California Department of Education Content Standards and Corresponding Common Core State Standards* as they apply to Amateur Radio

McBride High School ARRL Grant

Devon Day, KF6KEE is a National Boards Certified Teacher in Language Arts and has a Master's Degree in English. She identified Content Standards as they apply to Amateur Radio from the Language Arts. John Jacobson (call sign pending) is a math/physics teacher and co-advisor for the McBride High School AREC (Amateur Radio Emergency Communications) team. He identified the California Content Standards as they apply to Amateur Radio from Math and Physics. Michael J. Fox, W6MJF assisted in examples for both math and physics.

McBride High School is a brand new school in LBUSD. Students attending McBride were drawn by the three academic and career curriculums in Medicine, Engineering, and Civil Service/Forensics.

Math Common Core

Mathematical Connections for McBride High School's AREC Team

The Common Core Mathematics Curriculum is comprised of content standards for each high school course and a set of Standards for Mathematical Practice that reflect desired mathematical approaches, attitudes and habits of thinking. Over the course of four years at McBride, students will achieve the content standards for Geometry (currently all members of the club are in Accelerated Geometry), Intermediate Algebra, Pre-Calculus, and Calculus. The work of the McBride AREC club will reinforce, through application of mathematics in the context of amateur radio and emergency communications, five of the 8 Mathematical Practices.

CCSS.Math.Practice.MP1: Make sense of problems and persevere in solving them. **Whether one is trying to make sense of garbled communicate through noise, time-zone scheduling considerations, frequency or demodulation uncertainties, the persistent need for problem-solving skills abound in Amateur Radio.**

CCSS.Math.Practice.MP2 Reason abstractly and quantitatively
The use (and discovery) of reciprocal relationships in the quantitative formulas used by amateurs to model the relationship of frequency to wavelength of radio waves, capacity to inductance in electrical circuits, voltage to current, to resistance in DC circuits, etc., provide students an understanding of the quantitative laws that embody those abstractions.

As student progress from Technician Class to her Extra Class License, she will discover that more of the examination elements she'll need to pass those exams grow increasingly abstract and necessary to an understanding of the electro-magnetic properties of radio waves.

In preparing for their radio operators license, students will need to shift between abstract mathematically equations related to electric circuits and calculations that relate to specific scenarios. For example, a radio operator can mathematically calculate end to end a six meter, halfwave, wire dipole antenna by converting six meters over to megahertz. 300 divided by the frequency in megahertz to equal meters. 468 divided by 50 = 9.36 feet. Now, multiply 9.36 X 12 to convert the wire into inches. Answer is 112.3 However if you are trying to make the wire resonate on a higher frequency, you just jury rig the wire by twisting back a couple of inches of wire at each end and the dipole will work at a slightly higher frequency.

CCSS.Math.Practice.MP4 Model with mathematics. Every aspect of the radio arts from the simple arithmetic of Ohm's Law to the partial differential equations of Maxwell's Equations is a mathematical model of the physical relationships found in nature. Maps are 2-d geometric models of 3-d geographical data which can be used as tools for radio direction finding by means of simple geometric and trigonometric math-models to find the location of a small transmitter hidden on the schoolyard. And just locating cities, states, and countries of station operators contacted, on a map or globe, can provide valuable experience and understanding working with these models.

CCSS.Math.Practice.MP5 Use appropriate tools strategically. Amateur Radio provides an opportunity for students to use math tools appropriately and inappropriately. For example, discovering that resistors may sum in series, but give a different value when combined in parallel, is something a volt-ohmmeter can teach them, and which may be applied to many different and disparate measurements, leading to a few mathematical generalizations or laws, having a multitude of practical applications.

Amateur Radio can be used as a practical tool to help students understand the strategic use of the more abstract tools of mathematics. Whether a student adds or subtracts time-zones, multiplies or divides the speed of light by frequency to obtain wavelength, or uses the square or square-root of the span between radio stations to calculate how a signal's power diminishes with distance, matters.

Math teachers are always looking for word-problems to make math meaningful: Amateur Radio encourages understanding of real world-problems within a small and manageable paradigm.

CCSS.Math.Practice.MP6 Attend to precision. Precision is used in tuning a radio to a specific frequency, for making a pre-scheduled contact at a precise time. How precise, can mean the difference between success and failure. Are each communicator's tuners set to the

same numeric value? Are their clocks each coordinated with a common time-standard? How much precision is precise enough, and how much is overkill, is a matter of experience. Amateur Radio can be an excellent source of that experience.

