The Residential Design Process

A Student’s Guide

By Craig L. McAllester
INTRODUCTION

Welcome to The Residential Design Process. For the first time a text that shows how to do a complete set of building documents in CAD. The Residential Design Process is a student’s guide to learning the step by step process of designing a residential home. The content within this text is intended to the intermediate level student. This design process begins with the civil site plan and moves forward to the floor/framing, then through the plumbing and electrical plans.

The Residential Design Process uses the A+CAD software technology as the tool to draw the engineering/architectural plans for this project. A+CAD is a key component of The CAD Academy’s package, A+CAD offers the familiar AutoCAD® user-interface, functionality, and compatibility. The A+CAD technology offers the industry standard compatibility with AutoCAD®-native DWG files, commands, applications, and command set as well as programming APIs, such as LISP and SDS (A+CAD’s application programming interface).

A student’s success in this course is directly related to his or her ability to understand how to proceed in traditional and non-traditional class settings. It is imperative for students to:

1. Read all material carefully. Reread the material several times for total understanding. DO NOT SKIM.

2. Understand the concept of an activity before you start the process of typing commands on the keyboard.

3. The information you will type is presented in numbered sequence. Follow the steps carefully, watching the screen as you proceed.

4. Read the concepts again if you are having difficulty understanding a particular item.

5. Repeat the steps of an exercise over and over to develop mastery. Mastery means you are able to complete an exercise without looking at the book, and understand why you performed that particular function.

6. Ask questions if you do not understand or if you are having difficulty with the key strokes.

The Residential Design Process resources are flexible and instructors should feel comfortable supplementing curriculum resources that they have found successful throughout the years.

We welcome your suggestions, and hope that you will become part of the collaborative effort in educating our future engineers and architects.
IMPORTANT NOTE FOR INSTRUCTORS

The script and drawing files that are viewable when opening The Residential Design Process folder are referenced in specific sections of this text to provide visual representations.

ABOUT THE AUTHOR

Craig L. McAllester is a designer and CEO of CAD Construction & Design Co. His company provides Residential, Commercial, Industrial, and Tenant Improvement Designs. Mr. McAllester offers design expertise, architectural drawings, building code review (UBC 1988-1997 and IRC / IBC 2000-2006), project estimating and ADA compliance for accessibility and specializes in SIP, ICF Construction, Green Building, and Smart Home Design. He is also a coordinates civil, structural, mechanical, plumbing, and electrical plans as a consultant. In addition, Mr. McAllester invented and patented PitchFinder®, a tool for measuring roof pitch.

Rudy Aguilar is a Career and Technical Education Teacher at Apollo High School in Glendale, Arizona. Mr. Aguilar played a crucial role in editing this curriculum and ensuring the texts learning model was in line with level entry students. Mr. Aguilar is one of Arizona's top pre-engineering/architectural instructors who successfully use outcome based instructional methods. He has worked closely with industry and has held Senior Drafting positions for companies in the Phoenix area during his spare time. For the past eight years Mr. Aguilar has also taken an active role in State and National Education Associations for Professional and Personal Leadership Development.

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CONTENTS OVERVIEW

CHAPTER 1
Managing a Chronological File System.................................4

CHAPTER 2
Creating a Library of Symbols, Details, and Notes...............5

CHAPTER 3
The Site Plan, Sheet A1.................................6

CHAPTER 4
The Floor Plan, Sheet A3 .....................................................13

CHAPTER 5
The Roof Framing Plan, Sheet A4 ........................................28

CHAPTER 6
XREF the Floor Plan into the Site Plan.................................41

CHAPTER 7
The Elevations, Sheet A5 .....................................................47

CHAPTER 8
The Foundation Plan, Sheet A2..........................................59

CHAPTER 9
The Building Section, Sheet A5 ..........................................67

CHAPTER 10
The Foundation Details, Sheet D1 .....................................78

CHAPTER 11
The Framing Details, Sheet D2 ..........................................85

CHAPTER 12
The Plumbing Plan, Sheet P1 ..........................................90

CHAPTER 13
The Electrical Plan, Sheet E1 ..........................................93

CHAPTER 14
Appendix ..............................................................................104
OVERVIEW

You are well on your way to becoming a successful drafter. So far, you have learned many of the fundamentals of the drafting profession. You can measure, sketch, and describe objects through drawing orthographic projections. You can communicate your designs with a manufacturer by creating working drawings and assembly drawings, or providing illustrative pictorials of objects for a customer. You have the basic computer skills and understanding of CAD software. These skills are just the basics of the profession. There are many fields of drafting for you to explore while applying the skills you have learned thus far. Remember that you will have to learn additional and unique skills related to your chosen field.

