Puzzle Cube Checklist – For EMERGENCY REMOTE FORMAT (ENGR 100, Fall 2020)

Since we are doing emergency remote format in fall 2020, please note the modifications to turning in the puzzle cube project. This list should also serve as a way to *double-check* your project before uploading it on CANVAS. Many previous students did not carefully look through this list, and their project grade suffered.

General Instructions

- ☐ **Scan pages** (phone apps: AdobeScan, CamScanner), and create an **8-page PDF**.
- ☐ Please arrange pages in order: (a) Cover sheet, (b) Exploded Assembly Drawing, (c) Bill of Materials, and (d) the five Detailed Drawings, one for each of the five parts, in order.
- ☐ Rotate the bottom (title block) of each drawing so it is on the right side of the packet.
- ☐ All text on all drawings should be in CAPITALS.
- ☐ **Upload the PDF to Canvas**.

Prototype – Keep the prototype (the wooden model), but turn in pictures of each part, and a picture of the completed puzzle.

Submit the pictures as .jpgs (not company-specific file types), separate from the PDF.

- ☐ **There is no need to paint/color the part**. If you do not paint, **label each part** its intended color (e.g., "Red", "Blue", etc.) and/or number it (1,2…) so I know which picture of a wood-colored part goes with which drawing.
- ☐ **Take a picture of each of the five parts of the puzzle cube**. You may either have a picture for each part, or to save space, put more than one part in a picture.
- ☐ Try to get the best view of each part. A picture that shows the front, top and right sides would be ideal.
- ☐ **Take a picture of the solved puzzle cube**. Use the same view as the Exploded drawing.
- ☐ **Upload the pics to Canvas. Upload .jpgs as separate filed from the PDF.**

Exploded Assembly Drawing

- ☐ The parts are drawn within the frame.
- ☐ The parts are oriented correctly with respect to one another (they will fit together as drawn, without rotating them).
- ☐ In the picture, the parts all slide along only one axis to fit the puzzle together.
- ☐ The parts are numbered ①②③④⑤ to match the numbers in the Bill of Materials.
- ☐ The **NOTES: 1. SCALE 2:3** is written on the drawing

For each Detailed Drawing

- ☐ The parts are drawn within the frame.
- ☐ The orthogonal views (*Front, Top, Right*) are all in their correct locations.
- ☐ The views align (the left sides of *Front* and *Top* align, the bottoms of *Front* and *Right* align)
- ☐ The *Oblique* representation is drawn at 2/3 scale, with the oblique edges drawn up and to the right.
- ☐ The **NOTES: 1. MATERIAL: PLA** is written on the drawing.

Dimensions on Each Detailed Drawing

- ☐ All individual features of a part are dimensioned once, and only once.
- ☐ All **dimension lines have arrowheads at each end**.
- ☐ Dimensions are given to two decimal places: **.75, 1.50, 2.25**.

Puzzle Cube Assignment - Rubric

DRAFT 7/2020

Student		/45

General /10

☐ Y ☐ N Stapled In Order [−3 if not]
☐ Y ☐ N All Pages Present [−2 for each missing]

Pages Missing
- ☐ Cover Sheet ....
- ☐ Exploded View (isometric) ....
- ☐ Bill of Materials ....
- ☐ Detailed Part Drawings (5 total)......

☐ Y ☐ N Cover Page Correct [up to −2] ....
☐ Y ☐ N Bill of Materials Correct [−2] ....
☐ Y ☐ N Bottom (Title Block) of all pages to the right of each page [−2] ...
☐ Other

Prototype /10

☐ Y ☐ N Prototype completed
Comments

Drawings /20

☐ Y ☐ N All Title Blocks have DRAWN BY, CHECKED BY, TITLE, PART NUMBER in **CAPITALS** [−1,−2,−3,−4,−5]

☐ Y ☐ N Dimension Lines have Arrowheads? Total Dim Line w/o Arrowheads: ________ / 3 = _________

Detailed Drawings Correct (C/N: Correct / Not Correct)

Part	Top View Outline	Front View Outline	Right View Outline	Views Align	Dimension Errors	Visible/Hidden (Solid/Dashed) Line Errors	Oblique View Errors	Included MATL NOTE, etc.
1	C N	C N	C N	C N	0 1 2 3 4+	0 1 2 3 4+	0 1 2 3+	C N
2	C N	C N	C N	C N	0 1 2 3 4+	0 1 2 3 4+	0 1 2 3+	C N
3	C N	C N	C N	C N	0 1 2 3 4+	0 1 2 3 4+	0 1 2 3+	C N
4	C N	C N	C N	C N	0 1 2 3 4+	0 1 2 3 4+	0 1 2 3+	C N
5	C N	C N	C N	C N	0 1 2 3 4+	0 1 2 3 4+	0 1 2 3+	C N

Total Outline & Align Errors: _______ TOTAL Dim/Line/Oblique/Material Note Errors: _______ / 3 = ________

Isometric Drawing/Exploded View /5

☐ Y ☐ N Title Bock Correct? SCALE 2:3 note included?

	Part labeled? ①, ②	Part correctly drawn	Part shifted along only one axis	Remarks
1	Y N	Y N	Y N	
2	Y N	Y N	Y N	
3	Y N	Y N	Y N	
4	Y N	Y N	Y N	
5	Y N	Y N	Y N	

DJD 2/2020

Puzzle Cube Design Project

Based on a project assigned by: Duncan McGehee, PhD, *Cuyamaca College, El Cajon, CA*
Adapted by: Dom Dal Bello, *Allan Hancock College, Santa Maria, CA*

Materials Provided:

27 0.75″ wooden blocks; 1 bottle of glue; 1 sheet isometric paper; 5 sheets of quad-grid paper; 1 plastic bag (to hold blocks and glue); 1 manila folder (for paper). Extra sheets of paper are available, if necessary (just ask).

