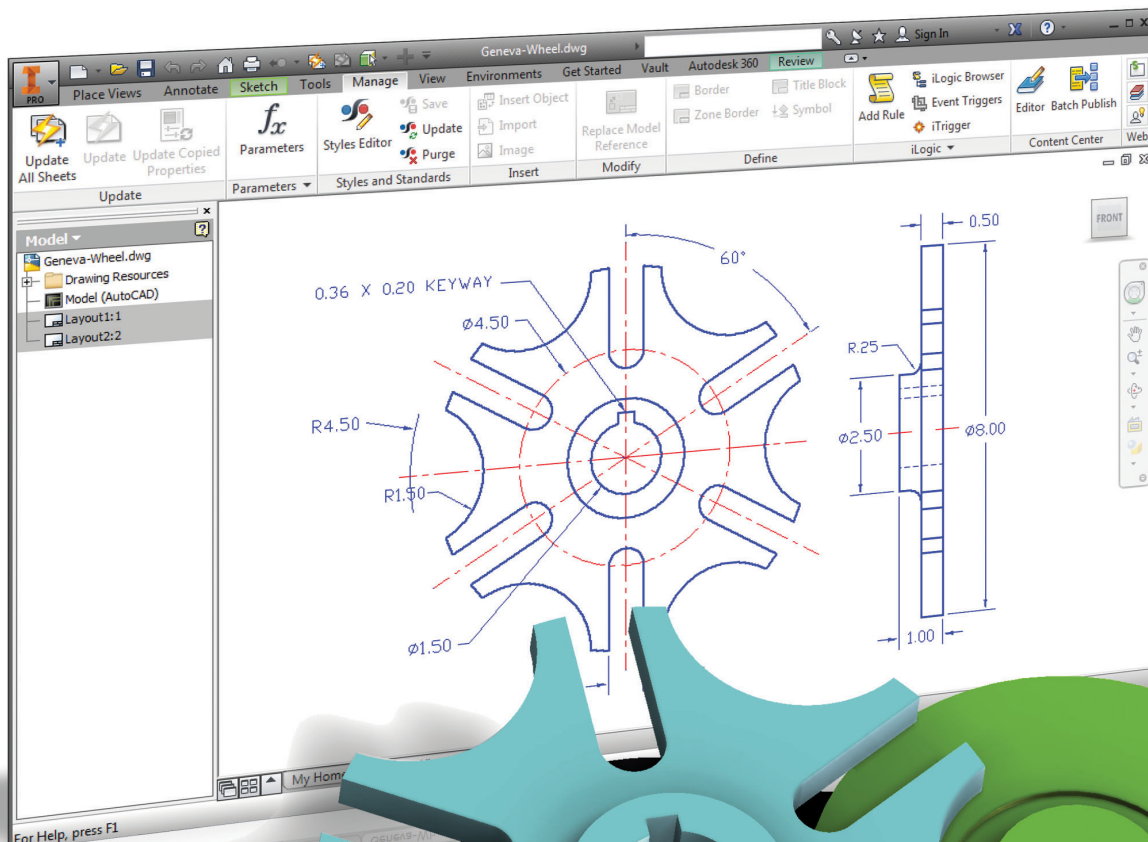


# Tools for Design Using AutoCAD® 2015 and Autodesk® Inventor® 2015

## Hand Sketching, 2D Drawing and 3D Modeling



Randy H. Shih

Visit the following websites to learn more about this book:



[amazon.com](https://www.amazon.com)

[Google books](https://books.google.com)

[BARNES & NOBLE](https://www.barnesandnoble.com)

# Table of Contents

<b>Preface</b>	i
<b>Acknowledgments</b>	ii
<b>Introduction</b>	
<b>Getting Started</b>	
Introduction	Intro-2
Development of Computer Aided Design	Intro-2
Why Use AutoCAD® 2015?	Intro-5
Why Use Autodesk® Inventor® 2015?	Intro-6
Tutorial Style Lessons	Intro-7
<b>Section I – AutoCAD®</b>	
<b>Chapter 1</b>	
<b>Fundamentals of AutoCAD®</b>	
Getting Started with AutoCAD® 2015	1-2
AutoCAD® 2015 Screen Layout	1-3
Application Menu	1-4
Quick Access Toolbar	1-4
AutoCAD Menu Bar	1-4
Layout Tabs	1-4
Drawing Area	1-5
Graphics Cursor or Crosshairs	1-5
Command Prompt Area	1-5
Cursor Coordinates	1-5
Status Toolbar	1-5
Ribbon Tabs and Panels	1-6
Draw and Modify Toolbar Panels	1-6
Layers Control Toolbar Panel	1-6
Viewport/View/Display Controls	1-6
Mouse Buttons	1-7
[Esc] – Canceling Commands	1-7
On-Line Help	1-8
Leaving AutoCAD® 2015	1-9
Creating a CAD File Folder	1-9
Drawing in AutoCAD	1-10
Starting Up AutoCAD® 2015	1-10
Drawing Units Setup	1-12
Drawing Area Setup	1-13

