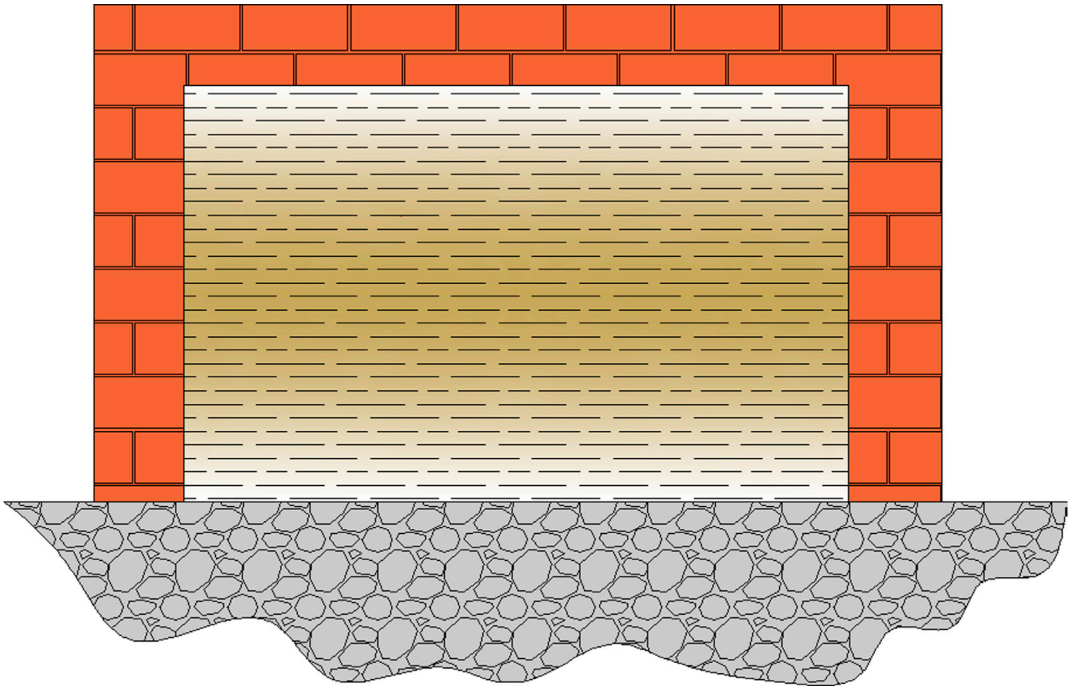
Chapter 5

Hatch Patterns



Learning Objectives

Hatch patterns allow you to indicate a variety of surfaces, from wood to concrete, on your design. In engineering, they are also used to indicate cross-section surfaces. In this chapter, we introduce boundary hatch and discuss the following:

- Hatch fundamentals
- Picking patterns
- Picking area or objects to hatch
- Adjusting scale and orientation
- Working with hatch patterns
- Gap tolerance
- Gradients and solid fills

At the end of this chapter, you will be able to add hatch patterns to your floor plan.

Estimated time for completion of this chapter: 2 hours (lesson and project).

5.1 INTRODUCTION TO HATCH

This is a chapter on the concept of boundary hatch or just *hatch* for short. This is simply a tool for creating patterns and adding fills to your design. These are not merely decorative; rather, they serve an important function of indicating types

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of materials, ground and floor coverings, and cross sections. As such, this topic is quite important and is the next logical concept to master in AutoCAD.

We cover hatch patterns in two sections. The first is with the Ribbon turned off, which makes the hatch command default to the classic dialog box seen in Fig. 5.1. It is easier for a beginner to visualize hatch concepts via this method. It was also the only way to access hatch up until AutoCAD 2011, good to know if you are using an older version of AutoCAD. Starting with AutoCAD 2011 and continuing through 2017, hatch can still be accessed the old way if the Ribbon is not on or, if it is, then via the Ribbon only. The Ribbon essentially duplicates the hatch dialog box, with maybe a few more bells and whistles; we cover this approach as well.

Hatch patterns are not an AutoCAD invention. In the days of hand drafting, there was also a need to visually indicate what sort of material one was looking at. Architects and engineers created easy to understand repeating patterns that somewhat, if not closely, resembled the actual material or at least gave you a very good idea of what it was. Just a few of the uses of hatch patterns follow.