Situation: Your design firm has been approached by a toy manufacturer with the request to design a 3-dimensional puzzle cube for children ages 8 through 10 years old.

Problem Statement: Design a 3-dimensional puzzle cube for children 8–10 years old.

Design Constraints:

1. The assembled cube must be composed of 3×3×3 smaller cubic elements.
2. The assembled cube must have overall dimensions of 2.25″ × 2.25″ × 2.25″.
3. The cube must be composed of 5 pieces, each a different color.
4. Each piece must incorporate between 3 and 6 smaller cubic elements.
5. Some of the pieces must interlock.
6. All parts are to be made of polylactic acid (PLA).

Deliverables (provide to the "toy manufacturer"/instructor):

(1) Design Report, composed of eight (8) total pages, stapled, and <u>in order</u>:

(a) a ***cover sheet*** (general description of project; 1 page of copy paper).

(b) an ***exploded assembly drawing*** (isometric view of how system pieces fit together; 1 page of isometric paper). Fill in the title block (<u>**PRINTED**</u>, <u>**CAPITAL LETTERS**</u>), and <u>have someone check your work and initial it</u>.

(c) a ***bill of materials*** (table of parts; 1 page of copy paper)

(d) a ***detailed part drawing*** <u>for each</u> of the 5 individual parts (3 orthogonal views and an 2/3-scale oblique view of each part; 5 pages of quad graph paper). Fill in the title block.

The <u>**BOTTOM OF EACH DRAWING**</u> should be <u>**placed towards the RIGHT SIDE of the packet**</u>.

(2) Prototype of your puzzle, made of wood.

A ***prototype*** is a *mock-up* of the real (production-grade) object so that a 3D object can be handled and analyzed.

The prototype is not necessarily made of the same material as the real object. The materials used for prototypes are generally easy to work with and/or readily available so that the prototype (and revised prototypes) can be quickly and inexpensively made. The prototype for this project is made from 3/4″ wooden blocks. The parts that we "will manufacture for sale" will be PLA plastic (Item #6 of the Design Constraints). The notes on your drawings should indicate the material is PLA (not wood).

The following pages describe the ***deliverables*** in detail. **CREATE <u>YOUR OWN</u> PUZZLE CUBE DESIGN.** <u>**Do not copy the design given**</u> **in the following pages.**

Figures 2, 4 and ***5*** show the exploded assembly and detailed part drawings with *instructional notes*. ***Figures 10*** and ***11*** show the drawings <u>without instructional notes/markings</u>. <u>**Do not**</u> **include the instructional notes in your drawings** (<u>yours should look similar to ***Figures 10*** and ***11***</u>).

1. DESIGN REPORT

A ***design report***, composed of, in order:

(a) a ***cover sheet***.
(b) an ***exploded assembly drawing***. Use a pencil for the drawings.
(c) a ***bill of materials***.
(d) ***detailed part drawings***, one for each of the 5 individual parts, in order. Use pencil.

The bottom of each drawing should be placed towards the right side of the packet.

a. COVER SHEET

The ***cover sheet*** must be typed and include the following information:

- your name.
- the words *ENGR 100*.
- the words *Puzzle Cube Design Project*.
- the due Date.
- the problem statement.
- the design constraints.

See ***Figure 1*** for what the *cover sheet* should look like. **Use this format**. Note that the material listed is for the production parts: PLA (not wood, which is the prototype's material).

Duncan McGehee

ENGR 100

Puzzle Cube Project

Due May 5, 2015

Problem Statement:
Design a 3-dimensional puzzle cube for children 8–10 years old.

Design constraints:
1. The assembled cube must be composed of 3×3×3 smaller cubic elements.
2. The assembled cube must have overall dimensions of 2.25″ × 2.25″ × 2.25″.
3. The cube must be composed of 5 pieces, each a different color.
4. Each piece must incorporate between 3 and 6 smaller cubic elements.
5. Some of the pieces must interlock.
6. All parts are to be made of polylactic acid (PLA).

Figure 1 Cover sheet of design report.

b. EXPLODED ASSEMBLY DRAWING

The ***exploded assembly drawing*** (***Figure 2***) shows how the parts fit together by separating them along the three primary axes (directions) of the assembly. The *exploded assembly drawing* should:

- be drawn on isometric paper (provided) to represent the parts in 3D. **Hint: use a ruler**.
- be drawn at a scale of 2:3 (2/3 full size), with a note on the drawing indicating the scale. Each equilateral triangle on the paper has a side of 1/4″ (0.25″). Two sides (1/2″=0.50″) will represent the edge of one 3/4″ (0.75″) wooden cube (the ratio 0.50:0.75 is 2:3).
- **show one part in a fixed position, with all other parts shifted away from it to show how they fit together**. Each part should be shifted in **only** one direction, and the parts should not touch each other in the picture. It is recommended that you choose the "central" piece of the puzzle to be in a fixed position (draw that piece at the center of the isometric paper). In ***Figure 2***, Item #4 is the central piece; all other pieces are slid away from it.
- **show the parts oriented as in the assembled puzzle.** Do not rotate them. The *assembly drawing* is the "solution" to the puzzle. Do not draw outside of the frame.
- not represent the individual ¾-inch cubes. Draw each part as if it is one solid piece.
- **number the parts** (①, ②, ③, ④, ⑤) to agree with the ***bill of materials***.
- not include any dimensions, and not include hidden lines.
- include the following information in the ***TITLE BLOCK*** (**PRINTED, CAPITAL LETTERS**):
  - your **NAME**, and the **INITIALS** of the person who checked your drawing.
  - the title **PUZZLE CUBE ASSEMBLY**.
  - The drawing number **PC-*n*00**, where *n* is a non-zero digit of your choice (here, PC-200).