Drawing Lines with the <i>LINE</i> command	1-15
Visual Reference	1-17
GRID ON	1-18
SNAP MODE ON	1-19
Using the <i>ERASE</i> Command	1-20
Repeat the Last Command	1-21
The CAD Database and the User Coordinate System	1-22
Changing to the 2D UCS icon Display	1-23
Cartesian and Polar Coordinate Systems	1-24
Absolute and Relative Coordinates	1-24
Defining Positions	1-25
<i>GRID Style</i> Setup	1-25
The <i>GuidePlate</i>	1-26
Creating <i>Circles</i>	1-30
Saving the CAD Design	1-32
Close the Current Drawing	1-33
The <i>Spacer</i> Design	1-34
Start a New Drawing	1-34
Drawing Units Setup	1-35
Drawing Area Setup	1-36
Using the Line Command	1-38
Using the <i>ERASE</i> Command	1-40
Using the Arc Command	1-40
Using the Circle Command	1-42
Saving the CAD Design	1-43
Exit AutoCAD 2015	1-43
Review Questions	1-44
Exercises	1-45

## Chapter 2

### Basic Object Construction and Dynamic Input - AutoCAD®

Introduction	2-2
Starting Up AutoCAD® 2015	2-2
Dynamic Input	2-3
The RockerArm Design	2-6
Activate the Startup Option	2-7
Drawing Units Display Setup	2-8
<i>GRID</i> and <i>SNAP</i> Intervals Setup	2-9
Drawing Area Setup	2-10
Referencing the World Coordinate System	2-11
Creating <i>Circles</i>	2-12
<i>Object Snap</i> Toolbar	2-13
Using the <i>LINE</i> Command	2-14
Creating <i>TTR Circles</i>	2-16
Using the <i>TRIM</i> Command	2-18

Using the <i>Polygon</i> Command	2-20
Creating a Concentric <i>Circle</i>	2-22
Using the <i>QuickCal</i> Calculator to Measure Distance and Angle	2-23
Saving the CAD File	2-27
Exit AutoCAD	2-27
Review Questions	2-28
Exercises	2-29

### Chapter 3

## Geometric Construction and Editing Tools - AutoCAD®

Geometric Constructions	3-2
Starting Up AutoCAD® 2015	3-3
Geometric Construction - CAD Method	3-4
• Bisection of a Line or Arc	3-4
• Bisection of an Angle	3-7
• Transfer of an Angle	3-9
• Dividing a Given Line into a Number of Equal Parts	3-13
• Circle through Three Points	3-15
• Line Tangent to a Circle from a Given Point	3-16
• Circle of a Given Radius Tangent to Two Given Lines	3-17
The <i>Gasket</i> Design	3-20
Drawing Units Display Setup	3-21
<i>GRID</i> and <i>SNAP</i> Intervals Setup	3-22
Using the <i>LINE</i> Command with <i>ORTHO</i> Option	3-23
<i>Object Snap</i> Toolbar	3-25
Using the <i>EXTEND</i> Command	3-28
Using the <i>TRIM</i> Command	3-29
Creating a <i>TTR</i> Circle	3-30
Using the <i>FILLET</i> Command	3-31
Converting Objects into a <i>Polyline</i>	3-32
Using the <i>OFFSET</i> Command	3-33
Using the Area Inquiry Tool to Measure Area and Perimeter	3-34
Using the <i>EXPLODE</i> Command	3-36
Create another <i>FILLET</i>	3-36
Saving the CAD File	3-37
Exit AutoCAD	3-37
Review Questions	3-38
Exercises	3-39

