ROI

INDIANA UPLANDS | PROUD PARTNER

Grade 9-12 STEM Challenge

Drawing in Detail

Inspired by Cory, a CNC Machinist in the Indiana Uplands.

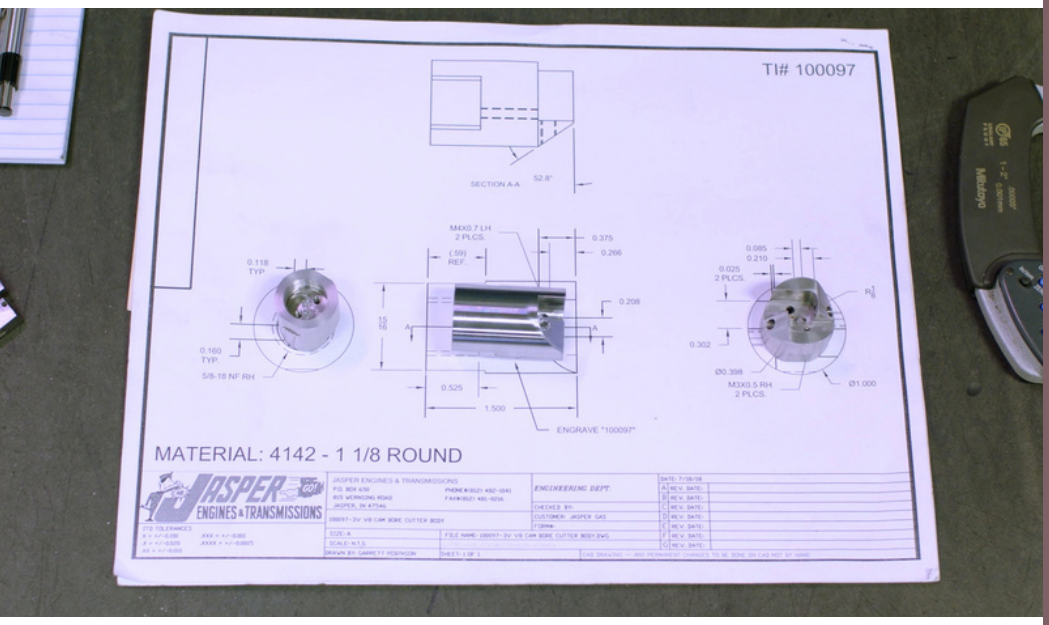
Published by Regional Opportunity Initiatives

GRADE 9-12 STEM CHALLENGE

Drawing in Detail

Inspired by Cory, a CNC Machinist in the Indiana Uplands.

Students will use isometric and orthographic drawings to create a blueprint to guide building a 3D object.



CAREER CONNECTION AND LESSON OVERVIEW

Cory is an advanced CNC machinist at Jasper Engines and Transmissions in Jasper, Indiana. CNC stands for Computer Numerical Control and describes how the machines use coordinate programming and mapping to guide a mill, router, or lathe. Machinists like Cory use math and computer skills to program machines to create objects out of a block metal, plastic, wood, or other raw material. What Cory loves most about his job is taking blank piece of metal and turning it into something useful. To create new parts, CNC machinists have to take technical drawings and convert them into a series of instructions for the machines. He then programs the CNC machine to precisely carve the raw metal into parts for engines and transmissions.

CNC machinists have to be able to draw and read blueprints for the parts they make. How do you communicate exactly what you want made using a drawing? These 2D representations of 3D objects require designers to have standardized ways to represent an object from multiple sides—usually top, front, and sides. In this activity, students practice drawing detailed design blueprints of Lego structures to learn about geometry, dimension, and tolerances.

LESSON TIMELINE

DAY 1

- Show the inspiration video, "Cory - Advanced CNC Operator" (5 minutes)
- Introduce isometric vs orthographic drawings (20 minutes)
- Practice (10 minutes)
- Begin Lego design drawing (remainder of class)

DAY 2

- Complete Lego design drawing activity
  - isometric (15 minutes
  - orthographic (15 minutes)
- Discussion (10 minutes)

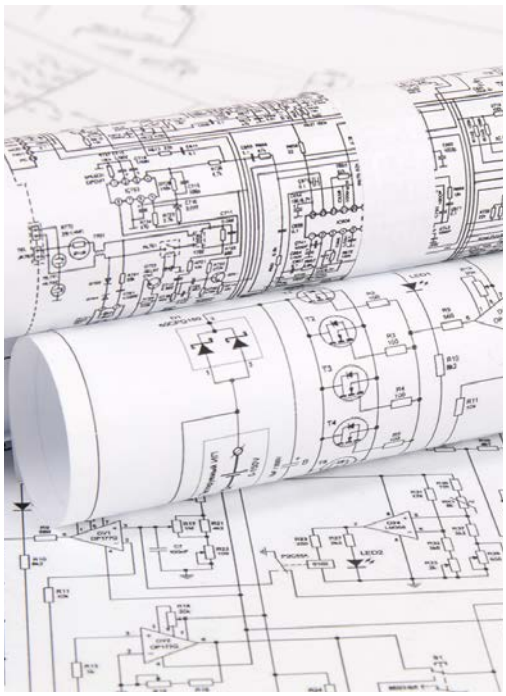
Recommended Supplies

General supplies (per group of 2):