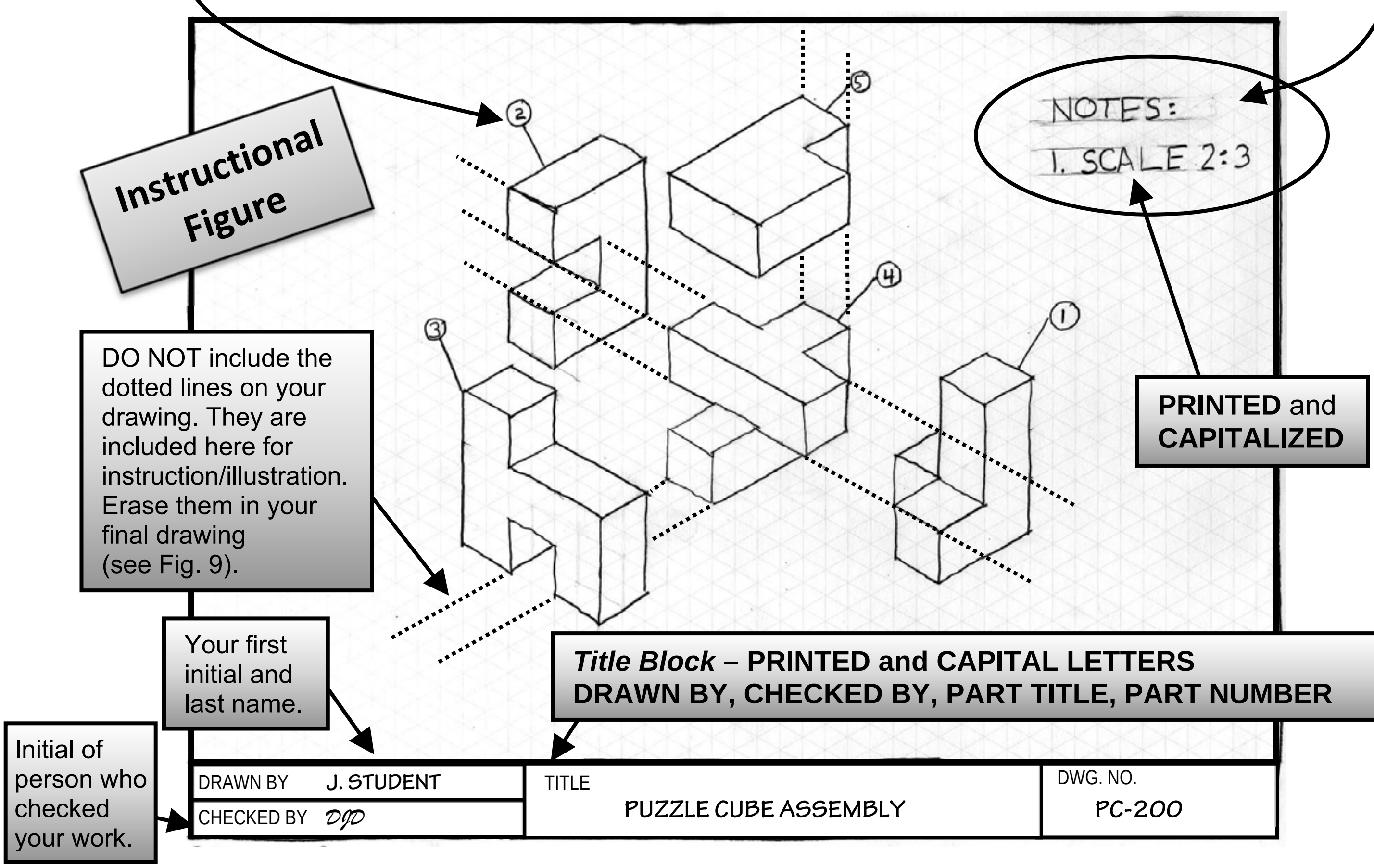


Figure 2 *Exploded Assembly Drawing on isometric paper*. Follow this format, but **do not copy this design**. Here, Part 4 is the central part, with each of the other parts moved away from it along one axis (direction) as illustrated by dotted lines. *Isometric paper* makes representing one part in 3D relatively easy, but spatial relationships between parts can be difficult to see. **Do not include the dotted lines on your final drawing (erase them); they are included here for instruction**; see ***Figure 10*** for the assembly drawing without instructional notes.

c. BILL OF MATERIALS

The ***Bill of Materials*** (shown in ***Figure 3***) lists the parts and quantity of each part needed (sometimes more than one copy of a particular part is needed). The Bill of Materials (BOM) ensures all parts are on-hand when assembling (or packing) the system.

The BOM should be typed, and be on a separate page after the exploded assembly drawing. The BOM should:

- list the individual parts with Item No. matched to the exploded assembly drawing.
- use the individual drawing number as the part number.
- indicate the quantity of each part required.
- include a brief description of the part (e.g., "Red part"). Parts are given both numbers (for organizing), and names (for descriptions). For example, Part No. 43217 might be the "baseplate, or "gasket, 3.5-inch" or "Bolt, 3/8 in. diameter".

Bill of Materials: Puzzle Cube

Item No. in Exploded View	Part Number	QTY	Description
1	PC-201	1	Red part
2	PC-202	1	Green part
3	PC-203	1	Blue part
4	PC-204	1	Yellow part
5	PC-205	1	White part

Figure 3 *Bill of Materials*. Make the part-numbers correspond to the drawing numbers. Item 1 is Part Number PC-201 , which is in drawing PC-201; Part 2 is Part No. PC-202, etc.