## Chapter 4

### Orthographic Views in Multiview Drawings - AutoCAD®

Introduction	4-2
The <i>Locator</i> Design	4-2
The <i>Locator</i> part	4-3
Starting Up AutoCAD® 2015	4-3
<i>Layers</i> Setup	4-4
Drawing <i>Construction</i> Lines	4-5
Using the <i>OFFSET</i> Command	4-5
Set Layer <i>Object</i> as the Current Layer	4-7
Using the <i>Running Object Snaps</i>	4-7
Creating <i>Object Lines</i>	4-9
Turn <i>OFF</i> the Construction Lines Layer	4-10
Adding More Objects in the Front View	4-10
AutoCAD's AutoSnap™ and AutoTrack™ Features	4-11
Adding More Objects in the Top View	4-13
Drawing Using the <i>Miter Line Method</i>	4-17
More <i>Layers</i> Setup	4-19
Top View to Side View Projection	4-20
Completing the Front View	4-22
Object Information Using the List Command	4-24
Object Information Using the Properties Command	4-25
Review Questions	4-26
Exercises	4-27

## Chapter 5

### Basic Dimensioning and Notes - AutoCAD®

Introduction	5-2
The <i>Bracket</i> Design	5-2
Starting Up AutoCAD® 2015	5-3
<i>Layers</i> Setup	5-4
The P-Bracket Design	5-5
Drawing Construction Lines	5-6
Using the <i>OFFSET</i> Command	5-6
Set Layer <i>Object Lines</i> as the <i>Current Layer</i>	5-8
Creating Object Lines	5-8
Creating Hidden Lines	5-9
Creating Center Lines	5-10
Turn OFF the Construction Lines	5-10
Using the <i>FILLET</i> Command	5-11
Saving the Completed CAD Design	5-12
Accessing the Dimensioning Commands	5-13
The <i>Dimension Toolbar</i>	5-14
Using the <i>Dimension Style Manager</i>	5-14

Dimensions Nomenclature and Basics	5-15
Using the <i>Center Mark</i> Command	5-18
Adding <i>Linear</i> Dimensions	5-19
Adding an <i>Angular</i> Dimension	5-20
Adding <i>Radius</i> and <i>Diameter</i> Dimensions	5-21
Using the <i>Multiline Text</i> Command	5-22
Adding Special Characters	5-23
Saving the Design	5-24
A Special Note on Layers Containing Dimensions	5-24
Review Questions	5-25
Exercises	5-26

## **Chapter 6**

### **Pictorials and Sketching**

Engineering Drawings, Pictorials and Sketching	6-2
Isometric Sketching	6-7
Isometric Sketching Exercises	6-9
Oblique Sketching	6-19
Oblique Sketching Exercises	6-20
Perspective Sketching	6-26
One-point Perspective	6-27
Two-point Perspective	6-28
Perspective Sketching Exercises	6-29
Review Questions	6-35
Exercises	6-36

---

## **Section II – Autodesk® Inventor®**

### **Chapter 7**

#### **Parametric Modeling Fundamentals – Autodesk® Inventor®**

Getting Started with Autodesk® Inventor®	7-2
The Screen layout and Getting Started Toolbar	7-3
The New File Dialog Box and Units Setup	7-4
The Default Autodesk Inventor Screen Layout	7-5
Application Menu	7-6
Quick Access Toolbar	7-6
Ribbon Tabs and Tool Panels	7-6
Online Help Panel	7-6
Create Toolbar	7-7
Graphics Window	7-7
Message and Status Bar	7-7
Mouse Buttons	7-8

[Esc] – Canceling Commands	7-8
Autodesk Inventor Help System	7-9
Data Management Using Inventor Project Files	7-10
Setup of a New Inventor Project	7-11
The Content of the Inventor Project File	7-14
Leaving Autodesk Inventor	7-14
Feature-Based Parametric Modeling	7-15
The Adjuster Design	7-16
Starting Autodesk Inventor	7-16
The Default Autodesk Inventor Screen Layout	7-18
Sketch Plane – It is an XY monitor, but an XYZ World	7-19
Creating Rough Sketches	7-21
Step 1: Creating a Rough Sketch	7-22
Graphics Cursors	7-22
Geometric Constraint Symbols	7-23
Step 2: Apply/Modify Constraints and Dimensions	7-24
Dynamic Viewing Functions – <i>Zoom</i> and <i>Pan</i>	7-27
Modifying the Dimensions of the Sketch	7-27
Step 3: Completing the Base Solid Feature	7-28
Isometric View	7-29
Dynamic Rotation of the 3-D block – Free Orbit	7-30
Dynamic Viewing – Quick Keys	7-32
Viewing Tools – Standard Toolbar	7-33
Display Modes	7-37
Orthographic vs. Perspective	7-37
Disable the Heads-Up Display Option	7-38
Step 4-1: Adding an Extruded Feature	7-39
Step 4-2: Adding a Cut Feature	7-44
Step 4-3: Adding another Cut Feature	7-47
Save the Model	7-50
Review Questions	7-51
Exercises	7-52