- 2-4 Lego Blocks or other modular building materials for building models to be drawn
- Triangle dot sheets
- Square dot grid sheets
- Blank standard blueprint sheets
- Pencils
- Erasers
- Ruler (metric, must include mm)

For the class:

- Wooden block, approximately 10 X 5 X 2.5cm
- Overhead projector or smartboard with triangle dot and dot grid paper patterns.



IN THIS CHALLENGE, STUDENTS WILL:

- Practice drawing 2D representations of 3D objects using standardized engineering drawing practices
- Create new 3D objects and drawings that describe them, then trade with a friend.

Standards

Science & Engineering Process Standards

SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.4 Analyzing and interpreting data
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)
SEPS.8 Obtaining, evaluating, and communicating information

Preparing for College and Careers Standards

PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change
PCC-2.4 Use appropriate technology and resources to research and organize information about careers.

Grade 9-10 Employability Skills

9-10.M.1 Seek and participate in challenging learning activities related to career goals.
9-10.M.2 Able to view feedback as data' that helps the learning process.
9-10.LS.7 Predict outcomes to problems based on data and evidence.
9-10.LS.10 Able to approach problems with reasoning and logic to hypothesize results.
9-10.LS.11 Able to combine concepts in different ways to create new ideas and innovative solutions.

8th Grade Science Standards

8.GM.3 Verify experimentally the properties of rotations, reflections, and translations, including: lines are mapped to lines, and line segments to line segments of the same length; angles are mapped to angles of the same measure; and parallel lines are mapped to parallel lines.

Geometry Standards

G.TS.1 Create a net for a given three-dimensional solid. Describe the three-dimensional solid that can be made from a given net.
G.TS.5 Apply geometric methods to create and solve design problems.

Planning and Implementation

DRAWING IN DETAIL

Essential Vocabulary

- CNC MACHINING: Computer Numerical Control Machining. Uses computers to guide the creation of tools and parts from blocks of metal, plastic, wood, or other materials.
- ISOMETRIC DRAWING: 2D representations of 3D drawings that show three sides of an object tin dimensional proportion, but the geometry is distorted.
- ORTHOGRAPHIC DRAWING: images that represent all sides of a 3D structure as flat, 2D images with correct geometry. This usually includes a side view, a front view, and a top view but it may include more depending on the level of detail.
- GEOMETRY: The shape of the features in a detailed mechanical drawing.
- DIMENSION: The measurements of the geometric shapes in a mechanical drawing.
- TOLERANCE: The amount of allowable error in the manufacture of a 3D part.

Guiding Questions

1. What is CNC Machining? Why is it used?
2. What kind of information should be in a drawing for it to accurately describe a three-dimensional object?
3. What are the limits of isometric drawings? Orthographic drawings?

In this challenge, students will:

- Practice drawing 2D representations of 3D objects using standardized engineering drawing practices
- Create new 3D objects and drawings that describe them, then trade with a friend.

Before Class:

- Read the activity outline sheet and leader notes to become familiar with the activity.
- Gather necessary materials for class demonstration (wood blocks, cups, etc). Be sure that you have enough materials and space for students to work in small groups or pairs.
- Gather enough basic Lego (or other blocks) for students to each student to create a small object from no more than 3 to 4 blocks. You will also want to start by having students practice creating design drawings of single simple blocks.
- Students will need at least one piece of triangle dot paper (page S2) for their isometric drawings and one piece of grid dot paper (page S4) for their orthographic drawings. Make sure you have extra copies of these in case there are mistakes. They will also need either blank “blueprint” paper (page S5) or plain blank paper for their final drawings.

Introduction

CNC machinists, like Cory, take information from detailed 2-dimensional drawings and use CNC machines to turn them in to 3-dimensional objects. Creating a new part from a block of raw materials and some pictures is no small feat, though. The blueprints for the objects he makes must be simple and straightforward while also containing all of the information he needs. These kinds of drawings are called “detail drawings” and they describe, in detail, a part’s dimensions, shape, tolerances, and how it should be manufactured.