---

d. FIVE (5) INDIVIDUAL DETAILED PART DRAWINGS

The **five (5) individual detailed part drawings** should each follow these general rules:

- Include the three ***orthographic views***: ***front***, ***top***, and ***right side views*** arranged as shown in ***Figure 4***. Draw the views at 1:1 scale (full scale), and completely dimension them. Each square in the quad-grid paper is 1/4″, so 3 squares is 3/4″ (the edge of one wooden cube).
- Include a 2/3-scale ***oblique*** **drawing** in the upper right corner. This view should show the ***front*** orthographic view in its true form, with the ***top*** and ***right side views*** receding 45° "into the paper." Do not include dimensions in the oblique view. Draw the oblique view at 2/3 scale, but do not include the scale information in the view.
- **Do not** label "Front", "Top" "Right" "Oblique" for the views. This arrangement is standard for engineering drawings; the reader wuld know that the ***front view*** is at the lower left.
- Align the views as illustrated in ***Figure 5***. The tops and bottoms of the ***front*** and ***right views*** should align, the lefts and rights of the ***front*** and ***top views*** should align.
- **Do not draw the individual ¾-inch cubes**, only the overall shapes of the parts (remember the wooden cubes are being used only to make the prototype; the parts are one solid piece).
- The drawings should be completely dimensioned and not over-dimensioned.
- Dimensions are given in inches, and to 2 decimal places, e.g., .75, 1.50, 2.25 (**not 1.5**). In the United States, inches are the assumed dimension in engineering drawings, so no inch marks are typically not included, i.e.: 1.50 not 1.50″. In engineering drawings, there is no zero in front of the decimal place.

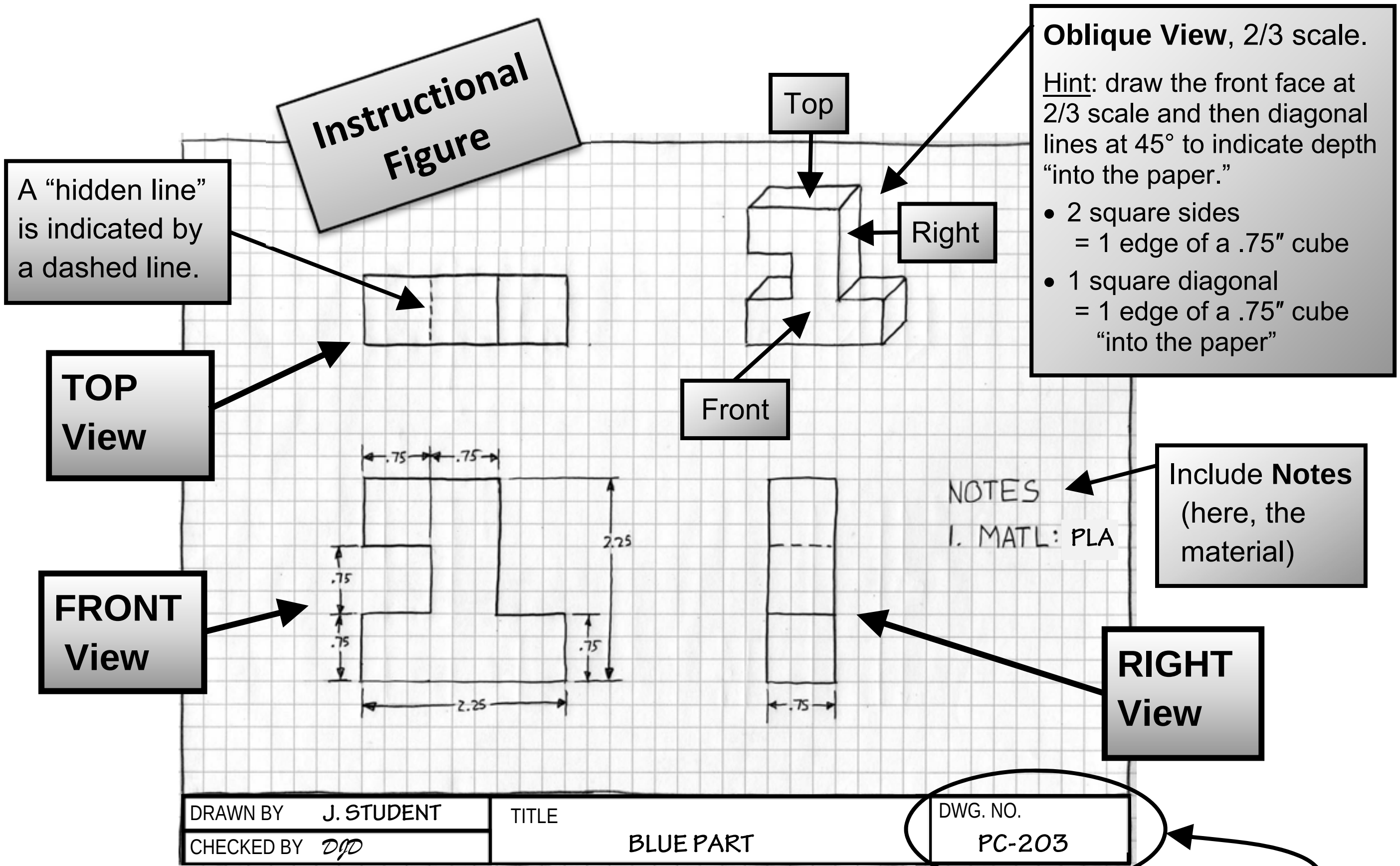


Figure 4 *Individual detailed part drawing for production*. **Follow this format**, but do not copy this design. The positioning of the views, clockwise from lower right, is: ***right view***; ***front***; ***top***; ***oblique***.
Do not label "**right**", "**front**", etc., in your drawing; this format is standard for engineering drawings.