## Chapter 8

### Constructive Solid Geometry Concepts – Autodesk® Inventor®

Introduction	8-2
Binary Tree	8-3
The Locator Design	8-4
Modeling Strategy – CSG Binary Tree	8-5
Starting Autodesk Inventor	8-6
Base Feature	8-7
GRID Intervals Setup	8-8
Model Dimensions Format	8-11
Modifying the Dimensions of the Sketch	8-11
Repositioning Dimensions	8-12



---

Using the Measure Tools	8-13
Completing the Base Solid Feature	8-16
Creating the Next Solid Feature	8-17
Creating a CUT Feature	8-21
Creating a PLACED FEATURE	8-24
Creating a Rectangular Cut Feature	8-26
Save the Model	8-28
Review Questions	8-29
Exercises	8-30

## **Chapter 9**

### **Model History Tree – Autodesk® Inventor®**

Introduction	9-2
The <i>Saddle Bracket</i> Design	9-3
Starting Autodesk Inventor	9-3
Modeling Strategy	9-4
The <i>Autodesk Inventor Browser</i>	9-5
Creating the Base Feature	9-5
Adding the Second Solid Feature	9-8
Creating a 2D Sketch	9-9
Renaming the Part Features	9-11
Adjusting the Width of the Base Feature	9-12
Adding a Placed Feature	9-13
Creating a Rectangular Cut Feature	9-15
History-Based Part Modifications	9-16
A Design Change	9-17
Assigning and Calculating the Associated Physical Properties	9-20
Review Questions	9-22
Exercises	9-23

## **Chapter 10**

### **Parametric Constraints Fundamentals - Autodesk® Inventor®**

CONSTRAINTS and RELATIONS	10-2
Create a Simple Triangular Plate Design	10-2
Fully Constrained Geometry	10-3
Starting Autodesk Inventor	10-3
Displaying Existing Constraints	10-4
Applying Geometric/Dimensional Constraints	10-6
Over-Constraining and Driven Dimensions	10-10
Deleting Existing Constraints	10-11
Using the Auto Dimension Command	10-12
Constraint and Sketch Settings	10-17
Parametric Relations	10-18

Dimensional Values and Dimensional Variables	10-20
Parametric Equations	10-21
Viewing the Established Parameters and Relations	10-23
Saving the Model File	10-24
Using the Measure Tools	10-25
Review Questions	10-29
Exercises	10-30

## **Chapter 11**

### **Geometric Construction Tools - Autodesk® Inventor®**

Introduction	11-2
The Gasket Design	11-2
Modeling Strategy	11-3
Starting Autodesk Inventor	11-4
Create a 2D Sketch	11-5
Edit the Sketch by Dragging the Sketched Entities	11-7
Add Additional Constraints	11-9
Use the <i>Trim</i> and <i>Extend</i> Commands	11-10
The <i>Auto Dimension</i> Command	11-12
Create Fillets and Completing the Sketch	11-14
Fully Constrained Geometry	11-15
Profile Sketch	11-17
Redefine the Sketch and the Profile	11-18
Create an OFFSET Cut Feature	11-22
Review Questions	11-25
Exercises	11-26

## **Chapter 12**

### **Parent/Child Relationships and the BORN Technique - Autodesk® Inventor®**

Introduction	12-2
The BORN Technique	12-2
The U-Bracket Design	12-3
Sketch Plane Settings	12-4
Apply the BORN Technique	12-5
Create the 2D Sketch for the Base Feature	12-7
Create the First Extrude Feature	12-10
The Implied Parent/Child Relationships	12-11
Create the Second Solid Feature	12-11
Create the First Cut feature	12-15
The Second Cut feature	12-16
Examine the Parent/Child Relationships	12-18

