of technology.

STCO.05.01.a Recognize the multidisciplinary approach in solving technological problems.

STCO.05.01.b Gather, analyze and interpret data on the quantity of energy in a system or object using appropriate measurements, equations and graphs.

STCO.05.01.c Develop an understanding of counting techniques to solve problems in real world contexts.

STCO.05.02 Implement trouble shooting techniques in problem solving.

STCO.05.02.a Gather knowledge to correct issues relevant to use and preventative maintenance. (the noisy belt, leaking window, screws to repair human joints, Hubble telescope).

STCO.05.02.b Analyze and interpret prior knowledge of tools, materials and processes to create a plan of action.

STCO.05.02.c Gather, analyze and interpret data and graphs regarding position, velocity and acceleration of moving objects.

STCO.05.02.d Develop new ideas to solve and eliminate recurring issues.

STCO.07 Understand and demonstrate engineering design by applying the design process and assessing the impact of systems.

STCO.07.01 Understand and apply tools, materials and processes of technology.

STCO.07.01.a Use tools to evaluate and select materials and processes for the design cycle.
STCO.07.02 Use engineering principles.

STCO.07.02.a Understand that modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.

STCO.07.02.b Explain that it involves the knowledge of the mathematical and natural sciences that are gained by study, experience and practice.

STCO.07.03 Understand the engineer’s role in the design process.

STCO.07.03.a Understand the engineering profession has developed well tested sets of rules and design principles that provide a systematic approach as well as an ability to quantify the design process in order to improve efficiency.

STCO.07.03.b Demonstrate the ability to collaborate and work effectively with others.

STCO.07.03.c Use teamwork and leadership skills effectively.

STCO.07.04 Understand the impact of systems.

STCO.07.04.a Evaluate final solutions and communicate observation, processes, and results of the entire design process, using verbal, graphic, quantitative, virtual, and written means, in addition to three-dimensional models.

STCO.08 Apply tools, materials and processes to manipulate and connect our designed world through the technology areas.

STCO.08.03 Understand and demonstrate the knowledge and skills required in Power and Energy.

STCO.08.03.b Understand that power systems must have a source of energy, a process and loads.

CONP.01 TECHNICAL SKILLS: Use the technical knowledge and skills required to pursue the targeted Architecture & Construction careers for all pathways in the career cluster, including knowledge of design, operation, and maintenance of technological systems critical to the career cluster.

CONP.01.02 Use and maintain appropriate tools, machinery, equipment, and resources to accomplish project goals.

CONP.01.02.a Select tools, machinery, equipment, and resources that match requirements of the job.

CONP.01.02.b Identify sources of information concerning state of the art tools, equipment, materials, technologies and methodologies.

CONP.01.02.c Demonstrate use of tools, machinery, equipment and other resources commonly used in design and construction.

CONP.01.03 Understand purpose for scheduling as it relates to successful completion of the project.
CONP.01.03.a  Develop a schedule for a specific project.
Glossary of Terms

A:

**Actuator:** something that moves. i.e. Robotic hand, motor

**Android:** Humanlike robot.

**AI:** Artificial intelligence. Attempting to emulate intelligence in living beings.

**A/D:** Analog to digital. Converts voltage to discrete value.

**Ampere:** Measurement of current.

**Anode:** The “+” end of a diode/LED, etc. See cathode.

**Base:** Middle pin (usually) of a transistor. Controls emitter to collector current. See emitter and collector

**Battery:** Converts chemical energy to electrical energy on demand.

**Binary:** A number system using 0 and 1s.

**Breadboard:** Board used for prototyping. Allows for quick plugging in of components.

**C:**

**C:** De facto programming standard for many microcontrollers.

**Capacitor:** Component which stores electrical energy. Measured in farads.

**Cathode:** The “-” end of a diode/LED, etc. See anode.

**Compiler:** Program that converts a computer program into bytecode, or code that the computer can understand.

**Conductor:** Anything that allows the passage of electrons.

**D:**
DC: Direct current. Non fluctuating voltage.

Diode: Allows current to flow in one direction.

E:

EEPROM: Electronically Erasable Programmable Read Only Memory.

EPROM: Electronic Programmable Read Only Memory.

Emitter: Transistor pin that has an arrow on circuit diagrams.

F:

Freeform: Technique used in building circuits. All components are soldered to each other, without the use of a board.

G:

Gear: Wheel with teeth. Used to drive other gears, and create a geardown.

Geardown: Converting high speed, low torque into high torque, low speed.

Gyroscope: Device used to determine how rapidly the robot is rotating or how fast it has rotated, relative to a fixed coordinated system. (Mobile Robots)

I:

IC: Integrated Circuit

I/O: Input Out. Can either receive or send information.

L:

Locomotion: movement.

Logarithmic amplifier: Amplifier in which the output is logarithmic to the input. i.e. 1 in 1 out. 10 in 1000 out.

M:

Microcontroller: Subclass of a microprocessor. Basically just a small computer without a monitor or keyboard, that is specially designed to control circuits, robot, etc.

O:

Ounce-inch: Common measurement for torque in servos and small
motors.

**P:**

**PC:** Personal Computer

**Photodiodes:** Diodes that are specially made to detect light. See sensors.

**Photoresistor:** Resistor which changes its resistance based on the amount of light striking the light sensitive surface. See sensors.

**Potentiometer:** Or Pot. Two variable resistors in one package. Composed of a resistor (i.e. 10k) and a wiper. When one side of the wiper's resistance goes up, the other side goes down.

**Proximity Detector:** Sensors which produces a digital (on/off) based on an obstacles distance from it.

**Pulse-width Modulation:** Means by which a digital processor (on/off) produces an analog varying voltage. Processor produces very fast on/off pulses. The average voltage from this is based on the pulse times.

**R:**

**Radian:** Measurement of angle. 2 PI radians in a circle. To convert radians to degrees, replace PI with 180. To convert degrees to radians: degrees / 180 * PI.

**RAM:** Random Access Memory.

**ROM:** Read Only Memory.

**Relay:** Switch which activates then power is applied over its terminals.

**Resistor:** Components which limits current flow. Measured in ohms.

**S:**

**Semiconductor:** Device which neither fully conducts, nor fully resists.

**Servo:** Non 360° rotating gear motor, which is positioned using a pulse stream. Commonly used for RC applications.

**Shaft encoder:** See Photointerrupter, Photoreflector, Sensors.

**Solenoid:** Device which either pulls, pushes, or turns a metal rod based on electromagnetic forces.

**Sonar:** Device which measures distance based on reflected sound waves.
T:

**Torque**: “Angular force that a motor can deliver at a certain distance from the shaft.” ([Mobile Robots](#))

V:


W:

**Wall following**: Technique used to solve mazes. Either left hand or right hand. Follow wall always on that side.

**Watt**: Measurement of power. Power is the rate you use energy. Power = voltage * current.