



sphero blueprint

CAD Guide

Blueprint CAD Guide

Overview

Ready to take Blueprint further? One of the foundations of engineering is using CAD, or computer-aided design, software. Engineers use CAD software to aid in the creation, modification, analysis, or optimization of a design. Using CAD to design everything from individual parts to fully simulated models before physically building them offers many benefits in industry; it can provide increased productivity, improved accuracy, and reduced costs. Developing your knowledge and skills in CAD early can help you kick-start your engineering career!

Modeling vs. Assembly

There are two main processes in using any CAD software:

- **Modeling:** the process of creating a 3D representation of an object. This is usually done by first extruding 2D shapes.
- **Assembly:** the process of combining multiple models into a single unit so they behave like they would in the physical world. This is usually accomplished using mates and constraints.

The main focus of this guide is assemblies since all the models of Blueprint parts are available on the [Blueprint resource page](#). If you would like to focus more on modeling, refer to our [3D printing guide](#) to start designing your own blueprint pieces to add to builds.

Software Options

There are many different CAD software options available, and while they are all similar, there are different levels of support available in this guide for the following options:

- **Onshape:** You will find the most support in this guide—all of the fully planned lessons use Onshape. All Blueprint parts and assemblies used in lessons are in Onshape documents and ready to use.
- **Solidworks:** While our fully planned lessons focus on Onshape, Solidworks tips are included in this guide. All Blueprint parts and assemblies used in lessons are available on the Blueprint resource page to download.

- **All other CAD Software:** Any other CAD software of your choice can still be used with Blueprint. We provide STEP files of all Blueprint parts, which can be uploaded to your preferred program. However, there is no specific support in this guide for other software.

Certifications

Many classes that are using CAD software are also working towards a certification in that software. Using the resources in this guide and the physical Blueprint pieces can aid students in preparing for those certification tests. One of the most powerful advantages of using CAD alongside Blueprint is the ability to build an assembly in CAD and then verify that a physical model performs exactly as expected; this process not only better prepares students for certification but also brings computer modeling into the real world.

Onshape

Learning any CAD software requires significant time and effort. While creating Blueprint designs in Onshape will certainly help develop and refine your skills, it will not teach you everything you need to know to pass a certification exam. For a more thorough introduction to Onshape, we recommend the [Onshape Learning Center](#) or [ITEEA's Engineering by Design Curriculum](#).

Document and Models

Onshape is cloud-based CAD software that uses a single document concept. This means that a single Onshape document can contain multiple parts, assemblies, drawings, and other data. There are two main file types included in the document:

- **Part Studio:** This is the place in the document to create parts. It includes the geometry of a part, including its features and dimensions. All parts for Blueprint are available in this [Onshape document](#).
- **Assembly:** This is the place in the document to create assemblies. It can store the complete geometry of an assembly, including its parts, subassemblies, and relationships. All assemblies for builds that are part of the Blueprint curriculum are available in these documents: [Units 1 & 2](#) and [Units 3 & 4](#)

Overview of Mate Connectors

Mate connectors in Onshape create a local coordinate system located on or between parts. These help to locate and orient parts or surfaces with respect to each other. The Blueprint Onshape document with assemblies includes mate connectors that will make it easier to connect some Blueprint parts to each other. For example, to fully constrain a connector to a truss requires multiple mates, including coincident, parallel, tangent, and others. With mate connectors, you can do all of these mates in one click.

Instructional Videos of Blueprint in Onshape

- [Getting Started with Blueprint in Onshape](#)
- [Creating Assemblies and Inserting Parts](#)
- [Fastened Mates/Snap Mode](#)
- [Slider Mate/Limits](#)
- [Revolute Mate Pt. 1: Shafts and Collars](#)
- [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)
- [Cylindrical/Screw Relations](#)

Solidworks

Files and Models

Solidworks is CAD software that is widely used in industry. There are two types of files that are available for Blueprint:

- **SLDPRT:** This is the file format for Solidworks parts. It includes the geometry of a part, including its features and dimensions. All part files for Blueprint are available on the [Blueprint Resources page](#).
- **SLDASM:** This is the file format for Solidworks assemblies. It can store the complete geometry of an assembly, including its parts, subassemblies, and relationships.

Overview of SmartMates

One of the features in Solidworks that we are taking advantage of with our Blueprint models is called SmartMates. A Smart Mate is a type of mate you can create in Solidworks that automatically creates the multiple mates needed to fully constrain two parts together. For example, to fully constrain a connector to a truss requires multiple mates including coincident, parallel, tangent, and others. We've included SmartMates on all Blueprint parts to make assemblies easier to create.

