Full Throttle STEM™ at Eldora Speedway

Implementation Guide

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1. CHALLENGE PROBLEMS: FULL THROTTLE STEM™ @ ELDORA SPEEDWAY

Modeling and Simulation professionals often utilize commercial off-the-shelf (COTS) games to provide a basis for the virtual environment training and simulation. Utilizing existing games reduces the economic investment required to provide a customized training environment and therefore moves the business or industry forward without a large investment in the development of the simulation. These challenge problems provide students with the opportunity to create virtual models similar to those used by industry professionals while using racing as the topic of interest.

The challenge problems simulate racing at Eldora Speedway, which is a half-mile dirt racing facility located in Western Ohio. The challenge problems may be implemented using another track if desired, but for the purpose of these materials, the track identified is Eldora Speedway. Also known as the "Big E," Eldora Speedway is the fastest dirt track in the nation and is owned by three-time NASCAR Sprint Cup Series champion Tony Stewart. Eldora hosts some of the largest dirt racing events in the country, including the Prelude To The Dream, The Dream, Kings Royal, and World 100 – each of which attracts more than 20,000 spectators annually. It is the second most popular track in the country – behind the Indianapolis Motor Speedway.

Figure 1: Eldora Speedway in Rossburg, Ohio

2. IMPLEMENTATION GUIDE AND INSTRUCTIONAL RESOURCES

This implementation guide provides an overview of the tools available. The Full Throttle STEM™ challenge problems are stand-alone problems, meaning students do not need to solve them in a particular order. Students developed the associated tutorials during summer internships at the GRILL™ along with students participating in Full Throttle STEM™ @ Eldora Speedway. Consistent with the philosophy of challenge problems, teachers should not give these resources and tutorials directly to students; this will help ensure students actively engage in the learning and problem-solving process. The resources and tutorials are a tool for teachers to help foster these processes and skills in students.

2.1. ENGINEERING LOGBOOKS

Students should use engineering logbooks as a personal reference about project learning and results. Logbooks help monitor and control where students have invested their time, knowledge learned, resources, and problem solving. Educators can also use logbooks as a resource for grades for educators.

Teachers should have the following general expectations for logbook entries:

- Date for each entry
- Log of personal activity, communications, and team activity
- Research and engineering analysis
- Review of individual/team performance
- Include everything contributed towards the solution
- Sketches
- Class notes
- Meeting notes
- Math calculations
- Design process
- Project reflections
- Rationale for decisions
- Decision criteria
- Design alternatives
- Project requirements
- Links to helpful resources

Note: Include everything contributed towards the solution; the good, the bad, and the ugly.

2.2. HARDWARE AND SOFTWARE

Each challenge problem requires some combination of hardware and/or software. Table 1 illustrates possible application of various tools to solve each of the problems. Do not use this list as the sole solution to the challenge problem, but as an example of a solution students may implement.

Table 1: Hardware and Software Tool Options for each Challenge Problem

Challenge Problem	Tools
1 – Eldora Speedway	Racing software, 3D modeling software, 3D graphics software
2– Virtual RC Car	Racing software, 3D modeling software, 3D graphics software
3 – Print 3D Replacement Parts	3D printer, 3D modeling software
4 – Integrated RC Controller	Racing software, remote controller, RC car
5 – Telemetric System	Arduino, Sensors
6 – The Big Challenge	RC car, remote controller, gaming software, sensors

Approximate costs and links to information regarding each of the potential tools are summarized in Table 2. We collected these estimates at the time we prepared this content. Accordingly, teachers implementing this content should verify the costs with the makers of each tool for planning purposes.

Table 2: Tools and Approximate Costs

Name	**Type of Tool**	**Link**	**Cost**
X-Motor Racing	COTS Racing Software	http://www.xmotorracing.com	$50-80
Rigs of Rods	COTS Racing Software	http://www.rigsofrods.com/content/	$0
Unity	Cross Platform Game Engine	http://www.unity3d.com	$0
SketchUp	3D Modeling	http://www.sketchup.com	$0
SolidWorks	3D Modeling	http://www.solidworks.com	$150