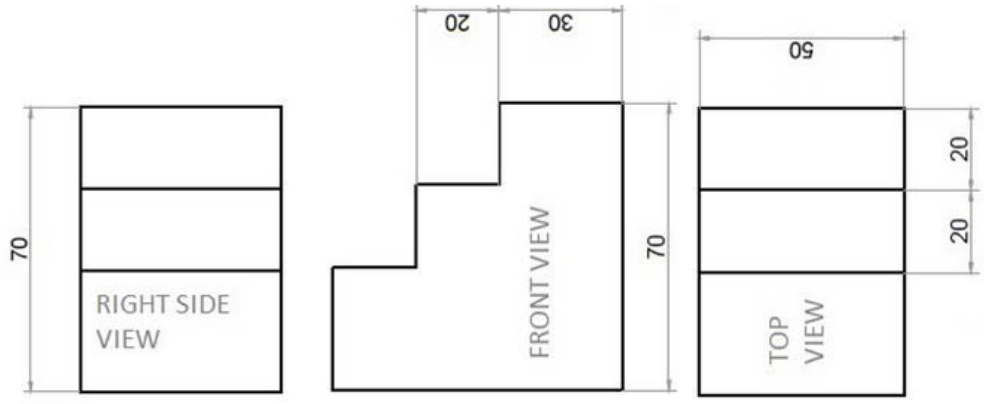
Note: even though we call these detailed drawings “blueprints” they are seldom actually printed on blue paper any more!

Design Drawings: A How-To

Orthographic Drawings

With orthographic representations, we’re not trying to fool the eye into seeing a 3D object. We’re instead looking at each side face-on so that we can see the shape and sizes without distortion. Orthographic drawings focus on three things:

- Geometry: What is the shape of each face?
- Dimensions: What are the measurements of each face?
- Tolerances: If I make this object, how much error can there be in those dimensions?

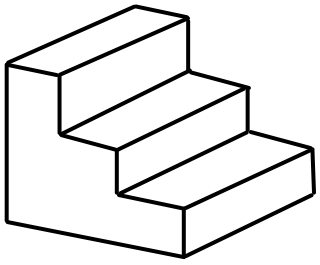


Orthographic Views
(multiple 2D views)

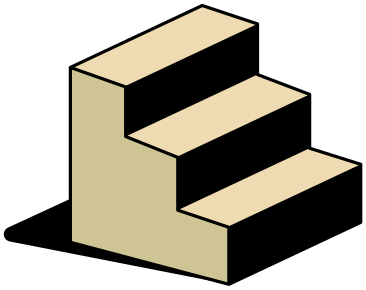
Isometric Drawings

Isometric drawings are drawings of figures that show three sides of a 3D object with everything in proportion. These images try to fool the eye into seeing a three dimensional object by distorting 90 degree angles. All of the vertical lines are drawn vertically but the horizontal lines are drawn at 30 degrees off the base line.

Engineers use triangle grid paper to create these images because even though the faces are distorted (for instance, the shapes of the surfaces of these stairs are not accurate to reality) the distortion is standardized. Students will want to place their Lego structures in such a way that they're looking directly at one corner.



Isometric View
(one 3D view)



Realistic View

When students think of blueprints, they probably picture a set of orthographic drawings. Orthographic projection is a technique used in spatial visualization and it's an essential skill for anyone who needs to take an idea in their brains and turn it into a physical product. A critical part of the design process is the ability to effectively communicate what has been designed to others, including machinists like Cory. Orthographic views are helpful for detailing an objects structure for manufacturing. An orthographic drawing shows multiple viewpoints—usually front, side, and top. These are different from isometric views, which are probably what students are used to seeing when they think of a "3D" drawing.

Prompt students to discuss:

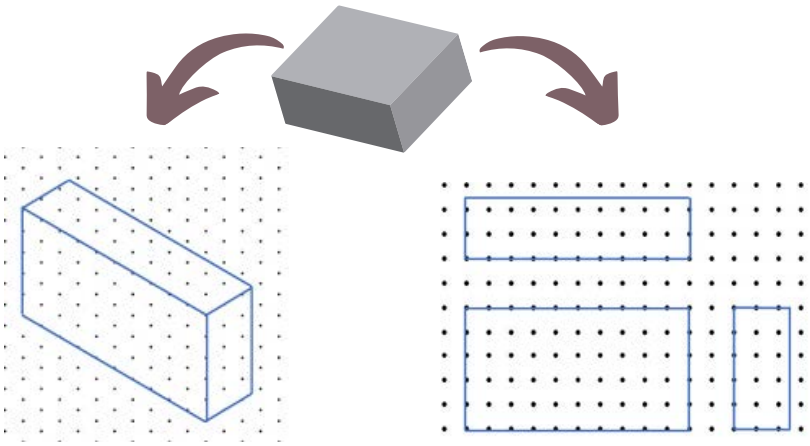
- *What are the limits of an isometric view of an object?*
  May hide some features or misrepresent shapes. Also: things look distorted because we're trying to present a 3D object with a 2D picture. These steps, for example, are presented as parallelograms, even though the surfaces are rectangles.
- *What kind of information are we going to want to include in our orthographic views?*
  Answers will vary, but anything similar to: Measurements and dimensions. Any error allowed (tolerances) in sizes. If there are open areas or the object is hollow, we'll need to have a way to show that as well. Scale is important.