Learn about as many fields as you like. Exploring different drafting careers will give you the opportunity to find your niche and help to plan for your further education. Use your own interests and hobbies as a starting point. Perhaps your interest of fixing, building, or designing things means you may be interested in mechanical drafting. Or your knack for interior design or landscaping means you want to learn more about architectural drafting. Perhaps your curiosity for constructing the tallest building, the longest bridge, or the most extravagant rollercoaster means you desire to learn more about civil drafting. So what kind of drafter do you want to become?

The rest of this textbook is divided into three career fields of the drafting profession. These three fields are the foundation for the many other drafting fields not mentioned here. Select one or more of the fields you want to gain a more thorough understanding. You can learn these fields in any sequence you like. Remember that this is only an introduction to each profession. These lessons are designed to prepare and inspire you to further your drafting education.
Chapter 4

The Floor Plan, Sheet A3
Once the site information has been defined, design development of the home can begin. From the site plan, the setbacks and easements show where the home may be placed. The home must be designed to fit within these parameters. The topography also defines how the house will be positioned.

The term ‘plan’, as used in architectural design, refers to a drawing that is viewed from above and represents a horizontal section at 4’-0” above the floor line. The floor plan allows the designer to see how the building flows and how it will be used. For instance, having the kitchen near the garage allows the owner to carry groceries in from the car quickly, and having a family room adjacent to the kitchen brings the whole family together while the dinner is being prepared. Having the bedrooms separate from the television area allows some to sleep while others are watching TV.

Every family has different needs. If the family entertains often, what size rooms are needed to accommodate the gathering? If there are several children, does each child need his or her own bedroom? How many bathrooms will the children need? Is there a family member with special needs? The questions are endless. The designer must identify the family’s most important needs in order to limit the design possibilities. Lesser important wants and desires can be taken into consideration later in the design process.

Usually your clients have been dreaming of building a home for some time. They spend time looking at model homes or going through plan books to get ideas of what they would like. Those ideas are then drawn in the form of a floor plan.

A floor plan shows room sizes and dimensions, changes in elevation, such as stairs going up or down from the plan level. It shows doors and door swings, cabinets and closets. Also, the floor plan can show where furniture, fixtures and equipment are located. Perhaps a special piece of furniture needs a special place in the home.

If the clients have no idea where to begin with the design, they might begin by listing the rooms that they will need and what is to go into each room. For instance, the master bedroom might need a king-size bed, two night tables, two dressers and an armoire to house a TV and linens. With this kind of information for each room in mind, the designer will often start with a letter size sheet of paper and hand-draw a bubble plan. The bubble plan, though not to scale, shows how rooms might be arranged. The example below shows the bubble plan of our house project.

The Bubble Plan

Once the clients’ needs are established, a floor plan is started and drawn to scale. An accurate floor plan is crucial for project development as it will become the background drawing for all of the building plans. The foundation plan, floor framing plan, roof framing plan, electrical plan, mechanical plan, plumbing plan, etc. all will be drawn using the floor plan. Even the building elevations and the site plan will be developed using the floor plan as you will soon see.

Activity: Our house project floor plan will be drawn on a D-size sheet at a scale of ¼” = 1’-0”. Follow these steps to set up a new drawing for the floor plan.
1) The floor plan **Linear Units** are drawn as **Architectural** units. Enter the command **SETTINGS** or select **DRAWING SETTINGS** under the **SETTINGS** pull down menu. Select the **Drawing Units** tab at the top left.

In the Change settings for: box, select **Linear Units**. Set the Unit Types box to **Architectural** and the Display Precision box to 8 as shown at the right. (setting the precision to 8 here, allows for very accurate dimensioning)

The floor plan **Angular Units** are drawn as **Decimal degrees** units. In the Change settings for: box, select **Angular Units**. Set the Unit Types box to **Decimal degrees**. Set the Display Precision to 2. Ensure the Angular Direction is set to **Counter Clockwise** and that the Angle base is set to 0.00 as shown here.

2) **DIMSCALE** to 48 – our floor plan scale is \( \frac{1}{4}'' = 1' - 0'' \). Since there are 48 quarter inches in 12'', our **DIMSCALE** is 48.

