

AndyMark Academy:

C-Base Drive Chassis Activity Pack

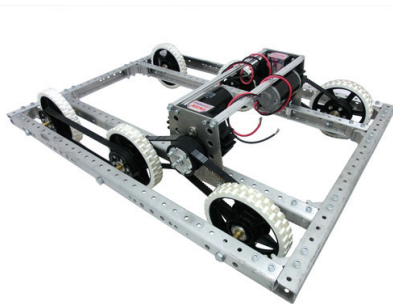
Unit Overview

UNIT CHALLENGE

Students will design, build, and test an operating robot drive base that meets specific Design Criteria:

- Select a drive chassis configuration that will work effectively in a given scenario. (See Suggested Scenarios for Unit Challenge)
- Understand a given scenario and identify tasks the robot will need to complete. (See Suggested Scenarios for Unit Challenge)
- Build a drive chassis that can carry a load of up to 100lbs.
- Determine how to attach appropriate structures to a drive chassis.
- Determine how to lock the wheels on a drive chassis so they do not turn.

Note: Locking the wheels of the drive chassis provides an opportunity to perform a friction pull test using a force gage. Calculations can then be completed to determine “mu” or coefficient of friction.



Kit of Parts

The AndyMark 2013 C-Base Drive Chassis Kit includes 6" HiGrip FIRST Wheels and a Toughbox Mini gearbox with flat mount plates. It is a 30" C-Base chassis that can be used as the foundation for a robot drive system, with a variety of applications.

Materials included in the kit of parts, as well as additional required materials are outlined at the beginning of each lesson. For a full list of the materials included in the kit of parts, consult the printed parts list in each kit or follow the link below:

files.andymark.com/am-2239C-Base2013AssemblyInstructions.pdf

Suggested Scenarios for Unit Challenge

Below is a list of possible scenarios that the teacher can assign to students. This will inform the Scenario Constraints of the completed robot and meet the Design Criteria listed in the Unit Challenge. This information is most applicable in *Lesson 1: Chassis* and *Lesson 4: Design Challenge*.

Note: The AndyMark C-Base Chassis Kit contains all necessary parts and directions for constructing a complete drive chassis. Additional parts will be needed if the teacher chooses to have students construct an appendage for the drive chassis after completing *Lesson 4: Design Challenge*.

- Design and build a drive chassis for a robot that can carry sensory, sound, or camera equipment for exploratory science. The drive chassis may need to fit into a small space, travel over particular types of terrain, or travel up or down inclined surfaces.
- Design and build a drive chassis for a robot that can transport goods or equipment for police or rescue services. The drive chassis may need to fit through narrow doorways, travel over different kinds of flooring, or maneuver around sharp corners.
- Design and build a drive chassis for a robot that can act as an assistive device for someone with reduced mobility or strength. The drive chassis may need to support weight that is well-distributed and the wheels may need to lock so that the robot can push or pull an object.
- Design and build a drive chassis for a robot that can hold and transport litter. The drive chassis may need to support weight that is well-distributed as the robot moves over uneven terrain on the side of a road or over grassy areas in a local park.
- Design and build a drive chassis for a robot that can support a pneumatic t-shirt cannon at a local sporting event. The drive chassis may need to be sturdy enough to withstand the “kick back” from firing the cannon and the wheels may need to lock to keep the robot from moving when it is fired.
- Create your own scenario to highlight the Design Criteria listed in the Unit Challenge.

LESSON SUMMARIES

LESSON 1: Chassis



Lesson Overview:

In this lesson, students will use aluminum C-channels to build the chassis, which is the foundation for the AndyMark C-Base Drive Chassis. The chassis kit can be built into a narrow (6-wheel) configuration or a wide (4-wheel) configuration. Students will work in teams to investigate both configurations and build the chassis that they feel best meets their team's needs.

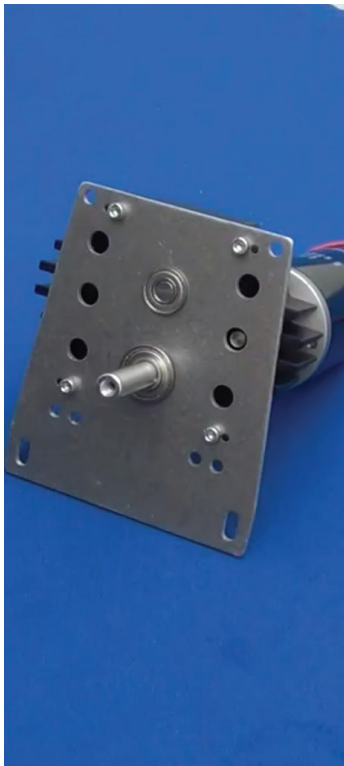
Objective:

Students will understand how a drive chassis supports and connects components in a robot. They will begin to appreciate how scenario constraints impact design decisions and consider how different variables, such as the width of a chassis or the number of wheels used, affect a drive system's performance.