Name	Type of Tool	Link	Cost
Blender	3D Graphics Software	http://www.blender.org	$0
3ds Max	3D Graphics Software	http://www.autodesk.com/products/autodesk-3ds-max/overview	$0
Redcat Racing	RC Car	http://www.redcatracing.com	$150
Cube3D	3D printer	http://www.cubify.com	$1300
Ultimaker	3D Printer	http://www.ultimaker.com	$1560
Buccaneer	3D Printer	http://www.pirate3d.com	$400
Arduino	Microcontrollers	http://www.arduino.cc	$25
SparkFun	Electronics Distributor (sensors)	http://www.sparkfun.com/	Varies
Gimp	Image Manipulation	http://www.gimp.org	$0
Paint.Net	Image Manipulation	http://www.getpaint.net/	$0
Solder Iron	Hand tool for soldering	Various locations	$10
Solder	Electrical solder	Various locations	$10
JoyToKey	Control software with a joystick	http://www-en.jtksoft.net/	$0
USB Simulator Cable	Simulator Cable for R/C Remotes	http://dx.com/p/mystery-fs-sm101-usb-simulator-cable-for-r-c-remotes-13158	$6

2.3. RESOURCES TO GUIDE AND SCAFFOLD INSTRUCTION

Users and participants have used the resources listed in this section to help solve the Full Throttle STEM™ Challenge problems. These resources are neither exhaustive nor comprehensive and *should not be treated as complete tutorials*. Teachers should use these resources to help familiarize themselves with the relevant tools and to guide and scaffold instruction. Table 3 includes educational resources for M&S and Full Throttle STEM™. Table 4

includes resources focused on modeling and RC cars. Coding and programming resources are included in

Table 5 and X-Motor Racing resources are included in Table 6. Rigs of Rods and Unity resources are included in Table 7 and Table 8, respectively. Arduino resources are included in Table 9. Lastly, Table 10 provides information regarding other resources applicable to the Full Throttle STEM™ challenge problems.

Table 3: Educational Resources for M&S and Full Throttle STEM

Title	URL	Brief Description
Full Throttle STEM™ @ Eldora	http://www.youtube.com/watch?v=RDZVS523tYg	Senior Airman Richard Ware showcases Full Throttle STEM™ @ Eldora, highlighting how students from the area are having fun with STEM and solving challenge problems.
Design Thinking for Educators Toolkit	http://designthinkingforeducators.com	This toolkit has been adapted to meet the context of K-12 education. These processes, methods, and tools help tackle complex challenges
A Primer of Modeling and Simulation	http://www.corporatepress.com/clientfiles/ntsa/	Primer includes definitions, history, applications, value, and future of modeling and simulation

Table 4: Modeling and RC Car Resources

Title	URL	Brief Description
SketchUp Tutorials	http://www.sketchup.com/learn	Various self-paced tutorials in a variety of formats including reference cards, videos, and documents to guide users step-by-step on concepts of modeling
STL Plugin	http://helioslabs.blogspot.com/2013/02/sketchup-8-stl-files-for-3d-printing.html	Instructions for installing STL plugin to SketchUp for 3D printing
Redcat Racing	http://www.redcatracing.com	Resource for RC cars, parts, and tutorials Full Throttle StemTM@Eldora Day uses 1/10th scale, electric RC vehicles

Table 5: Coding Resources

Title	URL	Brief Description
Blue Pelican	http://www.bluepelicanjava.com	Free high school computer science textbook available for download or online use, complete with exercises and programming projects
Code Academy	http://www.codeacademy.com	Provides online tutorials for learning various languages including JavaScript, HTML, CSS, Ruby, Python, and APIs
Lynda Tutorials	http://www.lynda.com	Online video-training library with more than 1,400 software and training titles allowing anyone to learn software, design, and business skills, membership is required
Greenfoot	http://www.greenfoot.org/	Visual and interactive tool to teach object orientation with Java

Table 6: X-Motor Racing Resources

Title	URL	Brief Description
X-Motor Racing	http://www.xmotorracing.com/	XMR is an independent racing simulator that features high precision simulation, open architecture, and constant updates
Car Creation in X-Motor Racing	http://www.youtube.com/watch?v=7--kaeJVYog	A tutorial demonstrating how to create vehicles in XMR with only text directions
Car Creation in X-Motor Racing	http://www.youtube.com/watch?v=bTf-8lcQ1VI	A tutorial demonstrating how to create vehicles in XMR and apply physics
Track Creation in X-Motor Racing	http://www.youtube.com/watch?v=hxs2OP_HJuw	A tutorial demonstrating how to create tracks in XMR with only text directions
Track Creation in X-Motor Racing #2	http://www.youtube.com/watch?v=J_d8ngxluIU&feature=relmfu	The second video to a 2-part series on track creation
XMR Forums	http://www.xmotorracing.com/forum/index.php	Dynamic forum with tutorials, guides, additional cars and tracks, and tech support