3) **LTSCALE** to 24 – the linetype scale is \( \frac{1}{2} \) of the **DIMSCALE**, remember?

4) **LIMITS** are set to 0,0 for lower left point and 144,96 for upper right. A D-size sheet is 144 feet wide and 96 feet tall at a \( \frac{1}{4}'' = 1' - 0'' \) scale.

5) **GRID** to 48 sets the grid spacing to 4' - 0" in both the X & Y direction.

6) Just as we did on the site plan, you will add layers to this new drawing. Each layer name begins with the building level assignment ‘1ST’, indicating the first level. In a multi story building, the level assignment is different for each level. After the level assignment, enter the layer name which describes the entities that go on that layer. Using a layering method like this helps to manage the many layers of a multi story building easier than if each level were in a separate drawing. (It also helps to ensure that the bearing walls are supported from one level to the next.)

Don’t be concerned with the number of layers; we will address them one at a time so you will understand when each is used. Use the **SCRIPT** command and run the 1st Level Floor Plan.scr script file. Note that some layers do not pertain to the floor plan, and some layers pertain to multiple plans. Any layer ending in a ‘-1’ or ‘-2’, etc. indicates that that layer has a broken linetype. Let’s have a look at the layers that the script file loaded:

- **1ST-AREA** is used to calculate the area of **POLYLINES** on the first level for our area calculations.
- **1ST-COLUMN** is used for columns or posts that show on the first level floor plan. They include posts from above, supporting the roof or second floor, and to below, distributing loads to the footing. Position the columns accurately, especially in a multistory building, for they assist the structural engineer in his task of calculating the building point loads.
• **IST-DEMO** is used for any entities to be demolished.
• **IST-DEMO-TEXT** is used for text relating to the demo layer.
• **IST-DIM-EXTERIOR** is used for dimensioning the exterior of the building including inside and outside corners, doors, windows, interior walls abutting the exterior walls and outside columns.
• **IST-DIM-INTERIOR** is used for all interior dimensions of the first level.
• **IST-DOOR** is used for all doors of the first level.
• **IST-DOOR-WINDOW-TEXT** is used to label first level doors and windows. This layer is frozen in all plans except the floor plan.
• **IST-ELECT** is used for electrical symbols on the electrical plan. The lineweight is darker than the **1ST-ELECT-TEXT** layer so that the symbols stand out on the electrical plan.
• **IST-ELECT-1** is used for connecting lighting and equipment to electrical switches on the first level and has a phantom2 linetype.
• **IST-ELECT-DIM** is used for dimensioning on the first level electrical plan.
• **IST-ELECT-TEXT** is used for notes and text on the first level electrical plan. (Electric symbols will go on the **1ST-ELECT** layer.)
• **IST-EQUIP** is used for first level equipment not otherwise listed.
• **IST-EQUIP-1** is used for first level equipment below or above the finished floor.
• **IST-FOUNDATION** is used for the foundation and will have a hidden linetype.
• **IST-FOUNDATION-DIM** is used for dimensioning the foundation plan.
• **IST-FOUNDATION-HATCH** is used for hatching the foundation plan.
• **IST-FOUNDATION-STEM** is usually indicated by the exterior wall line. Entities on this layer will fill-in where door openings occur and no exterior wall line exists.
• **IST-FOUNDATION-TEXT** is used for any foundation plan text or symbols.
• **IST-HATCH** is used for any hatch on the floor plan.
• **IST-JOIST-1** is used for the floor framing members of the first level.
• **IST-JOIST-2** is used for the floor framing members of the first level except it offers a different line type than the **1ST-JOIST-1** layer.
• **IST-JOIST-DIM** is used for first level floor framing dimensions.
• **IST-JOIST-TEXT** is used for first level floor framing text and symbols.
• **IST-MECH** is used for first level mechanical and HVAC (Heat, Ventilation and Air Conditioning) equipment.
• **IST-MECH-DUCT** is used for the first level HVAC ducting.
• **IST-MECH-DIM** is used for the first level mechanical plan dimensions.
• **IST-MECH-TEXT** is used for the first level mechanical plan notes.
• **IST-MILLWORK** is used for all millwork and base cabinets. Since this layer is turned on in all plans, millwork layers are used for other entities as well. For instance, exhaust fans are on this layer because exhaust fans show up in all plans just like cabinets do.
• **IST-MILLWORK-1** is used for the first level upper cabinets and shelving. This has a hidden linetype.
• **IST-OVERHEAD-EXTERIOR** is used for the edge of the roof or soffits etc. outside the building.
• **IST-OVERHEAD-INTERIOR** is used for attic scuttles and soffits, etc. inside the building.
• **IST-PLUMB** is used for all main level plumbing fixtures or equipment needing water supply and or DWV (Drain Waste or Vent).
• **IST-PLUMB-1** is used for first floor waste lines on the plumbing plan.
• **IST-PLUMB-DIM** is used for plumbing plan dimensions.
• **IST-PLUMB-TEXT** is used for text on the plumbing plan.
• **IST-RMNO** is used for labeling room names or numbers.
• **IST-ROOF-1** is used for joists, trusses, bridging, etc. on the roof framing plan.
• **IST-ROOF-2** is used for the same as **1ST-ROOF-1** but it offers a different line type.
• **IST-ROOF-BEAM** is used for heavier members as in beams and headers.
• **IST-ROOF-DIM** is used for roof plan dimensions.
• **IST-ROOF-RIDGE** is used for ridges and valleys on the roof plan.
• 1ST-ROOF-TEXT is used for roof plan text and symbols.
• 1ST-ROOF-WINDOW is used for skylight locations. This layer will be visible in the floor plan as a dashed line and in the roof plan as a continuous line.
• 1ST-SH-H is used for heavy shade.
• 1ST-SH-L is used for light shade.
• 1ST-SH-M is used for medium shade.
• 1ST-SH-VL is used for very light shade.
• 1ST-SLAB is used for concrete slabs beyond the building outline.
• 1ST-STAIR is used for stairs going up or down from the 1st level. Note which way the stairs are going with an arrow and note indicating up or down. Use capital letters if abbreviating the stair direction, as a ‘dn’, short for down, read upside down can be misconstrued as an ‘up’.
• 1ST-STAIR-1 is used for stairs beyond the level of the floor plan.
• 1ST-TEXT is used for any text that is to appear in the floor plan only.
• 1ST-WALL-BEARING is used for exterior and bearing walls.
• 1ST-WALL-NONBEARING is used for nonbearing walls.
• 1ST-WINDOW-EXTERIOR is used for exterior windows. There will be a header over any door or window. They will go on the roof-beam layer as we will see later.
7) The exterior walls are considered bearing walls because they carry both the weight of the roof from above (a gravity load) and resist the wind applied load (a lateral load). For our house project, the wall between the garage and the living space also is a bearing wall. Set the layer 1ST-WALL-BEARING current and draw the bearing walls in the following exercise.