Science Common Core

Students who demonstrate understanding can:

HS-PS4- **Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.** [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, **sound waves traveling through air and water**, and seismic waves traveling through the Earth.] [*Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.*] **For example, while Amateur Radio is normally concerned with the properties of radio frequency waves that travel at nearly the speed of light, the relationship of a waves frequency to its wavelength is identical to that which occurs in water and sound waves. While water wave tank experiments are often used to model sound and radio wave physics, it is just as reasonable to model the physical properties of all these waves based on the properties of radio wave propagation through the air, through copper wire, or through aluminium wire -- wherein the propagation speeds of radio waves**
are measurably different, and as result, differences easily measured by students. Such observed results can be compared mathematically more easily than they can be in water wave-tank experiments, which experiments are far less reproducible, and which do not easily allow students to measure the effects of reflection, refraction, speed, and amplitude of wave propagation in various media.

HS-PS4-2. **Evaluate questions about the advantages of using a digital transmission and storage of information.** [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

For example, Radio waves are often digitally modulated, and used to send graphics, text, sound, and GPS positioning information to other stations. These communications are easily reproduced, stored, and manipulated by other radios equipped with computers running appropriate demodulating software. Such amateur radios are analogous to wireless routers used to communicate from computer to computer (or server) through WiFi Technology. They are not subject to the power and frequency limitations of WiFi routers, and so can provide a useful adjunct to such technologies.

HS-PS4 **Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.** [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [*Assessment Boundary: Assessment does not include using quantum theory.*]

For example, just as with water waves, radio waves exhibit both wave-like and particle-like properties -- depending in part on the scale at which they are viewed. Defraction interference scattering and periodic patterning in radio wave propagation can be used to demonstrate this partical-vs-wave duality. Each paradigm can be useful depending on whether one is measuring charges or fields. Both aspects are necessary to understand the entire picture.

HS-PS4-4. **Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.** [Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [*Assessment Boundary: Assessment is limited to qualitative descriptions.*] **For example, students learn that charged particles in the ionsphere are affected by the time of day, sun spots, volcanic activity. They learn that these charged particles effect different wavelengths differently and affect all radio waves, not just ham radio. Predicting what can happen in any situation is as much art and science.**

HS-PS4-5. **Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*** [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [*Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.*] **For example, Communicating technical information via radio waves is the essence of Amateur Radio's basis and purpose. Radio waves are often reflected and refracted through interactions with different ionized layers of the Earth's Ionosphere to effect such communications as make distant contacts (called "DX") possible. Whether an incident radio wave is reflected, refracted, defracted, or absorbed by matter depends on the wavelength and charge-exchange characteristics of such interactions.**

Language Arts.

Part I: Interacting in Meaningful Ways

A. Collaborative

1. Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics. For example, Students gain practice through participating in radio nets, speaking on world-wide repeaters such as the WINsystem, and working towards FEMA certification using NIMS and receiving certification is ISO 100, 200, and 700, to become eligible for ARES participation upon reaching the age of 18.

- ***SI. 9-10.1, 6: L. 9-10,3 6**

2. Interacting with others in written English in various communicative forms. For example, when running emergency traffic, students are required by AREC team rules to transmit only messages approved by the school administration. Students are taught in their first year to never embellish emergency traffic and when in doubt to hand the radio over to an administrator and stand by. Students are also taught to copy emergency traffic including the source, the time, the frequency and keep logs of relevant information to be shared with the administration in a timely manner.

- *W. 9-10.6 WHST. 9-10.6, SL. 9-102; L. 9-10.3, 6

3. Offering and justifying opinions, negotiating with and persuading others in communicative exchanges. For example, when communicating on the air, a student might offer a radio check which requires him to determine the clarity of another radio operator's signal and report Readability, Strength and Tone (RST Report). Another example might be when one radio operator offers recommendations for equipment purchases or station equipment that could improve a station's efficiency. In preparing this grant, many expert radio operators were consulted and decisions were made as result of the expert's first-hand experience and ability to persuade the McBride High School advisors to choose one piece of equipment over another.

- *W.9-10.1 WJST 9-10.1; SL. 9-10.1, 4, 6; L. 9-10.3, 6

4. Adapting language choices to various contexts (based on task, purpose, audience, and text type. For example, amateur radio requires very polite communications. FCC rules actually prohibit profanity. Good operating procedures encourages brief, succinct language, FCC rules requires a radio operator identify their call sign every ten minutes and so a radio operator must monitor his communications to adjust to that requirement. Emergency communications is actually challenging because of the chance for a "pile up" when many operators are attempting to communicate on the same frequency at the same time. Breaking through a pile up requires some skill and patience and always, courtesy.

- *W.9-19. 4-5; WHST. 9-10.1; SL. 9-10 4.5; SL 9-10.6; L-9-10.1, 3, 6

B. Interpretive

5. Listening actively to spoken English in a range of social and academic contexts. For example in amateur radio, radio operators must listen before speaking to make sure they are not stepping on another radio operator's transmission. Radio operators practice good operation technique by taking notes about another radio operator's call sign, location, and the frequency they are speaking on. New radio operators begin by listening in order to learn the purpose and type of radio transmission they are picking up. Good operators would never speak during emergency transmissions. Good operators would rarely interrupt conversations that they have no reason to interrupt. In contrast, a student operator might ask to be included in a conversation between two or more amateur radio operators if the discussion had to do with a topic they were interested in or a radio net they wished to join.