Practice Makes Perfect

Once students understand the different drawing types and approaches, have the class do a practice activity. Show them a wooden block, approximately 10 X 5 X 2.5cm (these dimensions may be different but it should be a simple box shape for best results.)

As a group, work through the isometric and orthographic representations of the block. An overhead projector, computer projector, or smart board is good for this. The isometric drawing of a simple block in on the left, the orthographic images are on the right.

CNC machinists need as much detail as possible in their drawings to be able to turn 2D ideas into a 3D part or tool. They need to know how much material to cut away and how accurate those cuts must be. Detailed mechanical drawings ensure that they have enough information to do their job.



Isometric drawing on triangle grid paper.

Orthographic drawing on square grid paper.

Challenge

Students will complete this activity in pairs. Each person in the group should have a piece of both triangle dot paper and dot grid paper. Dot paper is a handy tool to make sure that their isometric and orthographic drawings are consistent. Triangle dot paper is best for isometric imagines, but the gridded dots are better for their orthographic views. Once they have used the dot paper to work out their different views, they will create a scaled design drawing of their partner's object.

Part 1: Building a shape and isometric drawing.

1. Ask each pair of students to create a shape out of their provided Lego pieces. Remind them that more complicated shapes will be more difficult to draw.
2. Trade these pieces (so that each student is drawing their partner's shape.) Using their triangle dot paper, create an isometric drawing of the shape and then three orthographic drawings (front, side, and top).
3. The triangle dot grid should provide them a way to align and lay out their drawings. Tell them not to worry too much about scale at this point—that will come in the next step! Drawing on the triangle dot paper is to help them get a feel for how they need to draw each view.

Part 2: Orthographic Drawing

1. Using the square grid paper, students will create an orthographic drawing of their Lego shape. Each drawing should include top, front, and side view(s), depending on the shape. Prompt students: How many views are necessary to fully describe this shape?
2. Remind students to think about scale.
    a. They will need to measure their shapes and draw their objects to scale.
    b. They will also need to be mindful of what scale and size drawings will fit on their sheets.
3. They may want to think about tolerances as well. If this were a design being sent to a machinist, how "off" could each measurement be? Half a centimeter? .1 centimeter? .05 centimeters?

Once the students have created their drawings on dot paper, have them create a true blueprint design drawing on the blueprint template.

Discuss and Report

Prompt students to discuss what they found difficult (or easy) about creating these drawings.

- Why are orthographic drawings important to engineers? Answers will vary, but students should be able to recognize that
- Why is an isometric view not enough?
- Ask students to explain their drawings and how they decided on the different views of their orthographic drawings.

Prompt students to discuss what they found difficult (or easy) about creating the different kinds of drawings.

Career Exploration and Extension

Prompt students to think about and research what a career as an Information Assurance Analyst might entail.

- What does a CNC machinist do all day? What does Cory do?
- What kind of training would a student need to become a CNC machinist? What about other related jobs, like a designer or a regular machinist?
- Are jobs like Cory's in demand? Will more people be hired for machinist jobs in the future?
- What kind of education is needed to become a machinist? Where could a student be trained locally for a career in producing new products or tools from plans or blueprints?