Note 1: Hidden lines are indicated with dashed lines.

Note 2: PC-203 represents is "Puzzle Cube Part 203." Consider this the "200-series" of the Puzzle Cube line; Drawing "200" is the assembly drawing; "201" is part #1, "202 is part #2, etc.

Note 3: The **Title Block** includes **DRAWN BY**: Your first initial, last name; **CHECKED BY**: the initials of the person who checked your work (have them initial it with a pencil); **TITLE**: the name of the part; **DWG NO:** the drawing number.

See ***Figure 11*** for the detailed part drawing without instructional notes. Your drawing should look like ***Figure 11***.

- **Dimension lines have arrowheads at both ends**.
- **Do not over-dimension**. ***Over-dimensioning*** means the same feature is located more than once on the drawing, which causes confusion since there are different origins from which to measure. The location of each feature should only be indicated once in the three orthogonal views (avoiding ambiguity).
  - Example 1: in ***Figure 4***, in the ***front view***, notice that the dimensions on the left side are .75″ and .75″, but there is no third .75″ dimension to reach the top of the part. The overall height of 2.25″ is already indicated on the right side of the front view.
  - Example 2: in ***Figure 4***, only the thickness of the part is indicated on the ***right view***… the vertical distances of the step and notch above the bottom (indicated by solid and dashed lines) are not dimensioned because they are already located in the ***front view***.
  - Example 3: in ***Figure 4***, the ***top view*** has no dimensions since all necessary dimensions have already been given in the ***front*** and ***right views*** (this may not always be the case).

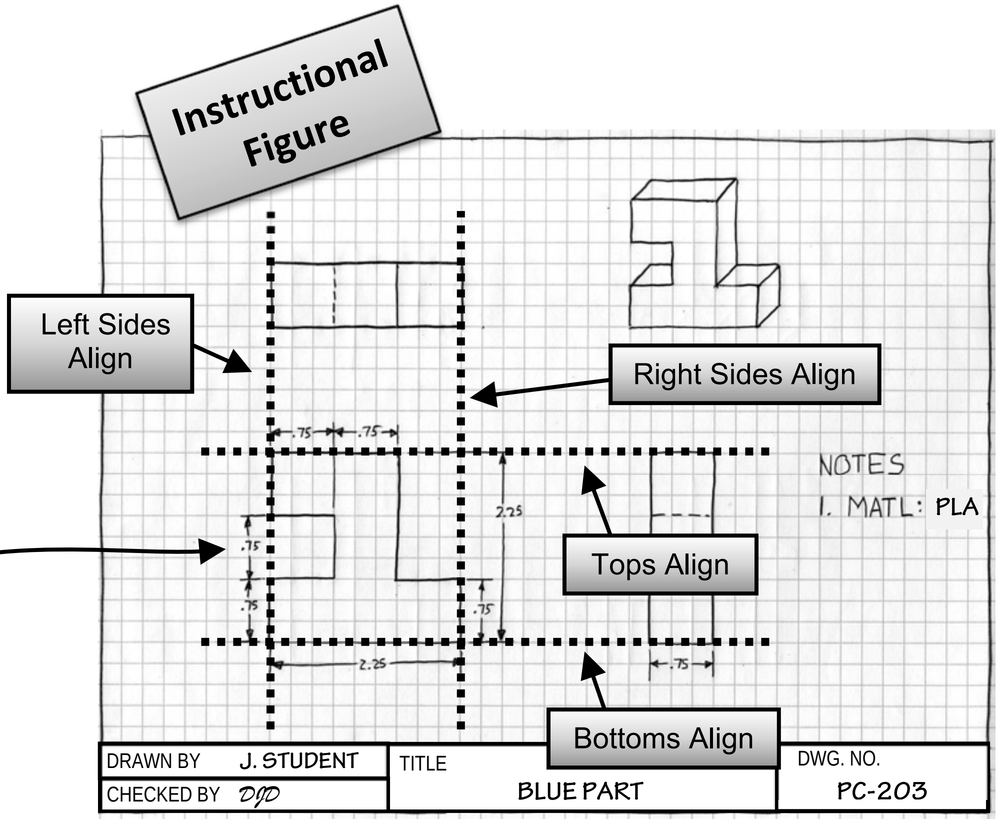


Figure 5 *Alignment of the three orthogonal views and dimensioning hints*.

Hint 1: Plan out where the views will be located so – as a group – they are approximately centered on the page. The first view you will draw is the ***front view***, as it is related to each of the other views by a simple 90°-rotation of the part. The front is typically the widest and tallest view.

Hint 2: The **top and bottom sides** of the ***front view*** and ***right view*** are aligned, as illustrated by the heavy dotted lines. The **left and right sides** of the ***front*** and ***top views*** are aligned. Aligning the views makes interpreting the drawing easy. **Do not include the heavy dotted lines on your final drawings**; they are included here for illustration purposes. Your final drawing should look like the drawing in ***Figure 11***.

Hint 3: Here, the dimensions in each view are consistently drawn from the same origin or baseline(s), so that measurements are made in the same directions. In the ***front view***, the origin is at the bottom-left. Horizontal dimensions always build (add) from the left side (towards the right); vertical dimensions build from the bottom (upward). In the ***front view***, the top of the notch is dimensioned upward .75″ from the bottom of the notch, not downward .75″ from the top edge.