Architecture:

- *Brick*: An important and popular pattern to render the exterior and (sometimes) interior of buildings. AutoCAD has numerous brick patterns available.
- *Herringbone, parquet*: Important for flooring designations.
- *Honeycomb*: Insulation designation.

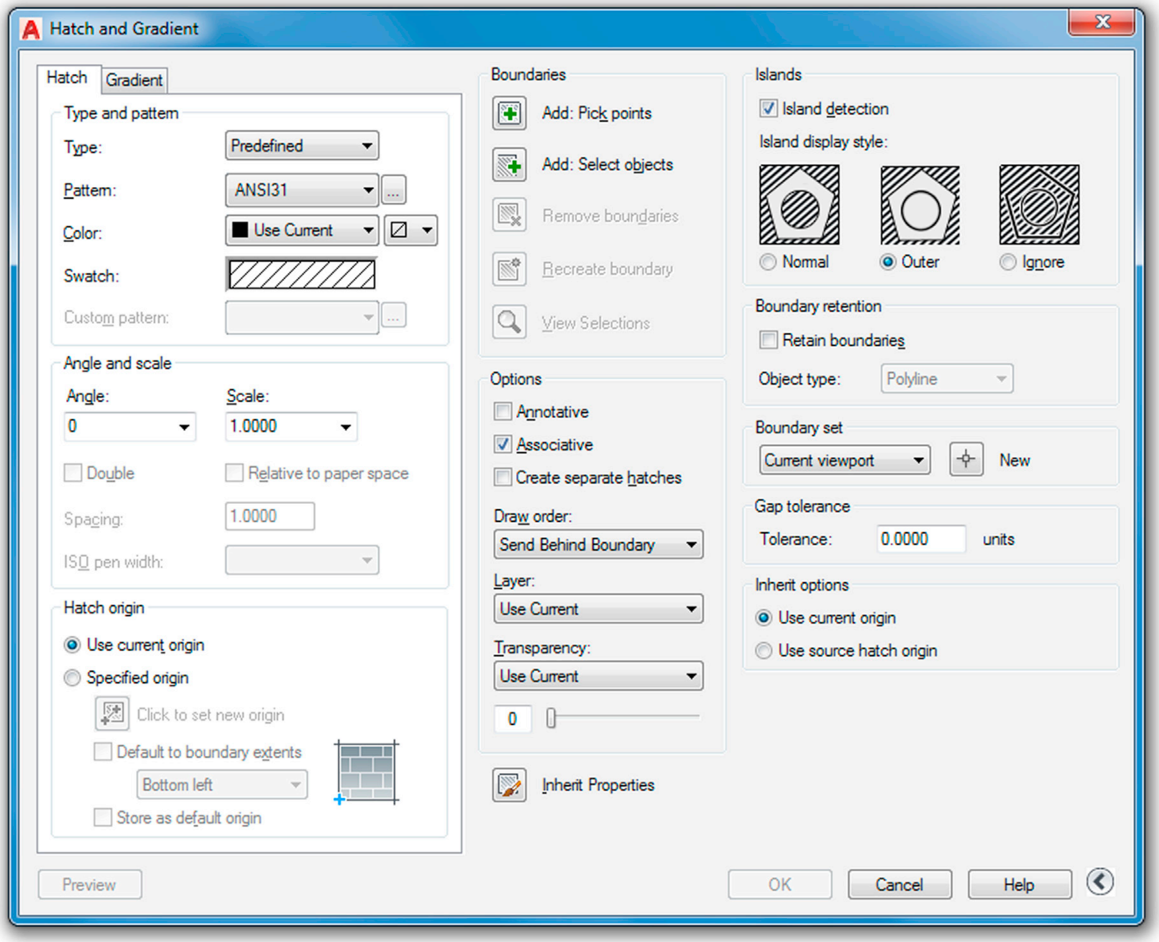


FIGURE 5.1 Hatch and Gradient dialog boxes.

Civil engineering:

- *Concrete, sand, clay, earth, gravel*: All used in designating surfaces in civil and site plan design.

Mechanical engineering:

- *Various ANSI diagonal patterns*: Used to designate the visible inside of an object cut in cross section.

With AutoCAD, creating these patterns is easy, as they are all predrawn and saved in a library, which is called up anytime you use the command. Often a designer can purchase or download additional patterns, if the basic ones are inadequate. You can even make your own and save them for future use, although this is a tedious process and only briefly covered in Appendix D, Custom Linetypes and Hatch Patterns.