Name: _____

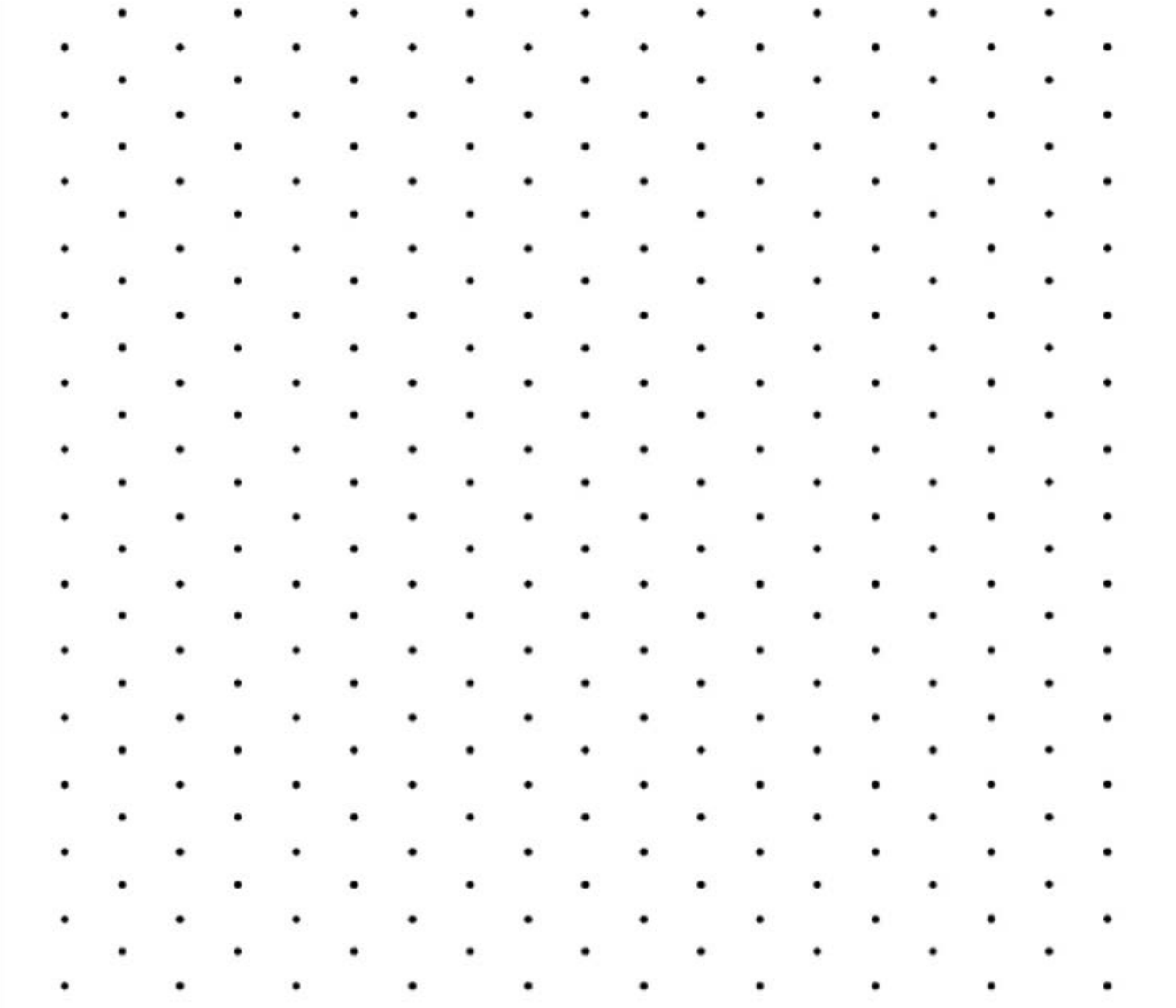
Drawing in Detail

Student Data Sheet

CNC machinists require detailed drawings of the parts they make to ensure that the shape of the object is correct in all dimensions. To ensure accuracy, they use detail drawings, or blueprints, that show the object om all sides. Here, you will sketch a small object made of Legos, first as an isometric drawing, then the orthographic views of the front, side and top.