Essential Questions:

- Why is it important to review Design Criteria and Scenario Constraints throughout the Engineering Design Process?
- How do engineers make design decisions?
- How can students ensure they are working safely when machining parts and building?

LESSON 2: Toughbox Mini



Lesson Overview:

In this lesson, students will start by building the Toughbox Mini gearbox. The gearbox will modify the torque and rotational speed that is output from the motor. Students will learn about gearing ratios and their effect on torque and rotational speed. They will also investigate the potential top speed of their robot and the design decisions that affect this. Also, using gear ratios, the Toughbox Mini allows speed and torque conversion from the CIM motor to the wheels.

Objective:

Students will understand how gearing is used to control the potential speed of a robot. They will begin to understand variables that affect potential speed and gain experience problem-solving possible solutions to better control the speed of their robot.

Essential Questions:

- How do gears function in a drive chassis?
- How does gearing affect the completed robot?
- How can the Toughbox Mini be assessed to determine if it meets the linear speed requirements of the Design Criteria?

LESSON 3: Wheel Assembly



Lesson Overview:

In this lesson, students will build the wheel assembly on the C-Base Drive Chassis. They will amend their top speed calculations from the previous lesson to account for the effect of the pulley system and add the remaining components from the kit. Students will complete an activity to identify different sources of inefficiency in the completed drive system.

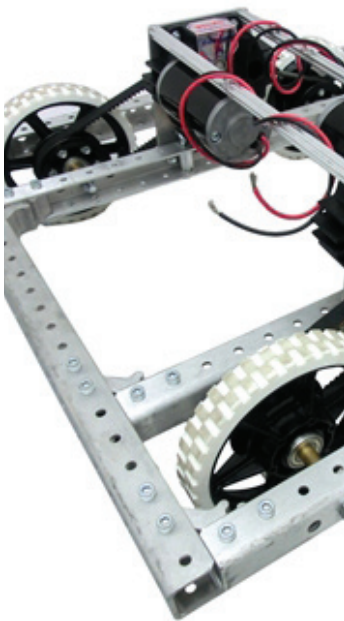
Objective:

Students will understand how different components and design choices, such as the use of ball-bearings or wheel size selection, affect the efficiency of a drive chassis in a situation where friction is a factor. They will also gain experience identifying and testing for inefficiencies in a drive chassis' performance.

Essential Questions:

- How does friction affect the performance of the drive chassis?
- How can inefficiencies in a system be tested?

LESSON 4: Design Challenge



Lesson Overview:

In this lesson, students will use the completed C-Base Drive Chassis as the basis for an appendage that they will design in order to complete a task laid out in the scenario given during Lesson 1: Chassis. They will work collaboratively to design this appendage and present their ideas to the rest of the class.

Objective:

Students will understand the design and prototyping stages of the Engineering Design Process. They will gain experience researching, defining, presenting, and evaluating their own ideas and the ideas of others.

Essential Questions:

- Why do engineers create prototypes?
- How do engineers generate a prototype?
- How is a prototype evaluated?
- Why is it important to share a prototype with other designers?

STUDENT ASSESSMENT AND EVALUATION

Pre-Tests:

Reproducible pre-tests have been provided for each lesson in this activity pack to assess students' prior knowledge and experience. These can be used as a diagnostic assessment for data collection purposes.

Lesson 1: Chassis
Assessment of Prior Knowledge

Answer the questions below to the best of your ability.

- What does a chassis do?
- What makes a chassis a chassis?
- What are the main parts of a chassis?
- What are the main parts of a chassis?
- What are the main parts of a chassis?

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Engineering Journal:

Engineering Journals are used by engineers during project development. They can be used for documenting and tracking technical information, modeling designs, brainstorming ideas, recording milestones or schedules, and for allocating tasks to team members. The Engineering Journal is an important part of the designing and building process, as it helps to skillfully manage projects and enhance problem-solving skills.

Engineering Journal entries can be used to assess and document student progress during lessons. Encourage students to start each Engineering Journal entry on a new page and include the subject, date, and time of the entry. Students should record all ideas; discourage them from erasing failed ideas. If an idea does not work, ask them to describe the reasons why it was not successful. Journals are often written in pen so that ideas cannot be erased.

