Appendix A

Standards

Information in this appendix correlates The Science of Speed curriculum to national standards in science, mathematics, English, and technology. The purpose of this information is to help teachers identify specific content areas that are addressed by The Science of Speed. **Note:** Activities that address all or some aspects of a content standard are listed. Activities do not necessarily cover the entire standard. Not all standards are listed.

National Science Standards (5-8)

Source: *National Science Education Standards.* National Committee on Science Education Standards and Assessment. National Research Council, Washington, D.C.: National Academy Press, 1995, cf. http://www.nationalacademies.org/nrc/

National Science Standards (5-8)	The Science of Speed
Science Inquiry – Content Standard A	
Abilities necessary to do scientific inquiry	This standard is covered in all phases of the investigation.
Identify questions that can be answered through scientific investigations Students should develop the ability to refine and refocus broad and ill-defined questions. An important aspect of this ability consists of students' ability to clarify questions and inquiries and direct them toward objects and phenomena that can be described, explained, or predicted by scientific investigations. Students should develop the ability to identify their questions with scientific ideas, concepts, and quantitative relationships that guide investigation.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 9. Analyze Data Phase 10. Propose Technical Changes
Design and conduct a scientific investigation Students should develop general abilities, such as systematic observation, making accurate measurements, and identifying and controlling variables. They should also develop the ability to clarify their ideas that are influencing and guiding the inquiry, and to understand how those ideas compare with current scientific knowledge. Students can learn to formulate questions, design investigations, execute investigations, interpret data, use evidence to generate explanations, propose alternative explanations, and critique explanations and procedures.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 9. Analyze Data Phase 10. Propose Technical Changes

Use appropriate tools and techniques to gather, analyze, and interpret data The use of tools and techniques, including mathematics, will be guided by the question asked and the investigations students design. The use of computers for the collection, summary, and display of evidence is part of this standard. Students should be able to access, gather, store, retrieve, and organize data, using hardware and software designed for these purposes.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes
Develop descriptions, explanations, predictions, and models using evidence Students should base their explanation on what they observed, and as they develop cognitive skills, they should be able to differentiate explanation from description — providing causes for effects and establishing relationships based on evidence and logical argument. This standard requires a subject matter knowledge base so the students can effectively conduct investigations, because developing explanations establishes connections between the content of science and the contexts within which students develop new knowledge.	Phase 1. Preliminary Activities Phase 9. Analyze Data Phase 10. Propose Technical Changes
Think critically and logically to make the relationships between evidence and explanations Thinking critically about evidence includes deciding what evidence should be used and accounting for anomalous data. Specifically, students should be able to review data from a simple experiment, summarize the data, and form a logical argument about the cause-and-effect relationships in the experiment. Students should begin to state some explanations in terms of the relationship between two or more variables.	Phase 1. Preliminary Activities Phase 9. Analyze Data Phase 10. Propose Technical Changes
Recognize and analyze alternative explanations and predictions Students should develop the ability to listen to and respect the explanations proposed by other students. They should remain open to and acknowledge different ideas and explanations, be able to accept the skepticism of others, and consider alternative explanations.	Phase 1. Preliminary Activities Phase 9. Analyze Data Phase 10. Propose Technical Changes
Communicate scientific procedures and explanations With practice, students should become competent at communicating experimental methods, following instructions, describing observations, summarizing the results of other groups, and telling other students about investigations and explanations.	Phase 1. Preliminary Activities Phase 9. Analyze Data Phase 10. Propose Technical Changes
Use mathematics in all aspects of scientific inquiry Mathematics is essential to asking and answering questions about the natural world. Mathematics can be used to ask questions; to gather, organize, and present data; and to structure convincing explanations.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data

Understandings about scientific inquiry

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.

- Current scientific knowledge and understanding guide scientific investigations. Different scientific domains employ different methods, core theories, and standards to advance scientific knowledge and understanding.

- Mathematics is important in all aspects of scientific inquiry.

- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations.

- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.

- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.

- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.

Phase 1. Preliminary Activities
Phase 2. Design (graphics/layout)
Phase 3. Design Phase: Go/No Go
Phase 4. Car Construction
Phase 5. Collect Data
Phase 6. Trial Phase: Go/No Go
Phase 7. Trial Races
Phase 8. Collect Data
Phase 9. Analyze Data
Phase 10. Propose Technical Changes
Phase 11. Design Modifications and Detail
Phase 12. Race-Ready Phase: Go/No Go

Physical Science – Content Standard B

Motions and forces

- The motion of an object can be described by its position, direction of motion, and speed. That motion can be measured and represented on a graph.

- An object that is not being subjected to a force will continue to move at a constant speed and in a straight line.

- If more than one force acts on an object along a straight line, then the forces will reinforce or cancel one another, depending on their direction and magnitude. Unbalanced forces will cause changes in the speed or direction of an object's motion.