Dimensioning in the same direction (e.g., left to right, bottom to top), makes it easier to:

1. Read the drawing (your eyes are always moving from the left to right, or bottom to top).
2. Build the object. Think about drilling holes… it is better to measure their locations from the same side, not opposite sides.

- Be careful not to assume dimensions.
  - Example: in ***Figure 4***, in the ***front view***, the dimension .75″ is given at both the lower left and lower right sides since they locate two different features (the bottom of the notch and the top of the right step). While it looks like those two features are the same distance above the bottom, **never** assume someone else can read your mind. Make the dimension of each feature clear so that the feature is made where you want it. If the .75″ at the lower right of the front view is not indicated, the right step might end up .75″ from the bottom, or it might not. When dimensioning drawings, it is important to be clear, complete and unambiguous.
- Draw dimensions from a single origin and set of baselines, as discussed in ***Figure 5*** (i.e., on the ***front***, dimension horizontal lengths from the left, vertical lengths from the bottom).
- ***Dimension lines*** have arrowheads at both ends to indicate the dimension is "from here to here". Include arrowheads.
- Don't forget to include a single-view general ***oblique*** drawing in the upper right corner. This view should show the ***front orthographic view*** in its true form (at 2/3 scale), with the ***top*** and ***right side*** views receding 45° "into the paper." Do not include dimensions in this view. Draw the ***oblique view*** at 2/3 scale, but do not include the scale information in the view.
- Include the material information in the drawing **NOTES** as follows: **1. MATL: PLA.**
- Include the following information (**PRINTED**, **CAPITAL LETTERS**) in the ***title block***:
  - **DRAWN BY:** Your first initial, last name (e.g., in the example "J. Student"),
  - **CHECKED BY:** get someone in the class to check your drawing and initial that they have done so and made recommendations (e.g., in example, initials are "DGD").
  - **TITLE**: the part name (e.g., **RED PART**, **BLUE PART**)
  - **DWG.NO**.: The ***drawing number***, e.g., **PC-201** through **PC-205** (or replace "2" with any non-zero digit of your choice).

Quick Hints on Drawing *Orthogonal Views, Visible Lines* and *Hidden Lines*

An ***orthogonal view*** of a 3D object (part) is a view along one of the three main axes of the object. Think of putting the object in an invisible cube and looking perpendicularly (orthogonally) through the front of the cube, then through the right side, and finally through the top. This gives you the ***front view***, ***right view*** and ***top view*** of the object. Two-dimensional (2D) drawings are made of each view; the three orthogonal views as a group illustrate the 3D object. For a simple cube, you would draw a square for each of the three views. For a cylinder standing on its end, the ***front*** and ***right views*** would be drawn as rectangles (the sides of the cylinder have no sudden changes in geometry), and the ***top view*** would be drawn as a circle.

The first step in drawing an orthogonal view is to draw the outline of the part in the view you are considering. Then draw any ***visible*** and ***hidden*** features. These features are sudden changes in geometry that you would encounter as you move into or out-of the paper.

A sudden change in the geometry that you can see in the view is indicated by drawing a ***solid line***, called a ***visible line***. Examples include steps along the direction of the viewing axis (i.e., perpendicular to the paper).

A sudden change in the geometry that you cannot see in the view is indicated by drawing a ***dashed line***, called a ***hidden line***. A feature is *hidden* from view when it is behind physical material. However, it is still drawn (as a dashed line) to help visualize what is going on in 3D.

Figures 6 and ***7*** show how the ***top*** and ***right views*** are created for the Blue Part (***Figure 4***). Note that there are no solid or dashed lines within the outline of the ***front view*** of ***Figure 4*** because there are no changes in depth of the part as viewed from the front – it is uniformly one-block thick.

Figure 8 shows how a 3-dimensional object is viewed from the ***top***, ***front***, ***right***, and the three 2-dimensional drawings that result.

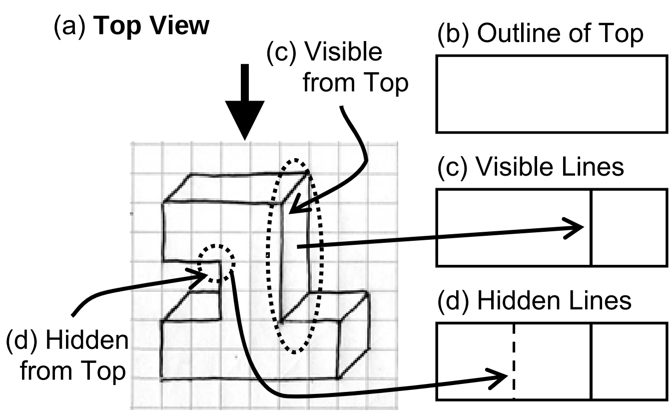


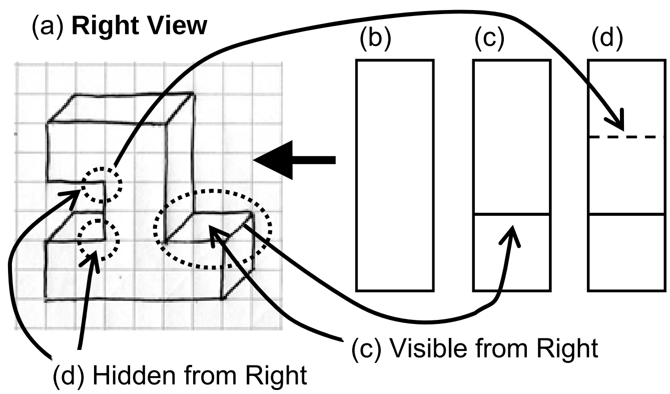
Figure 6 *Drawing the* ***Top View****.*

a. View the Top of the Blue Part (see ***Figure 4***).