Prompts and ideas for Engineering Journal entries have been provided throughout the lessons. Engineering Journals can be reviewed in sections for formative assessment throughout the planning, design, and building process. They can also be reviewed as a complete document to inform summative evaluation of student achievement and understanding.

Student Worksheets

Alternatively, for a more guided student experience, reproducible student worksheets have been provided for each lesson in this activity pack to assess and document student progress during lessons. These can be used as a formative assessment.

Lesson 1: Chassis
Student Worksheet

Answer the questions below to the best of your ability.

- What are the main parts of a chassis?
- What are the main parts of a chassis?
- What are the main parts of a chassis?
- What are the main parts of a chassis?
- What are the main parts of a chassis?

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Unit Test

A reproducible Unit Test has been provided for students to complete after they have participated in all four lessons. This can be used to inform summative evaluation of student achievement and understanding.

AndyMark Academy:
C-Base Drive Chassis Activity Pack
Unit Test

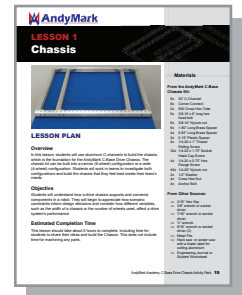
Answer the questions below to the best of your ability.

- What are the main parts of a chassis?
- What are the main parts of a chassis?
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Check List

A Student Checklist of accomplishments and skill development for each lesson has been provided for teachers when evaluating student progress at the end of the Unit.



Next Steps

Below are some suggestions that can be used after completing these four lessons that will allow students to continue to use AndyMark hardware to learn about technological and design principles:

Build Their Design

The principles of Engineering Design can be extended by having the students build the appendage they designed in *Lesson 4: Design Challenge*.

Test Their Design

After students have built an appendage and attached it to the drive chassis, they can continue the Engineering Design Process by conducting a test of the stability and traction of the robot. Attach a 100lb load to the appendage and drive chassis, and use a force gauge to test how much force it takes to move the robot when it is positioned on different surfaces.

Possible friction tests may include:

- Testing with wheels locked to assess the sliding friction of the wheels on a given surface, which is a good indication of traction
- Testing with wheels unlocked to assess the friction of the drive chassis components, such as the axles and gearbox

Discuss the impact that friction has on the design and mobility of the robot. Encourage students to consider how they could change their robot to ensure greater traction on a wider variety of surfaces.

RESOURCES

Below is a list of the resources used throughout the AndyMark Academy: C-Base Drive Chassis Activity Pack:

Resources From AndyMark	
LESSON 1: Chassis	
AndyMark 2013 C-Base (am-2239) Assembly Instructions	http://files.andymark.com/am-2239C-Base2013AssemblyInstructions.pdf
Video instruction for 2013 Drive System Assembly – Narrow	www.youtube.com/watch?v=JEkJiWdh5Ks&feature=youtu.be
Video instruction for 2013 Drive System Assembly – Wide	www.youtube.com/watch?v=YhYEcevf43E&feature=youtu.be
AndyMark Website for C-Base Chassis	www.andymark.com/product-p/am-2239.htm
AndyMark CAD files (.stp or .step) for any 3D modelling software. <i>*Files are located under the “Files & Documents” Tab</i>	www.andymark.com/product-p/am-2239.htm
LESSON 2: Toughbox Mini	
AndyMark Toughbox Mini (am-2236) Assembly Instructions	http://files.andymark.com/am-2236ToughboxMiniFlatAssemblyInstructions.pdf
Video instruction for Toughbox Mini Assembly	http://www.youtube.com/watch?v=uloJ0q3NDx0&feature=youtu.be
AndyMark’s Website for Toughbox Mini	http://www.andymark.com/product-p/am-2236.htm
AndyMark CAD files (.stp or .step) for any 3D modelling software. <i>*Files are located under the “Files & Documents” Tab</i>	www.andymark.com/product-p/am-2239.htm
LESSON 3: Wheel Assembly	
2013 AndyMark Drive System User Guide	http://files.andymark.com/2013DriveSystemUserGuide.pdf
Video instruction for 2013 Drive System Assembly – Narrow	http://www.youtube.com/watch?v=JEkJiWdh5Ks&feature=youtu.be
Video instruction for 2013 Drive System Assembly – Wide	http://www.youtube.com/watch?v=YhYEcevf43E&feature=youtu.be
AndyMark CAD files (.stp or .step) for any 3D modelling software. <i>*Files are located under the “Files & Documents” Tab</i>	www.andymark.com/product-p/am-2239.htm