8) **ZOOM ALL** and then turn ortho on. Use **F8** or type the command **ORTHO** to set it **ON**.

9) Start with the outermost wall line of the home. You will draw the garage separately.
10) Using the POLYLINE command, make a continuous POLYLINE to form the outside of the living space.

A) Begin by entering a starting point of 52’, 32’ for A in the drawing above.

B) Extending your cursor to the right and type in 24’ to point B.

C) Extending your cursor upward and type in 28’ to point C.

D) Extend your cursor to the left and enter 24’ to point D,

E) And finally, enter ‘C’, ↵ for close, taking you back to point A. You should have drawn a simple box.

F) PARALLEL the new polyline inward 6 inches to create the width of the exterior walls of the home.

G) Follow the same process for the garage wall. Start a POLYLINE at point G (same point as C) and extend your cursor to the right and enter 16’.

H) Extend your cursor down and enter 20’ and then to the left and enter 16’, taking you back to the house wall, creating the three exterior walls of the garage.
I) **PARALLEL** this new line to create a wall as before, except the garage wall is only 4 inches thick, so your offset will be 4.

J) Using the drawing above, clean up the corners and the openings by using **TRIM** and **FILLET**. There are 3 main door openings and one overhead door opening in the exterior walls. **EXPLODE** the walls and **PARALLEL** those lines to locate each door opening. **TRIM** the lines to form the jambs and **TRIM** the line of the inside wall between the jambs to create the door openings. The outside wall line indicates a change in floor elevation and is to remain.

K) **TRIM** the 6” walls where they intersect the 4” garage walls as shown.

L) Each exterior door must have a landing no narrower than the width of the door and no shorter than 36” in the direction of travel. Draw a landing at both exterior doors on the 1ST-SLAB layer.