b. Draw the outline of the ***top view***.

c. **Draw sudden changes in geometry that are <u>visible</u> with *solid lines* (*visible lines*)**. Here the depth of the part changes due to the step/edge at the right. The solid line locates the wall, which viewed from the top, separates the "roof" and the step of the part.

d. **Draw sudden changes that are <u>hidden</u> with *dashed lines* (*hidden lines*)**. The notch at the left of the part cannot be physically seen from the top. The top right of the notch is located by the dashed line. The bottom right of the notch is a



E

Figure 7 *Drawing the* ***Right View****.*

a. View the Right Side of the Blue Part.

b. Draw the outline of the ***right view***.

c. **Draw *visible lines* with *solid lines***;
Here the top of the step, 1/3 of the way up.

d. **Draw *hidden lines* with *dashed lines***.
The notch on the left cannot be seen from the right. The top of the notch is located by the dashed line. The bottom of the notch is behind the top of the right step – a hidden line <u>behind</u> another line; thus, the bottom of the notch is not represented.

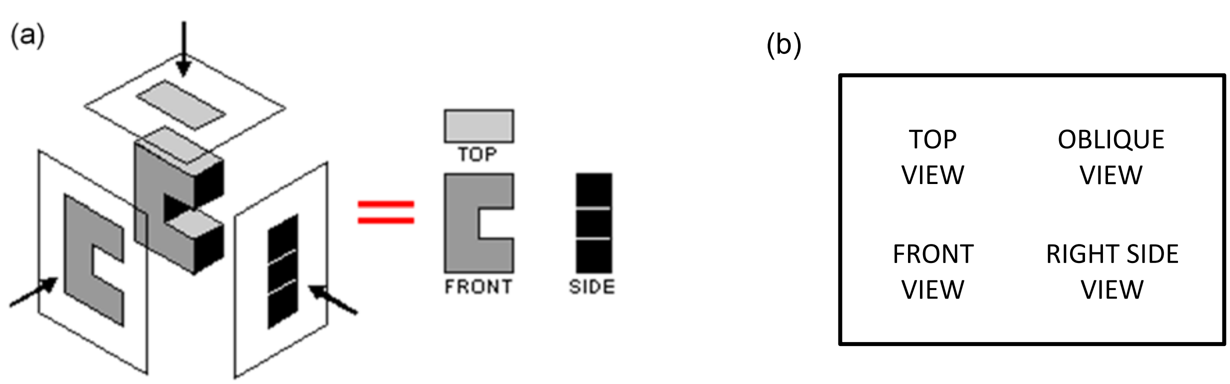


Figure 8 (a) Three-dimensional object viewed from the ***top***, ***front***, ***right side***, and the three 2-dimensional drawings that result. http://www.foothillsgraphics.com/images/ortho1.gif Accessed October 4, 2017. (b) Reminder of the location of views on detailed part drawings.

2. WOODEN PROTOTYPE

A ***full-scale hardwood prototype*** (***Figure 9***) must be included with the report.

To build the prototype, glue several 0.75″ wooden cubes together to make each of the five individual parts.

Each of the five parts should contain 3 – 6 cubic elements (no less than 3, nor more than 6).

The five parts should fit together to form the larger puzzle cube.

<u>CAUTION</u>: align the individual cubes carefully or you will have difficulty putting the individual parts together.

Each part may be painted the appropriate color, <u>OR</u> labeled with its name (e.g., BLUE).

Paints are available in M-212. Please arrange with the instructor if you wish to use them.

<u>CAUTION</u>: If you choose to paint, let the parts dry before assembling the puzzle.

<u>CAUTION</u>: Thick coats of paint will make it difficult to fit the puzzle together. The paints in M-212 should provide a coat that is thin enough.

The prototype that is submitted must:

a. be submitted fully assembled (the cube must be "solved").

b. be able to be disassembled into the 5 individual parts.

c. have individual parts that are:

- colored the appropriate color, <u>or</u>
- labeled with its appropriate color (e.g., write the word BLUE).

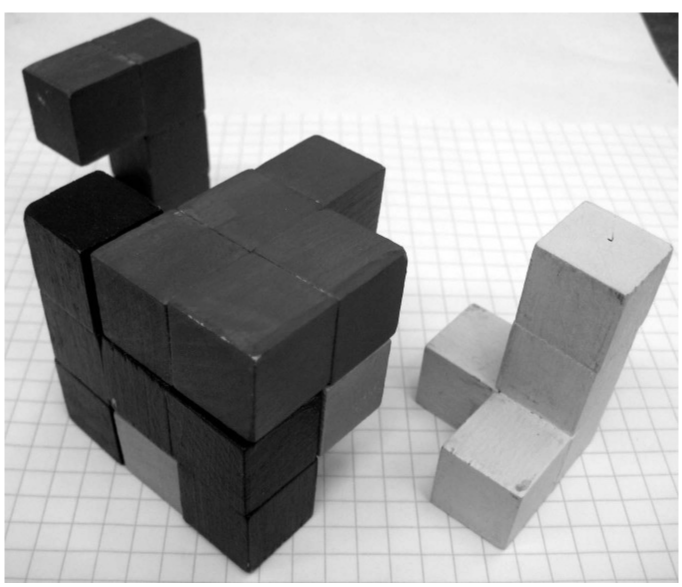


Figure 9 *Wooden prototype*.

Appendix A: Format for drawings <u>without</u> instructional notes on them.

Your final drawings should look like these examples.