Other Resources

LESSON 1: Chassis

New York Times' archive of robotics articles	http://topics.nytimes.com/top/reference/timestopics/subjects/r/robots/index.html
Gizmag's archive of robotics articles	http://www.gizmag.com/robotics/
HowStuffWorks' archive of robotics videos	http://science.howstuffworks.com/robot-videos-playlist.htm
United States Department of Labor Occupational Safety & Health Administration's Guide to Safe Hand and Power Tool Use	https://www.osha.gov/Publications/osha3080.html
FIRST Robotics Competition Safety Manual	http://www.usfirst.org/sites/default/files/uploadedFiles/Robotics_Programs/FRC/Game_and_Season_Info/2013/2013_FRC_Team_Safety_Manual_Final_rev_B.pdf

LESSON 2: Toughbox Mini

Online gear ratio calculator	http://www.grimmjeeper.com/gears.html
Simple step-by-step explanation of how to determine gear ratios	http://science.howstuffworks.com/transport/engines-equipment/gear-ratio.htm
United States Department of Labor Occupational Safety & Health Administration's Guide to Safe Hand and Power Tool Use	https://www.osha.gov/Publications/osha3080.html

LESSON 3: Wheel Assembly

A detailed explanation of the force and coefficient of friction	http://hyperphysics.phy-astr.gsu.edu/hbase/frict.html
An explanation of optimizing wheel size for a robot	http://cryogenius.wordpress.com/2011/01/16/optimizing-robot-wheel-diameter/

LESSON 4: Design Challenge

NASA's Engineering Design Challenge website	http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html
Engineering is Elementary's brief and simple description of the design process: Note: This resource is designed for younger learners and contains very basic information. It is a good resource for differentiation to support less confident students.	http://www.eie.org/content/engineering-design-process
Prezi's virtual whiteboard presentation tool website	http://www.prezi.com/

Other Resources

Glogster's online multimedia poster website:	http://edu.glogster.com/what-is-glogster-edu/#five
Wikispaces Classroom website	http://www.wikispaces.com/
Padlet's online multimedia poster website	http://padlet.com/

VOCABULARY

Below is a list of common vocabulary, including definitions, which may be helpful to teachers and students. These terms are commonly understood in the engineering world and have been used throughout the AndyMark Academy AndyMark C-Base Drive Chassis Activity Pack. Teachers may wish to introduce vocabulary as needed during lessons, or provide students with a list of vocabulary prior to each lesson for quick reference.

LESSON 1: Chassis

Appendage: a new structure or piece added on to the Drive Chassis that adds specific functionality

C-Channel: a metal piece that is used to create a chassis; a cross-section of the piece resembles the letter 'C'

Chassis: a rigid frame or a skeleton of a rolling, movable machine that supports all the parts of the machine

Configuration: an arrangement of elements in a particular form, figure, or combination

Drive Chassis: a chassis with a gear box, wheel assembly, and motors attached

Drive System: a drive chassis with an electronic control system attached

Hex Key: a tool of hexagonal shape, used to drive bolts and screws that have hexagonal socket in the head; also called an "Allen key"

Load capacity: the amount of weight a chassis can withstand without breaking or being damaged

Mobility: the ability to be mobile or move easily

Nylock Nut: a kind of nut that contains a nylon collar insert that allows the nut to lock around a screw

Robot: A machine that interacts with its environment to gather information, make a decision, and then carry out an action

Socket Head Cap Screw: a type of screw with a large, round head and a socket for driving with a hex key; sometimes abbreviated "SHCS"

LESSON 2: Toughbox Mini

Drive Gear: a gear that receives energy from a driving mechanism, such as a motor

Driven Gear: a gear that receives energy from the drive gear

Gearbox: a transmission device that translates the power of the motor into the rotating motion of the wheels

Gearing Ratio: the ratio between the angular speeds of the drive gear and the driven gear

Lubricant: a substance used to minimize friction between parts of a moving system; in this case, grease is used as a lubricant to reduce friction between the gears

Newton-meter: a unit of measure for torque; abbreviated N-m; one newton-meter is equal to the torque created by one newton of force acting at a perpendicular distance of one meter from a pivot point

RPM: revolutions per minute; a measure of rotational speed

System Efficiency: ratio of the output of the motor while driving a system to the output of the motor under ideal circumstances

Torque: a force that rotates an object about an axis

LESSON 3: Wheel Assembly

Ball Bearings: a ring-shaped track that consists of metal balls between two concentric tracks. The rotation of the inner circle causes the balls to roll and thus cause the outer circle to rotate. This technique is used to reduce friction.