Phase 1. Preliminary Activities
Phase 8. Collect Data
Phase 9. Analyze Data
Phase 10. Propose Technical Changes
Phase 11. Design Modifications and Detail

Transfer of energy • Energy is a property of many substances and is associated with heat, light, electricity, mechanical motion, sound, nuclei, and the nature of a chemical. Energy is transferred in many ways. • In most chemical and nuclear reactions, energy is transferred into or out of a system. Heat, light, mechanical motion, or electricity might all be involved in such transfers.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

Science and Technology – Content Standard E

Design a solution or product Students should make and compare different proposals in the light of the criteria they have selected. They must consider constraints – such as cost, time, trade-offs, and materials needed – and communicate ideas with drawings and simple models.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail
Implement a proposed design Students should organize materials and other resources, plan their work, make good use of group collaboration where appropriate, choose suitable tools and techniques, and work with appropriate measurement methods to ensure adequate accuracy.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 7. Trial Races Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go
Evaluate completed technological designs or products Students should use criteria relevant to the original purpose or need, consider a variety of factors that might affect acceptability and suitability for intended users or beneficiaries, and develop measures of quality with respect to such criteria and factors; they should also suggest improvements and, for their own products, try proposed modifications.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go
Communicate the process of technological design Students should review and describe any completed piece of work and identify the stages of problem identification, solution design, implementation, and evaluation.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go

Understandings about science and technology

- Perfectly designed solutions do not exist. All technological solutions have trade-offs, such as safety, cost, efficiency, and appearance. Engineers often build in backup systems to provide safety. Risk is part of living in a highly technological world. Reducing risk often results in new technology.

- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.

Phase 2. Design (graphics/layout)
Phase 3. Design Phase: Go/No Go
Phase 4. Car Construction
Phase 5. Collect Data
Phase 6. Trial Phase: Go/No Go
Phase 7. Trial Races
Phase 8. Collect Data
Phase 9. Analyze Data
Phase 10. Propose Technical Changes
Phase 11. Design Modifications and Detail
Phase 12. Race-Ready Phase: Go/No Go
Phase 13. Design and Aesthetic Judging

History and Nature of Science – Content Standard G
Science as a Human Endeavor
Nature of Science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models. Although all scientific ideas are tentative and subject to change and improvement in principle, for most major ideas in science, there is much experimental and observational confirmation. Those ideas are not likely to change greatly in the future. Scientists do and have changed their ideas about nature when they encounter new experimental evidence that does not match their existing explanations.

- In areas where active research is being pursued and in which there is not a great deal of experimental or observational evidence and understanding, it is normal for scientists to differ with one another about the interpretation of the evidence or theory being considered. Different scientists might publish conflicting experimental results or might draw different conclusions from the same data. Ideally, scientists acknowledge such conflict and work towards finding evidence that will resolve their disagreement.

- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists. Evaluation includes reviewing the experimental procedures, examining the evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations. Although scientists may disagree about explanations of phenomena, about interpretations of data, or about the value of rival theories, they do agree that questioning, response to criticism, and open communication are integral to the process of science. As scientific knowledge evolves, major disagreements are eventually resolved through such interactions between scientists.

Phase 1. Preliminary Activities
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Phase 11. Design Modifications and Detail

National Mathematics Standards (6-8)

Source: *Principles and Standards for School Mathematics.* National Council of Teachers of Mathematics (NCTM), 2000; cf, http://www.nctm.org

National Mathematics Standards (6-8)	The Science of Speed
Algebra	
Understand patterns, relations, and functions • Represent, analyze, and generalize a variety of patterns with tables, graphs, words, and, when possible, symbolic rules. • Relate and compare different forms of representation for a relationship. • Identify functions as linear or nonlinear and contrast their properties from tables, graphs, or equations.	Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes
Use mathematical models to represent and understand quantitative relationships • Model and solve contextualized problems using various representations, such as graphs, tables, and equations.	Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes
Analyze change in various contexts • Use graphs to analyze the nature of changes in quantities in linear relationships.	Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes
Measurement	
Understand measurable attributes of objects and the units, systems, and processes of measurement • Understand both metric and customary systems of measurement. • Understand relationships among units and convert from one unit to another within the same system.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 7. Trial Races Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go Phase 13. Design and Aesthetic Judging Phase 14. A Day at the Races Phase 15. Collect Data – complete database

Apply appropriate techniques, tools, and formulas to determine measurements • Solve simple problems involving rates and derived measurements for such attributes as velocity and density.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 7. Trial Races Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go Phase 13. Design and Aesthetic Judging Phase 14. A Day at the Races Phase 15. Collect Data – complete database