All Other CAD Software

STEP Files

A STEP file is the standard format for sharing parts and assemblies across different CAD platforms. STEP stands for Standard for the Exchange of Product Data. Not all features of a model are always included in a STEP file, so sharing between the same software is always recommended, but in the case that isn't possible, a STEP file helps.

You can find all STEP files on the [Blueprint Resources Page](#). You will need to download and save them to your computer before using them. Some STEP files may be large and will download as a ZIP file. In that case, you will need to unzip them before opening in CAD software.

3D Printing Basics

Most of this guide talks about assemblies, but if you want to focus more on part creation we suggest you start by checking out our [3D Printing Guide](#). While there are not complete lessons on how to do part creation in CAD there are a lot of things in this guide to help get you started.

Blueprint CAD Onshape Assemblies

Assembling Blueprint builds in Onshape requires many of the same mates, applied numerous times to different parts. Using the Instructional videos for each mate can help you assemble any of the Blueprint builds in our content. In this section you will find a link to a completed assembly for each content build and a list of instructional mate videos for you to reference when creating the assembly on your own.

Please note: all assemblies will require [Creating Assemblies and Inserting Parts](#) and [Fastened Mates/Snap Mode](#). We recommend those instructional videos for every build.

Unit 1: Simple Machines

[Inclined Plane Level 1](#)

Additional Suggested Instructional Videos: [Slider Mate/Limits](#), [Revolute Mate Pt. 1: Shafts and Collars](#)

[Wheel and Axle Level 1](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\)](#) and [Gear Relations](#)

[Levers Level 1](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

[Linkages Level 1 Build 1 & Build 2](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

[Pulley Level 1](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\)](#) and [Gear Relations](#)

[Screw Level 1](#)

Additional Suggested Instructional Videos: [Slider Mate/Limits](#), [Revolute Mate Pt. 1: Shafts and Collars](#), [Cylindrical/Screw Relations](#)

[Gear Level 1](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

[Inclined Plane Level 2](#)

No additional suggestion videos

[Wheel and Axle Level 2](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

[Levers and Linkages Level 2](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

[Pulley Level 2](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

[Screw Level 2](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Cylindrical/Screw Relations](#)

[Gear Level 2](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

[Motion Profile Level 3 \(Example Build\)](#)

Additional Suggested Instructional Videos: All listed as students can create their own designs

Unit 2: Carnival Builds

Prize Wheel

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

High Striker

Additional Suggested Instructional Videos: [Slider Mate/Limits](#)

Games and Inclined Planes

No additional suggestion videos

Roller Coaster Tracks

Additional Suggested Instructional Videos: [Slider Mate/Limits](#), [Revolute Mate Pt. 1: Shafts and Collars](#), [Cylindrical/Screw Relations](#)

Gearing for Teacups

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

Pirate Ship with Simple Machines

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

Wires in Builds

You will notice the builds linked below include wires from the Blueprint Bit Kit and have the wires in the Onshape model. This is not typical in most CAD models, usually, the wiring is outlined separately in a schematic. Because we want you to have the most accurate model possible, we decided to include them. Creating wires in Onshape is a complicated process that involves using [splines](#) and [sweeps](#). We recommend that, unless you are an advanced CAD user, you leave wires out of your models.

Unit 3: Control Systems

[Open Loop Systems](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Cylindrical/Screw Relations](#)

[Closed Loop \(Feedback\) Systems](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

[Rack and Pinion Steering](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

[Powered Flagpole](#)

Additional Suggested Instructional Videos: [Slider Mate/Limits](#), [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

[Data Collection](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#)

Unit 4: Farm to Table

[Historical Irrigation Systems](#)

No additional suggestion videos

[Center Point Irrigation](#)

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

Tractor Innovations

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), , [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

Elevating Food

Additional Suggested Instructional Videos: [Slider Mate/Limits](#), [Revolute Mate Pt. 1: Shafts and Collars](#), , [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#), [Cylindrical/Screw Relations](#)

Forklifts Example Build

Additional Suggested Instructional Videos: [Slider Mate/Limits](#), [Revolute Mate Pt. 1: Shafts and Collars](#), , [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)

Conveyor Controls

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), , [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#),

Garbage Truck

Additional Suggested Instructional Videos: [Revolute Mate Pt. 1: Shafts and Collars](#), , [Revolute Mate Pt. 2: Gears \(or Pulleys\) and Gear Relations](#)