11) That completes the exterior walls. Change to the first floor nonbearing wall layer. Using the dimensions given on the plan earlier in the chapter, draw the interior nonbearing partitions with the **LINE** and **COPY** commands and by offsetting the exterior walls inward using **PARALLEL**. **TRIM** for door openings and clean up wall corners with the **FILLET** command as shown in the plan.

i) Pay careful attention to where the dimension line leads. The dimensions are shown being measured to the edge of walls and to the sides of door and window openings. In a hand-drawn plan of years past, dimensions were drawn to the center of walls, doors, and window. Both are correct; however, the former is much easier to do in CAD because you have a corner or intersection to snap to. The center of a wall has nothing to snap to. Contractors indicate that it is easier to layout interior walls in the field when the dimensions are to one side rather than to the center.

ii) When you dimension to one side of a wall, make all the dimensions in that string snap to the same side of each wall. Be consistent.

12) Add the windows and doors as shown in the plan. The designations for the door and window sizes are the same. They read the width in feet and inches and then the height in feet and inches. So a door that is read 2668 is a 2'-6" wide by 6'-8" tall door. A window that is read 4050 is 4'-0" wide and 5'-0" tall. This can be confusing, so be careful! The labels on the plan will describe how wide to make the openings. Below are some typical door and window symbols.
13) The closet in the garage will house our water heater. In the drawing above, the fuchsia line outlining the closet is on the slab layer and it represents a step up from the garage floor. That line will show on the foundation plan indicating that the closet floor has the same elevation as the house. Draw these two lines.

A) The window pictured above is a 4'-0" wide by 5'-0" tall sliding window. The XO designation indicates that it is a horizontal sliding window, the X = active sash and the O = fixed sash.

The OH, overhead door, is a 10'-0" wide X 7'-0" tall door. The closet door is a 2'-6" wide X 6'-8" tall Hollow-Core door. The door into the house is a 2'-8" wide X 6'-8" 20 minute fire rated door.

Draw all the doors and windows as shown on the following plan.
14) Once the walls and doors are in place, draw in the cabinets and millwork.

A) **PARALLEL** the walls to get a 2’ wide kitchen base cabinets. Trim the cabinet for the 38” refrigerator opening. Change that to the millwork layer.

B) In each closet, **PARALLEL** for a shelf 12” as shown. Again, verify the shelves are on the millwork layer too.

C) **PARALLEL** each shelf line 2” more to show the hanging rod. That will go on the millwork-1 layer. Do the same for all closets as shown.

D) Also, on the millwork-1 layer are the 12” deep upper kitchen cabinets. Note the area above the cooktop for an exhaust fan and hood. TRIM the cabinets for the window as well. **CHAMFER** the corner cabinet 12”.

E) Create an exhaust fan symbol, on layer 0, and block it to your library. Insert the symbol in the bathroom. Though it is not millwork, it will be inserted on the millwork layer because the fan will need to show only when the cabinets show. When the cabinets are frozen, as in the roof plan, the fan should be frozen too. The diameter is 3/16” and the text height is 3/32”. The insert scale is 48.
15) To draw the plumbing fixtures, obtain fixture sizes by searching manufactures’ websites or your local home center. Be accurate with your dimensions because you will use these blocks again and again. You might even get an assortment of appliance sizes while doing your research. Start a new drawing, create each fixture, and block it into your symbols library. Each should be drawn on layer 0 and then inserted on the 1ST-PLUMB layer, UNO (unless noted otherwise). Here is a list of what you will need:

- Stove
- Toilet (WC)
- Lavatory sink
- Bath tub
- Refrigerator
- Kitchen Sink
- Dish Washer
- Washer / dryer
- Water heater
Draw each symbol and insert them as follows:

**A)** INSERT the stove onto the millwork layer. The other kitchen appliances will appear on the plumbing layer.

**B)** Insert the toilet or water closet, (WC) symbol. Maintain a minimum of 15" from the centerline of the WC to any side obstruction, as in a wall, tub, or sink.

**C)** The lavatory bowel goes on the plumbing layer. Draw the lavatory base being careful to maintain the WC clearances. It will go on the millwork layer.

**D)** Insert the bathtub. Note that all the bathroom plumbing fixtures back up to the same wall minimizing the length of the plumbing runs. Note too that the wall is a 6’ wall which will allow for a 2” plumbing vent.