Part 1: Isometric Drawings

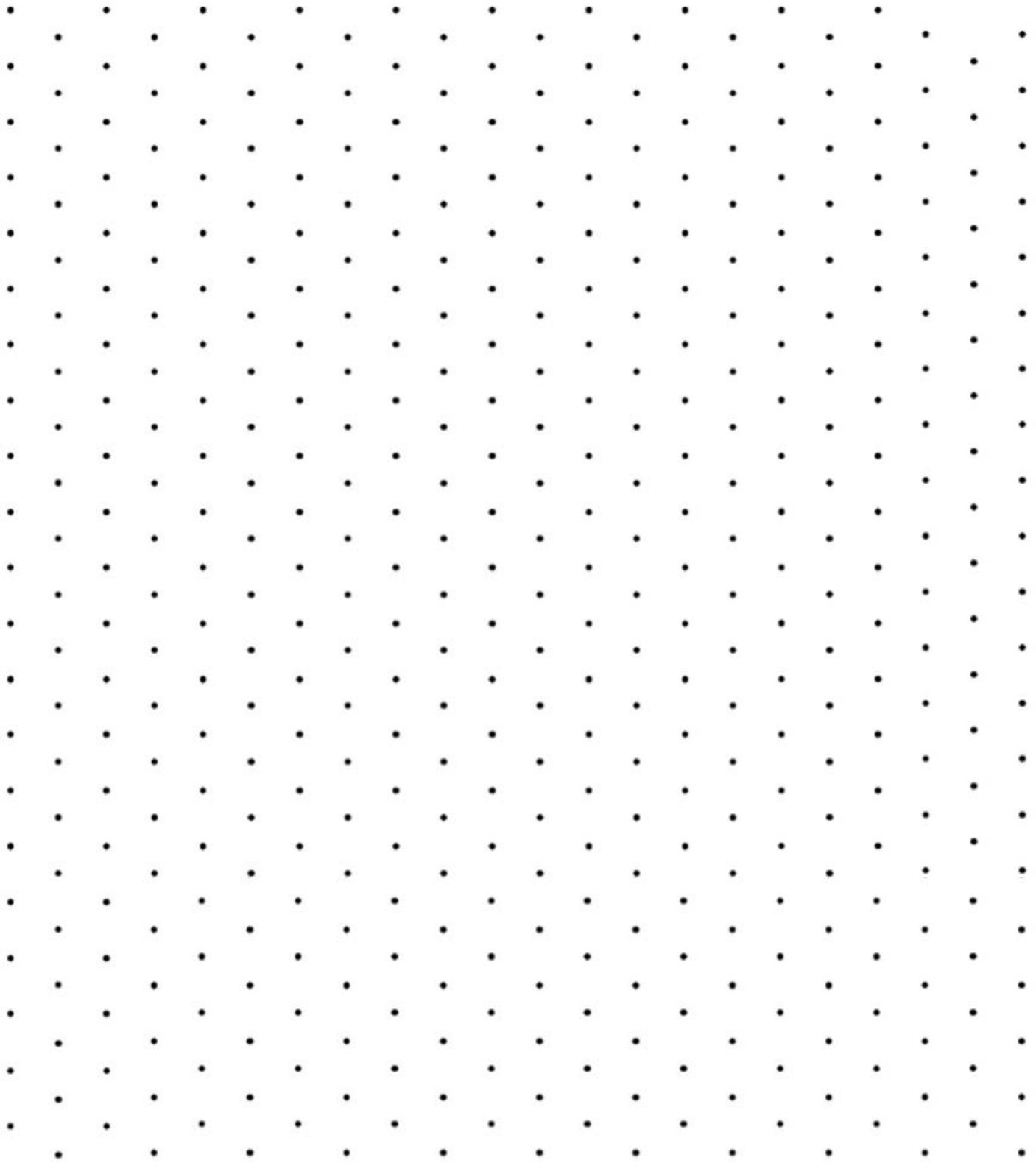
Using the triangle dot grid below, draw a single isometric view of your Lego object. It's up to you to choose which side to draw, but try to pick the most interesting one. If you're having trouble getting started, try starting by looking straight at one edge.



Name: _____

Drawing in Detail

Triangle Dot Grid (large)