Modify a Parent Dimension	12-19
A Design Change	12-20
Feature Suppression	12-21
A Different Approach to the CENTER_DRILL Feature	12-22
Suppress the Rect_Cut Feature	12-24
Create a Circular_Cut Feature	12-25
A Flexible Design Approach	12-27
View and Edit Material Properties	12-28
Review Questions	12-30
Exercises	12-31

## **Chapter 13**

### **Part Drawings and 3D Annotations - Autodesk® Inventor®**

Drawings from Parts and Associative Functionality	13-2
Starting Autodesk Inventor	13-3
Drawing Mode – 2D Paper Space	13-3
Drawing Sheet Format	13-5
Using the Pre-defined Drawing Sheet Formats	13-7
Delete, Activate, and Edit Drawing Sheets	13-9
Add a Base View	13-10
Create Projected Views	13-11
Adjust the View Scale	13-12
Repositioning Views	13-13
Display Feature Dimensions	13-14
Repositioning and Hiding Feature Dimensions	13-16
Add Additional Dimensions – Reference Dimensions	13-18
Add Center Marks and Center Lines	13-19
Complete the Drawing Sheet	13-22
Associative Functionality – Modifying Feature Dimensions	13-23
3D Annotations in Isometric Views	13-26
Review Questions	13-34
Exercises	13-35

## **Chapter 14**

### **Symmetrical Features in Designs - Autodesk® Inventor®**

Introduction	14-2
A Revolved Design: PULLEY	14-2
Modeling Strategy – A Revolved Design	14-3
Starting Autodesk Inventor	14-4
Set Up the Display of the Sketch Plane	14-4
Creating the 2D Sketch for the Base Feature	14-5
Create the Revolved Feature	14-9

Mirroring Features	14-10
Create a Pattern Leader Using Construction Geometry	14-12
Circular Pattern	14-17
Examine the Design Parameters	14-19
Drawing Mode – Defining a New Border and Title Block	14-19
Create a Drawing Template	14-23
Create the Necessary Views	14-24
Retrieve Dimensions – Features Option	14-27
Associative Functionality – A Design Change	14-29
Add Centerlines to the Pattern Feature	14-31
Complete the Drawing	14-32
Review Questions	14-35
Exercises	14-36

---

## **AutoCAD® and Autodesk® Inventor®**

---

### **Chapter 15**

### **Design Reuse Using AutoCAD® and Autodesk® Inventor®**

Introduction	15-2
The Geneva Wheel Design	15-3
Internet Download of the Geneva-Wheel DWG File	15-3
Opening AutoCAD DWG File in Inventor	15-4
Use the Measuring Tools	15-5
Switch to the AutoCAD DWG Layout	15-7
2D Design Reuse	15-9
Complete the Imported Sketch	15-13
Create the First Solid Feature	15-15
Create a Mirrored Feature	15-16
Circular Pattern	15-17
Complete the Geneva Wheel Design	15-18
Export an Inventor 2D Sketch as an AutoCAD Drawing	15-22
Design Reuse – Sketch Insert Option	15-23
Review Questions	15-29
Exercises	15-30

---

## **Chapter 16**

# **Assembly Modeling - Putting It All Together - Autodesk® Inventor®**

Introduction	16-2
Assembly Modeling Methodology	16-3
The Shaft Support Assembly	16-4
Additional <i>Parts</i>	16-4
(1) Collar	16-4
(2) Bearing	16-5
(3) Base-Plate	16-5
(4) Cap-Screw	16-6
Starting Autodesk Inventor	16-7
Placing the First Component	16-8
Placing the Second Component	16-9
Degrees of Freedom and Constraints	16-10
Assembly Constraints	16-11
Apply the First Assembly Constraint	16-14
Apply a Second Mate Constraint	16-15
Constrained Move	16-16
Apply a Flush Constraint	16-17
Placing the Third Component	16-19
Applying an Insert Constraint	16-20
Assemble the Cap-Screws	16-21
Exploded View of the Assembly	16-22
Editing the Components	16-24
Adaptive Design Approach	16-25
Delete and Re-apply Assembly Constraints	16-29
Setup a Drawing of the Assembly Model	16-31
Creating a Parts List	16-33
Edit the Parts List	16-34
Change the Material Type	16-36
Add the Balloon Callouts	16-38
Completing the Title Block Using the iProperties Option	16-38
Bill of Materials	16-40
(a) BOM from Parts List	16-40
(b) BOM from Assembly Model	16-41
Review Questions	16-42
Exercises	16-43