**E)** Insert the refrigerator. Maintain a minimum clearance for a 12” cabinet adjacent to the refrigerator.

**F)** Insert the kitchen sink. Center it on the window.

**G)** Insert your dishwasher. Note the broken linetype on our dishwasher in the drawing below. It indicates the dishwasher is below the countertop.

**H)** Insert the washer and dryer. Ensure you have a 6” plumbing wall behind.

**I)** Insert the water heater and show the path that the pressure relief valve will follow. Later, we will add a note explaining the code relating to that valve.
16) Start a new drawing and, using MTEXT, type each note from the plan above onto layer 0 and use 3/32” text. Block each into the notes subfolder. Insert them into the plan on the 1ST-TEXT layer with a scale of 48. Whenever you insert your notes from your notes subfolder, reread each to ensure that all is pertinent to the specific application. If you need to edit the text, you may explode it, but don’t forget to put it back on the 1ST-TEXT layer afterwards. Use a top center justification, typical, for all the notes.

A) It is required to have a water resistant finish to 6’-0” above the drain height.

B) Every attic space over 30” high needs to have an attic access. The access may be a simple 22X30 scuttle or an attic stair.

C) Note the wall thickness and the type of wall. In our case, it is a wood frame wall, either 2x4 or 2x6, with studs spaced at 16” O.C.

D) A garage is an area susceptible to fire. These notes pertain to fire protection.

i) The walls and ceilings are required to have a fire rated assembly where they abut (touch) any living space and at any bearing wall.

ii) The door between the garage and the dwelling unit must be either a solid wood door or a metal door with a honeycomb core, each with a minimum of 1 3/8” thick, or a 20 minute labeled fire rated door assembly. The door must be self-closing and tight-sealing.

iii) Any appliance with an ignition source located within the garage or in a utility room off the garage shall be elevated 18” above the garage floor.

E) This note describes how and where the water heater relief valve may be installed.

F) The last note in our plan concerns the dryer vent.

17) Add the room names as shown. The text is 6” high except in the bath and laundry where space is too tight. The labels will go on the 1ST-RMNO layer.

18) To finish the floor plan, we need to insert a title block into paper space and edit the attributes.

A) First, open the title block drawing and look at the notes 1-4 in the body of the block.

i) This area is reserved for a fictional company logo that you are to create.

ii) This area is reserved for an informational block which we will discuss shortly.

iii) This area is reserved for revision numbers contained within a block which you will be drawing in another lesson.

iv) This area contains attributes and is to remain as is.

B) Once the logo is complete, save your title block to the symbols library and close the drawing and open the floor plan.

C) It is assumed that you understand the use of paperspace and modelspace, so follow these steps to insert the title block.

D) PSLTSCALE 1

E) TILEMODE 0, notice the change to the UCS icon.

F) ATTDIA 0

G) INSERT TITLE-D1

(i) The insertion point is always 0,0 for the title block.

(ii) The scale factor is 1 for both X and Y

(iii) The insertion angle is 0

(iv) The sheet # is A3

(v) The drawing scale is 1/4” = 1’-0”

(vi) Title-1 information is FLOOR

(vii) Title-2 is PLAN
H) Set the paperspace grid for a 36X24 sheet: **LIMITS** for the lower left are 0,0 and for the upper right **36,24**

I) **Turn the GRID ON** and set it to 2.

J) Next, **ZOOM ALL** to see the entire title block.

K) **Make a new layer called “VPORT”** and set that layer current.

L) **Create a view port, MVIEW, 4,2→ 30,22→**

M) **Set layer 0 current.**

N) **Type MSPACE.** Now you are inside the view port.

O) **ZOOM→ EXTENTS→**

P) Then set the scale to \( \frac{1}{4}” = 1’-0” \) by typing **ZOOM→ 1/48XP→**

Q) **PAN** if needed to center the drawing. Type **PSPACE** to take you back to paperspace.

R) **FREEZE** the VPORT layer.

S) **INSERT** the DET_TAG symbol and the north arrow symbol onto the title block and orient the north arrow pointing up as shown below

T) Open the file info.dwg and save it to your PROJECTS directory. Edit the text in this drawing to reflect your fictional client’s information. Using a separate drawing for this information and xrefing it into the title block allows you to make changes to this information in all drawings quickly.

U) **XREF** the file info.dwg onto the title block of your drawing. The insertion point is 0,0 and the scale is 1.

V) **Now, save the drawing again.**

Congratulations! You have just created a complete floor plan.