Data Analysis & Probability

Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them • Formulate questions, design studies, and collect data about a characteristic shared by two populations or different characteristics within one population. • Select, create, and use appropriate graphical representations of data.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail
Select and use appropriate statistical methods to analyze data • Discuss and understand the correspondence between data sets and their graphical representations.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail
Develop and evaluate inferences and predictions that are based on data • Use observations about differences between two or more samples to make conjectures about the populations from which the samples were taken. • Make conjectures about possible relationships between two characteristics of a sample on the basis of scatter plots of the data and approximate lines of fit. • Use conjectures to formulate new questions and plan new studies to answer them.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

Problem Solving

• **Build new mathematical knowledge through problem solving** • **Solve problems that arise in mathematics and in other contexts** • **Apply and adapt a variety of appropriate strategies to solve problems** • **Monitor and reflect on the process of mathematical problem solving**	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

Reasoning and Proof

• **Recognize reasoning and proof as fundamental aspects of mathematics** • **Make and investigate mathematical conjectures** • **Develop and evaluate mathematical arguments and proofs** • **Select and use various types of reasoning and methods of proof**	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

Communication

• **Organize and consolidate mathematical thinking through communication** • **Communicate mathematical thinking coherently and clearly to peers, teachers, and others** • **Analyze and evaluate the mathematical thinking and strategies of others** • **Use the language of mathematics to express mathematical ideas precisely**	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

Connections

• **Recognize and use connections among mathematical ideas** • **Understand how mathematical ideas interconnect and build on one another to produce a coherent whole** • **Recognize and apply mathematics in contexts outside of mathematics**	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

Representation

• **Create and use representations to organize, record, and communicate mathematical ideas** • **Select, apply, and translate among mathematical representations to solve problems** • **Use representations to model and interpret physical, social, and mathematical phenomena**	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail

National English Standards

Source: *Standards for the English Language Arts.* The National Council of Teachers of English and the International Reading Association, 1996; http://www.ncte.org/standards/

National English Standards	The Science of Speed
Standard 4	
Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes
Standard 5	
Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes.	Phase 10. Propose Technical Changes
Standard 8	
Students use a variety of technological and information resources to gather and synthesize information and to create and communicate knowledge.	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes
Standard 12	
Students use spoken, written, and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion, and the exchange of information).	Phase 1. Preliminary Activities Phase 8. Collect Data Phase 9. Analyze Data Phase 10. Propose Technical Changes

National Technology Standards

Source: *Standards for Technological Literacy: Content for the Study of Technology.* Standards for Technological Literacy. The International Technology Education Association (ITEA), 2000; cf. http://www.iteawww.org

National Technology Standards	The Science of Speed
The Nature of Technology	
Standard 1: Students will develop an understanding of the characteristics and scope of technology.	This standard is covered in all phases of the investigation.
Design	
Standard 8: Students will develop an understanding of the attributes of design. • Design is a creative planning process that leads to useful products and systems. • There is no perfect design. • Requirements for a design are made up of criteria and constraints.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go
Standard 9: Students will develop an understanding of engineering design. • Design involves a set of steps, which can be performed in different sequences and repeated as needed. • Brainstorming is a group problem-solving process in which each person in the group presents his or her ideas in an open forum. • Modeling, testing, evaluating, and modifying are used to transform ideas into practical solutions.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go
Standard 10: Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving. • Troubleshooting is a problem-solving method used to identify the cause of a malfunction in a technological system. • Invention is a process of turning ideas and imagination into devices and systems. Innovation is the process of modifying an existing product or system to improve it. • Some technological problems are best solved through experimentation.	Phase 1. Preliminary Activities Phase 2. Design (graphics/layout) Phase 3. Design Phase: Go/No Go Phase 4. Car Construction Phase 5. Collect Data Phase 6. Trial Phase: Go/No Go Phase 9. Analyze Data Phase 10. Propose Technical Changes Phase 11. Design Modifications and Detail Phase 12. Race-Ready Phase: Go/No Go Phase 14. A Day at the Races

Abilities of a Technological World

Standard 11: Students will develop abilities to apply the design process.

- Apply a design process to solve problems in and beyond the laboratory/classroom.
- Specify criteria and constraints for the design.
- Make two-dimensional and three-dimensional representations of the designed solution.
- Test and evaluate the design in relation to preestablished requirements, such as criteria and constraints, and refine as needed.
- Make a product or system and document the solution.

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Phase 11. Design Modifications and Detail
Phase 12. Race-Ready Phase: Go/No Go
Phase 14. A Day at the Races

The Designed World

Standard 16: Students will develop an understanding of and be able to select and use energy and power technologies.

- Energy is the capacity to do work.
- Energy can be used to do work, using many processes.
- Power is the rate at which energy is converted from one form to another or transferred from one place to another, or the rate at which work is done.
- Power systems are used to drive and provide propulsion to other technological products or systems.

Phase 1. Preliminary Activities
Phase 9. Analyze Data
Phase 10. Propose Technical Changes
Phase 11. Design Modifications and Detail