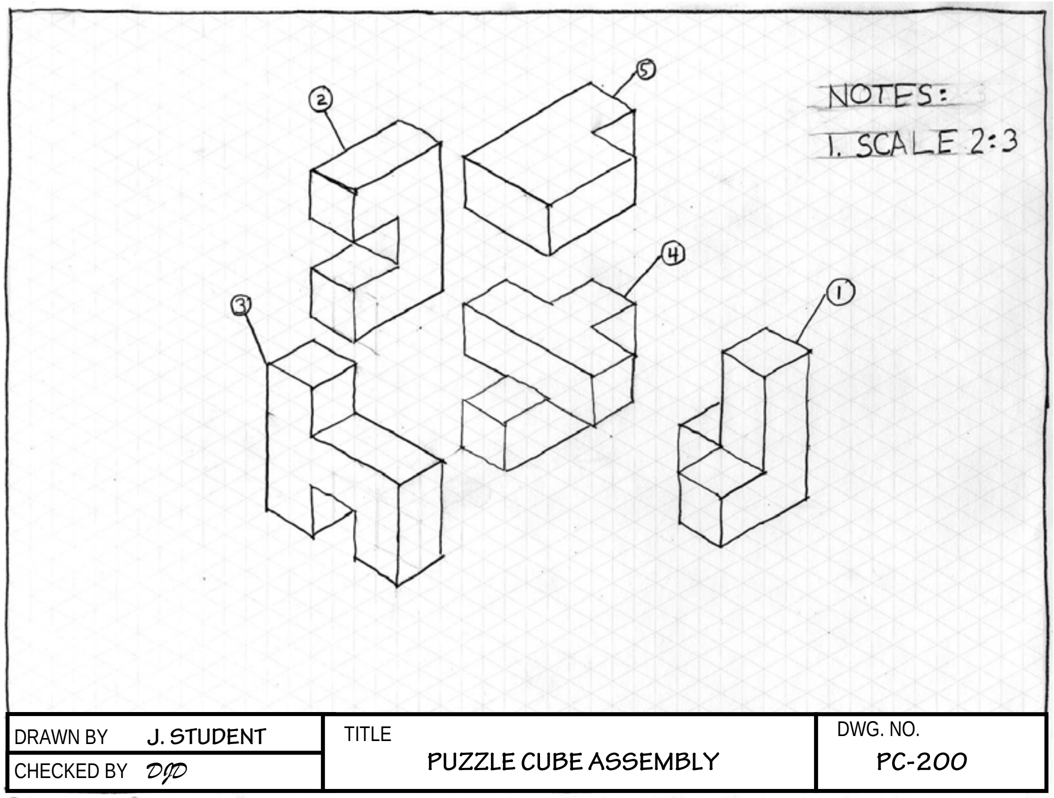


Figure 10 *Exploded Assembly Drawing on isometric paper* (guide lines erased).

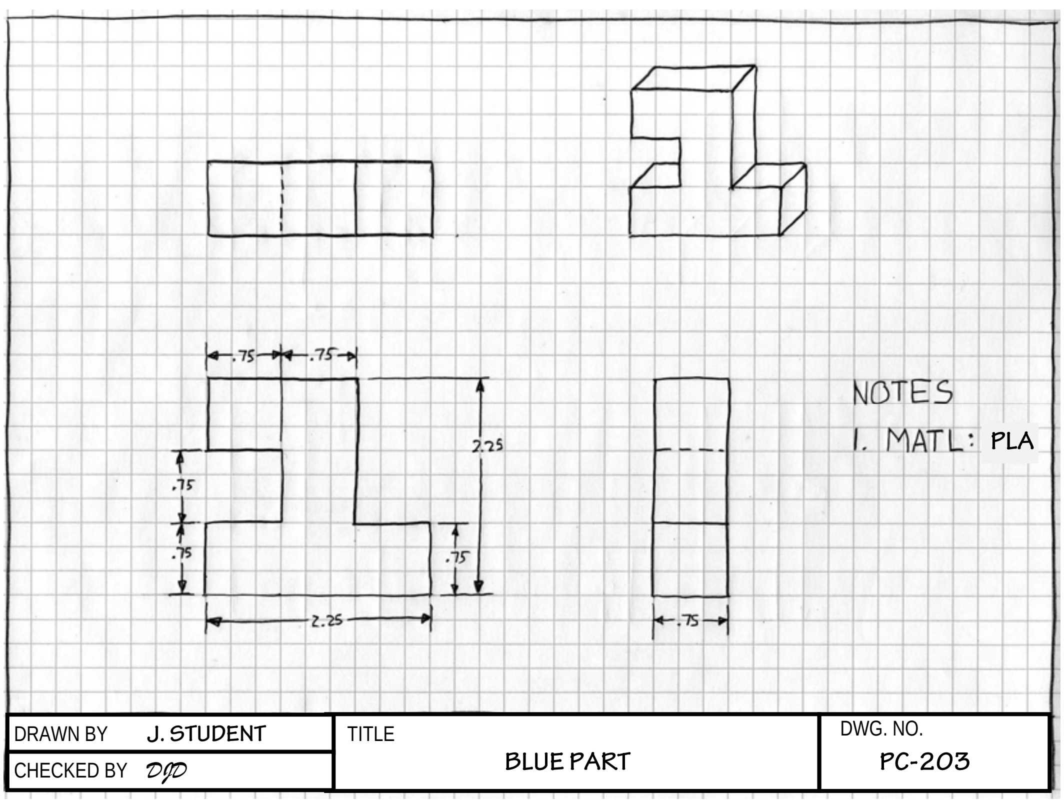


Figure 11 *Detailed part drawing on quad-paper*.