- *SL. 9-10.1, 3, 6; L. 9-10. 1, 3, 6

6. Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language. For example, Amateur Radio has a unique language learned through radio instructional books, journals, and articles. Students study to pass their FCC exam by reading and understanding specific vocabulary and radio related concepts that effect propagation, safety, FCC rules and regulations, schematics, electrical principles, math for electronics, electronic principles, electrical components, semiconductors, component functions, station equipment, common transmitter and receiver problems, basic repair and testing, amateur satellite operations, non-voice communications, antennas, feed lines, AC power circuits, feed lines, RF hazards. In addition, amateur radio uses specific vocabulary to express big ideas quickly in a kind of abbreviated language short hand. Those who use Morse Code need to study text and video instructional materials in order to learn how to send and receive messages correctly.

- *RL. 9-10.1-7, 9-10; RI. 9-10.1-10; RH. 9-10.1-10; RST.9-10.1-10; SL. 9-10.2 L.9-10. 1, 3, 6

7. Evaluating how well writers and speakers use language to support ideas and arguments with details or evidence depending on modality, text type, purpose, audience, topic, and content area. Especially in the event of transmitting emergency traffic in the event of a disaster, experienced Emergency Communications Radio Operators need to provide details and accurate information to emergency agencies.

- *RL 9-10. 4-5; R1.9. 9-10. 4, 6 8; RH. 9-10. 4-6, 8; RST. 9-10. 4-6, 8; SL. 9-10.3; l. 9-10. 3, 5-6

7. Analyzing how writers and speakers use vocabulary and other language resources for specific purposes (to explain, persuade, entertain, etc.) depending on modality, text type, purpose, audience, topic and content area. In amateur radio, experienced radio operators understand the specific vocabulary used to convey information. A type of short hand including QTH (what is your location), QSL (can you acknowledge receipt or I am acknowledging receipt), CQ (any station), 73 (best regards), QST (General call preceding a message for all amateurs and ARRL members) are just a few of examples of specific language used in amateur radio. In addition, radio operators must conform to the operating procedures set out by the FCC when transmitting on amateur radio bands.

- *RL 9-10.4-5; RI. 9-10.4-5; RH. 9-10.4-5; RST. 9-10.4-5; SL. 9-10.3; L.9-10. 3, 5-6

C. Productive

9. Expressing information and ideas in formal oral presentations on academic topics. The McBride AREC team is already scheduled to speak on February 7th at the Long Beach Amateur Radio Club meeting for ARALB. The team will present a formal oral presentation about building their classroom radio station and mobile radio station along with Gordon West,

WB6NOA. In addition, the McBride AREC team will make a formal oral presention to the Long Beach Optimists in the winter of 2014 about the teams formation, classroom station, training, and the building of the team's mobile radio station.

- *W 9-10.1-10; WHST. 9-10.1-2,4-10; L.9-10 1-6

10. Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas. As mentioned in CA content standard 7, amateur radio has specific vocabulary, language and format to convey ideas clearly and specifically.

- *W 9-10.4-5; WHST.9-104.5; SL. 9-10. 4,6; L 9-10.1, 3, 5-6

Part II: Learning About How English Works

A Structuring Cohesive Texts

1. Understanding text structure. When taking the FCC Amateur Radio Exam, students are required to analyze both the question and the multiple choice answer for negatives, distracters, similar but different answers and logic. In effect, the FCC Technician's exam is a type of reading test that challenges reading, vocabulary, and critical thinking skills, and requires some pre-test instruction to assist students in understanding the structure of the test and how to prepare for a difficult exam that integrates science, physics, electronics, safety, FCC rules, operating procedure, and the history of radio.

- *W 9-10.4-5; WHST.9-10.4-5; SL. 9-10.4,6; L.9-10. 1,3,5-6

2. Understanding cohesion. Coherence in linguistics is what makes a text semantically meaningful. It is especially dealt with in text linguistics. In preparing students to take the FCC Technicians, and later General Amateur Radio exam, special care needs to be given to alert students to those critical linguistic clues including literary devices such as similes, antonyms, cause and effect, conjunctions and transitions which in some cases are used to clarify and in other cases are used as distracters. This kind of skill in language arts is necessary in developing good test taking skill and in writing.

- *W 9-10.5; RH.9-10.5; RST. 9-10.5; W.9-10.1-5, 10: WHST.9-10.1-2, 4-5, 10:.1,3,-6