## Chapter 17

### Design Analysis - Autodesk® Inventor® Stress Analysis Module

Introduction	17-2
Problem Statement	17-4
Preliminary Analysis	17-4
• Maximum Displacement	17-5
Finite Element Analysis Procedure	17-6
Create the <i>Autodesk Inventor</i> Part	17-7
Creating the 2D Sketch for the Plate	17-7
Assigning the Material Properties	17-10
Switch to the <i>Stress Analysis</i> Module	17-11
Create an FEA Simulation	17-12
Apply Constraints and Loads	17-14
Create a Mesh and Run the Solver	17-16
Refinement of the FEA Mesh – Global Element Size	17-18
Refinement of the FEA Mesh – Local Element Size	17-20
Comparison of Results	17-23
Create an HTML Report	17-24
Geometric Considerations of Finite Elements	17-25
Conclusion	17-26
Summary of Modeling Considerations	17-26
Review Questions	17-27
Exercises	17-28

## Index

**Bonus Chapters Available at:**  
[www.SDCpublications.com/downloads/978-1-58503-873-2](http://www.SDCpublications.com/downloads/978-1-58503-873-2)

---

**Chapter 18 – LEGO<sup>®</sup> MINDSTORMS<sup>®</sup> NXT  
 Assembly Modeling with the LEGO<sup>®</sup> MINDSTORMS<sup>®</sup> NXT Set –  
 Autodesk<sup>®</sup> Inventor<sup>®</sup>**

Introduction	18-2
The Basic Car Assembly	18-2
Modeling Strategy	18-3
Starting Autodesk Inventor	18-4
Creating a Subassembly	18-5
Placing the Next Component	18-6
Degrees of Freedom Display	18-7
Apply the Assembly Constraints	18-8
Assemble the Next Components	18-13
Assembling Bushing and Axle	18-15
Completing the Motor-Right Subassembly	18-18
Starting the Main Assembly	18-20
Assemble the Frame and Motors	18-23
Assemble the Motor Assemblies	18-25
Adding the Motor-Right Subassembly to the Main Assembly	18-30
Assemble the Rear Swivel Assembly and Wheels	18-31
Assemble the NXT Micro-controller	18-37
Assemble the Sensors	18-40

**Chapter 19  
 Assembly Modeling with the TETRIX<sup>®</sup> by Pitsco Building System  
 – Autodesk<sup>®</sup> Inventor<sup>®</sup>**

Introduction	19-2
The ST1 Assembly	19-2
Modeling Strategy	19-3
Starting Autodesk Inventor	19-4
Creating a Subassembly	19-5
Placing the Next Component	19-6
Degrees of Freedom Display	19-7
Apply Assembly Constraints	19-8
Starting the Main Assembly	19-18
Adjusting the Orientation of a Grounded Part	19-20
Adjusting the Orientation of Parts	19-22
Assemble the DC Motor Controller	19-25
Assemble the Servo Controller	19-27

Completing the Chassis	19-29
Assemble the Front-Wheel Assembly	19-30
Assemble the Motor-Wheel Assembly	19-33
Assemble the NXT Micro-controller	19-38
Assemble the NXT Touch-Sensor	19-39
Conclusion	19-41

## **Chapter 20 – VEX**

### **Assembly Model with Vex Robot Kit - Autodesk® Inventor®**

Introduction	20-2
The Tumbler Assembly	20-2
Starting Autodesk Inventor	20-3
Creating a Subassembly	20-4
Placing the Second Component	20-5
Degrees of Freedom Display	20-6
Adjusting the Component's Orientation	20-7
Apply Assembly Constraints	20-8
Assemble the Next Component	20-11
Assembling Bearing Rivets and Screws	20-13
Assembling Shaft Collars, Shafts and Motors	20-16
Assemble the Wheels	20-23
Modifying the Wheel Directions	20-27
Starting the Tumbler Assembly	20-30
Assemble the Chassis	20-33
Assemble the Chassis Plate	20-37
Adding the Battery Pack Under the Chassis Plate	20-39
Adding the RF Receiver on the Rear Chassis Bumper	20-40
Assemble the VEX Microcontroller	20-43
Assemble the Antenna	20-46
Conclusion	20-47
Review Questions	20-48
Exercises	20-49