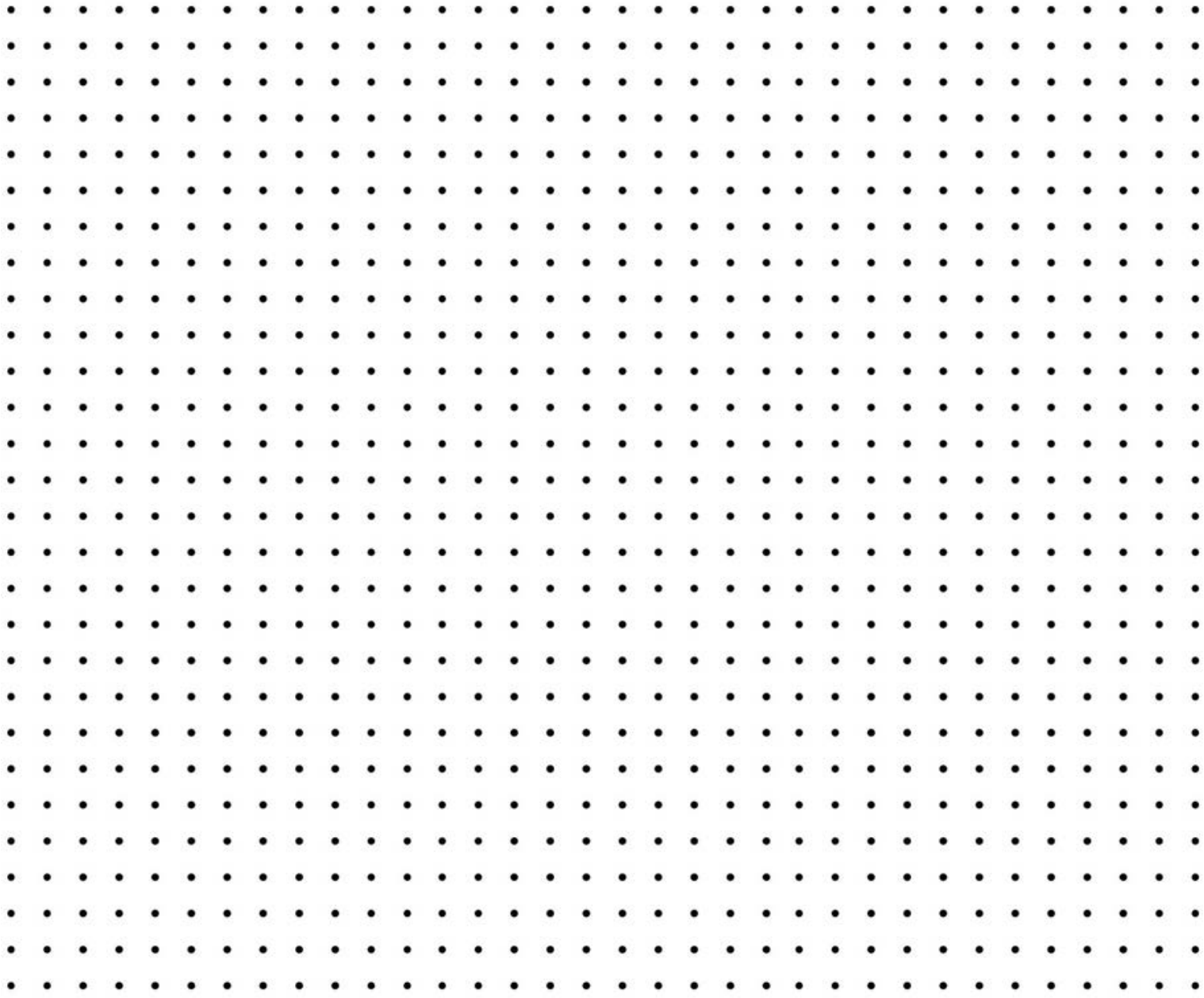
Name: _____

Drawing in Detail

Student Data Sheet

Part 1: Orthographic Drawings

Using the dot grid below, draw at least three orthographic views of your Lego object. Look at each face of your object—what do you see? What shapes is it made of? You will definitely need a top and front view. Will one side view be enough? Use this grid to layout your drawings to scale.



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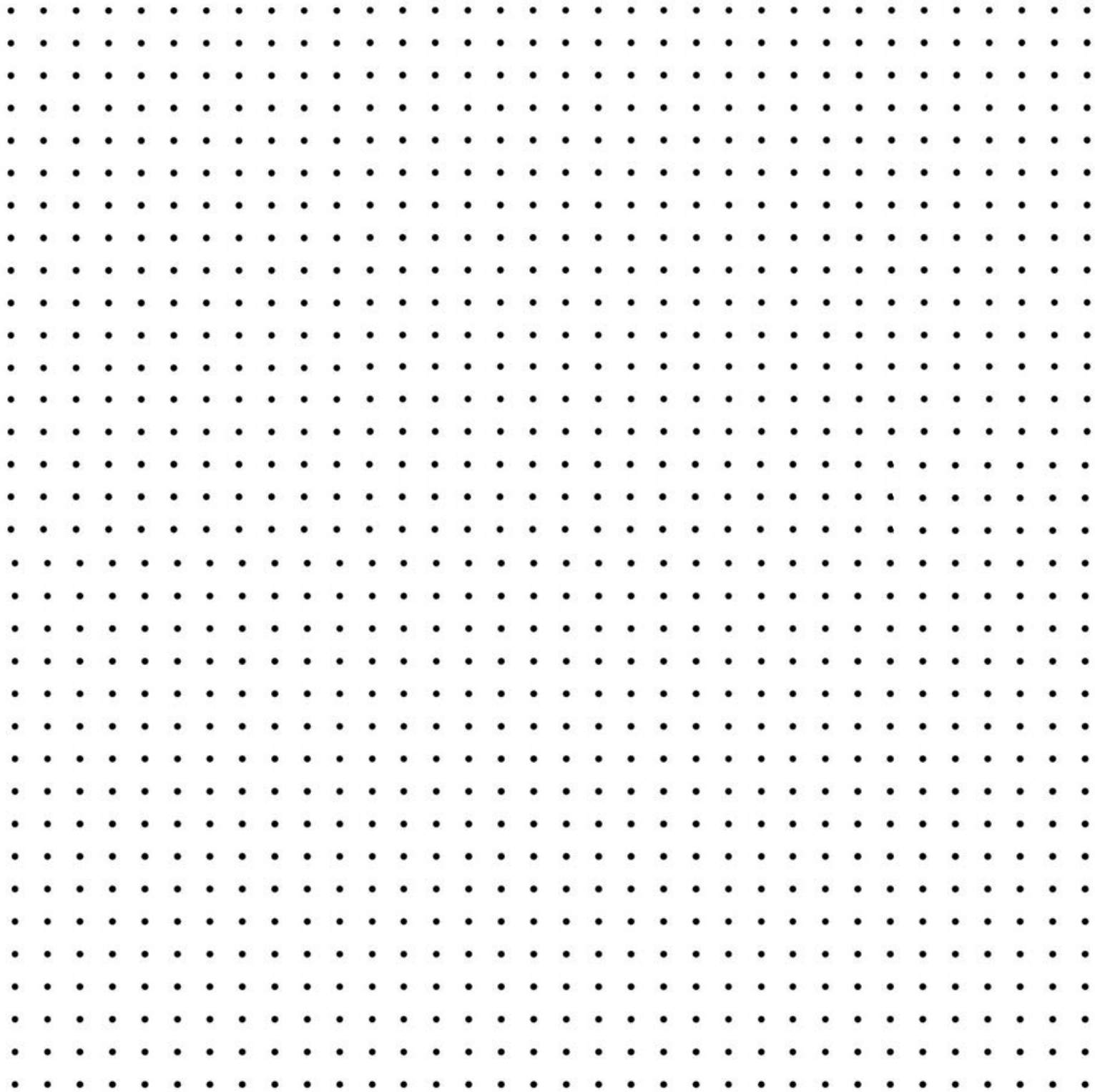
Drawing in Detail