Friction: the force that resists the slipping motion of an object on a surface

Inefficiency: suboptimal operation of a system due to various constraints

Pulley system: two or more pulley wheels connected by a belt that transfers rotational energy from the driving wheel to the driven wheel; the effect is similar to meshed gears

LESSON 4: Design Challenge

Appendage: a new structure or piece attached to the Drive Chassis that adds specific functionality

Engineering Design Process: the process by which a plan is formed and executed in the field of engineering; the process may vary, but generally includes steps to identify criteria and constraints, brainstorm solutions, select an approach, design through drawing or modelling, building a prototype, identifying areas for improvement, redesigning through drawing or modelling, and changing the prototype

Prototype: a preliminary model that demonstrates functionality of a design

Robot: A machine that interacts with its environment to gather information, make a decision, and then carry out an action

CURRICULUM GRID

The learning objectives listed below have been drawn from the *International Technology and Engineering Educators Association Standards for Technological Literacy, Grades 9-12* and the *US Common Core State Standards English Language Arts Standards for Science & Technical Subjects, Grades 11-12*.

Standards	Indicators	Lesson			
		Lesson 1: Chassis	Lesson 2: Toughbox Mini	Lesson 3: Wheel Assembly	Lesson 4: Design Challenge
ITEEA Standards for Technological Literacy (Grades 9-12) http://www.iteea.org/TAA/PDFs/xstnd.pdf					
1. Students will develop an understanding of the characteristics and scope of technology.	L. Invention and innovations are the result of specific, goal-directed research.				
2. Students will develop an understanding of the core concepts of technology.	AA. Requirements involve the identification of the criteria and constraints of a product or system and the determination of how they affect the final design and development.				
	EE. Management is the process of planning, organizing, and controlling work.				
8. Students will develop an understanding of the attributes of design.	H. The design process includes defining a problem, brainstorming, researching and generating ideas, identifying criteria and specifying constraints, exploring possibilities, selecting an approach, developing a design proposal, making a model or prototype, testing and evaluating the design using specifications, refining the design creating or making it, and communicating processes and results.				
	J. The design needs to be continually checked and critiqued, and the ideas of the design must be redefined and improved.				
	K. Requirements of a design, such as criteria, constraints, and efficiency, sometimes compete with each other.				
9. Students will develop an understanding of Engineering Design.	I. Established design principles are used to evaluate existing designs, to collect data, and to guide the design process.				
	L. The process of engineering design takes into account a number of factors.				

Standards	Indicators	Lesson			
		Lesson 1: Chassis	Lesson 2: Toughbox Mini	Lesson 3: Wheel Assembly	Lesson 4: Design Challenge
10. Students will develop an understanding of the role of troubleshooting, research and development, intervention, and innovation, and experimentation in problem solving.	L. Many technological problems require a multidisciplinary approach.				
11. Students will develop abilities to apply the design process.	M. Identify the design problem to solve and decide whether or not to address it.				
	N. Identify criteria and constraints and determine how these will affect the design process.				
	O. Refine a design solution using prototypes and modeling to ensure quality, efficiency, and productivity of the final product.				
	P. Evaluate the design solution using conceptual, physical, and mathematical models at various intervals of the design process in order to check for proper design and to note areas where improvements are needed.				
	Q. Develop and produce a product or system using a design process.				
	R. Evaluate final solutions and communicate observations, processes, and results of the entire design process, using verbal, graphical, quantitative, virtual, and written means, in addition to three-dimensional models.				
12. Students will develop the ability to use and maintain technological products and systems.	K. Document process and procedures and communicate them to different audiences using appropriate oral and written techniques.				

Standards	Indicators	Lesson			
		Lesson 1: Chassis	Lesson 2: Toughbox Mini	Lesson 3: Wheel Assembly	Lesson 4: Design Challenge
16. Students will develop an understanding of and be able to select and use energy and power technologies.	J. Energy cannot be created nor destroyed; however it can be converted from one form to another.				
USCCSS English Language Arts- Literacy Standards for Science and Technical Subjects (Grades 11-12) http://www.corestandards.org/ELA-Literacy/RST/11-12					
Reading: Science and Technical Subjects	11-12.3 Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.				
	11-12.4 Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 11–12 texts and topics.				
	11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.				
	11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.				