Table 7: Rigs of Rods Resources

Title	URL	Brief Description

Rigs of Rods	http://www.rigsofrods.com/content/	Rigs of Rods is an open source vehicle simulator based on soft-body physics
Rigs of Rods Forum	http://www.rigsofrods.com/forum.php	Dynamic forum with general chat, development discussion, tools and techniques for content creation, and technical support

Table 8: Unity Resources

Title	URL	Brief Description
Get Started in Games & Simulations	http://www.youtube.com/watch?v=ry4ie_O4Bqc	An introduction to Unity including use in creating simulations and games, 2:25 is where introduction begins
Unity Tutorial Modules	http://unity3d.com/learn/tutorials/modules	Unity's modules on various topics and difficult level, users can sort through content to meet specific needs or complete modules step-by-step to create an example game
Unity Car Tutorial	https://www.assetstore.unity3d.com/#/content/10	An in-depth tutorial with graphics and coding to create racecar
Unity Reference Manual	http://docs.unity3d.com/Documentation/Components/index.html	Reference Manual for components for specific platforms including OSX, iOS, Windows, and Android
Arduinity	https://github.com/uclagamelab/Arduinity	Arduinity is a flexible, lightweight set of Unity scripts and Arduino code meant to allow Arduino and Unity to speak between applications
Basic Arduino to Unity Tutorial	http://www.youtube.com/watch?v=of_oLAvWfSI	Tutorial created to demonstrate sending input from an Arduino board to Unity3D
Distance Tool	http://the3dninja.com/blog/?p=1104	The distance tool provides the ability to measure objects in the scene and has the option to show a ratio between object scale in pixels and can help define proper texture resolution

Table 9: Arduino Resources

Title	URL	Brief Description
Arduino in a	http://hci.rwth-aachen.de/arduino	Introduction to Arduino, written for people

Nutshell		that have limited exposure to programming and new to electronics
An Introduction to the Arduino	http://www.youtube.com/watch?feature=player_embedded&v=CqrQmQqpHXc	An overview of what the Arduino is and its possibilities
Writing a Library for Arduino	http://arduino.cc/en/Hacking/LibraryTutorial	Explains how to create a library for Arduinio, which will allow other people to easily use the code and update it as it improves
Basic Arduino to Unity Tutorial	http://www.youtube.com/watch?v=of_oLAvWfSI	Tutorial created to demonstrate sending input from an Arduino board to Unity3D
RC Car Controlled by Wii Remote	http://www.circuitsathome.com/mcu/rc-car-controlled-by-wii-remote-on-arduino	Includes a video of an RC car controller made of a Wiimote and links to available code
Wiimote + Arudio + RC Car	http://www.youtube.com/watch?v=t7sakR81xjg	Shows how to use the Arduino with a Wii controller to drive a remote controlled car

Table 10: Other Resources

Title	URL	Brief Description
X-CTU Software	http://www.digi.com/support/productdetail?pid=3352&osvid=57&type=utilities	Software for setting up XBee Bluetooth communication devices with Arduino
Eye Toy Driver	http://www.mediafire.com/download/y25p6s6avk5cc2s/EyeToy_Driver_Namti_x64.zip	Driver to allow the webcam device and computer to communicate

APPENDIX: ONLINE MULTIPLAYER IN X-MOTOR RACING

This tutorial provides step-by-step directions to host and join an online race in X-Motor Racing. Directions to host a game over a LAN as well as the internet are included.

To host a race online:

1. In X-Motor Racing, select Multiplayer → List of Hosts → Run Your Server.
2. In the lower right corner of the screen above the Quit button, a program called XMR Dedi Server will open.
3. Rename the server. The IP Address and port number for the server should be filled in. This IP address will only work if the game is being played over a LAN. To host a game online,

replace the IP Address with the external IP, which can be identified on sites such as http://www.whatismyip.com/.

4. Adjust the settings. The Misc. tab provides multiple options to customize the game including the number of players allowed on the server. The maximum number is 32 and can be adjusted in the Max Clients box. The Tracks tab allows the host to select which tracks can be used in-game and the Cars tab allows the host to determine cars that users have access to on the server.
5. Click Create Server.

To join an online race in X-Motor Racing:

6. Select Multiplayer → Join Game.
7. Type in the IP address, port number, and password (if necessary) of the host of the match.
8. Click GO!, select a car, and select GO! again to begin the race.

Note: Make sure that each player has the same track and car file—otherwise players cannot race each other on the same track. To put the track file in the X-Motor folder, copy the track folder and paste into C:/Program Files/X-Motor Racing/Data/Tracks. Repeat this process for cars and use the destination folder C:/Program Files/X-Motor Racing/Data/Cars