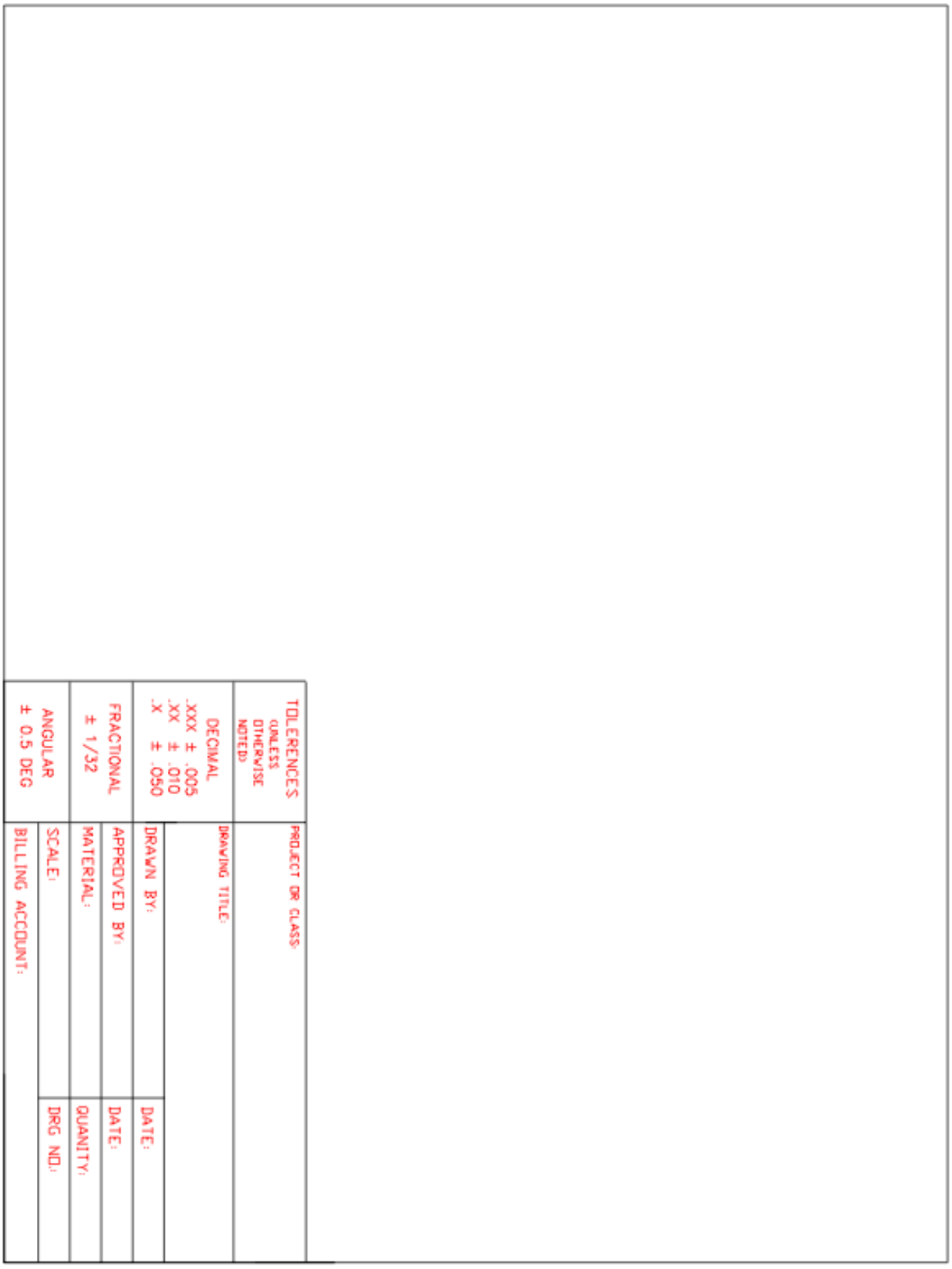
Square Dot Grid (large)



Name: _____

Drawing in Detail

Blueprint Template



ACKNOWLEDGEMENTS

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IMAGE AND CONTENT CREDITS

Images

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Blueprint template courtesy of Jim Crider

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