5.2 HATCH PROCEDURES

At the most basic level, AutoCAD's hatch command requires only four steps:

Step 1. Pick the hatch pattern you want to use.
Step 2. Indicate where you want the pattern to go.
Step 3. Fine-tune the pattern by adjusting scale and angle (if necessary).
Step 4. Preview the pattern and accept it if OK.

Memorize the four steps and their sequence; this will help you when looking at the Hatch dialog box.

Before we get into the details, it goes without saying that you first need something to hatch. The command will not work on a blank screen or a bunch of unconnected lines. You need a closed area (although later on we violate that rule), and the easiest way to do this is to form a circle or rectangle. Open a new file and draw a square, sized 10″ × 10″. Follow the steps carefully as described next. All advanced hatch functions flow from these basics.

Step 1. Pick the Hatch Pattern You Want to Use

Keyboard: Type in **hatch** and press Enter
Cascading menus: **Draw→Hatch…**
Toolbar icon: **Draw** toolbar 
Ribbon: **Home** tab→**Hatch** 

With the Ribbon turned *off* (Tools→Palettes→Ribbon), begin the hatch command via the keyboard, cascading menus, or icons. The Hatch and Gradient dialog box appears (Fig. 5.1). At the bottom right of the dialog box is an arrow that expands or collapses additional options. Make sure it is expanded, as seen in the figure.

Now select a pattern. The choices are listed in the upper left of the dialog box under the heading *Type and pattern*. Below that are four fields, called *Type:*, *Pattern:*, *Color:*, and *Swatch:*. Leave Type as Predefined and also ignore Color for now. For the actual pattern selection, if you use Pattern, then select it by name; if you pick Swatch, patterns are selected *visually*, a much better option. Click on the diagonal lines to the right of Swatch: (or the little box with the three dots to the right of Pattern), and a new box, called the *Hatch Pattern Palette*, appears (Fig. 5.2).

Take a look through the tabs: ANSI, ISO, Other Predefined, and Custom. We have a use for some of the ANSI patterns, not so much for the ISO ones, and Custom is where the custom defined patterns go if you are inclined to create them. We are most interested in the Other Predefined tab. Go ahead and select it; you will see what is shown in Fig. 5.3.

Scroll up and down the patterns. You will notice some of the ones mentioned at the start of this chapter. Go ahead and pick one that you like, preferably one that is distinct and stands out; AR-HBONE is a good choice and is used in this example. When you click on it, the pattern is highlighted blue. Go ahead and click on OK. We are done with Step 1, and the new pattern choice is reflected in the Swatch area.

Step 2. Indicate Where You Want the Pattern to Go

You can indicate where to put the pattern in two ways, either by *directly picking* the object that will contain the pattern or by *picking a point inside* that object. Which method to use is easy to determine. If the object is actually made of joined-together lines and is one piece (such as your rectangle or circle), then it can be picked directly. If not and the "object" is really just

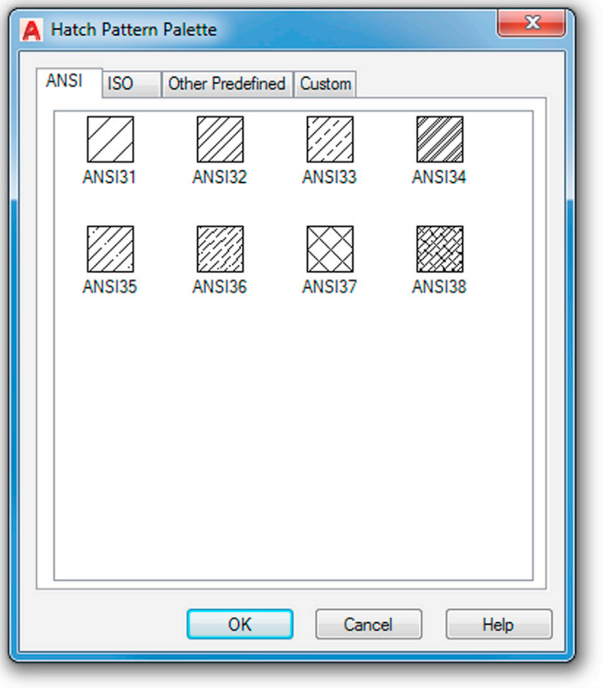


FIGURE 5.2 Hatch Pattern Palette.

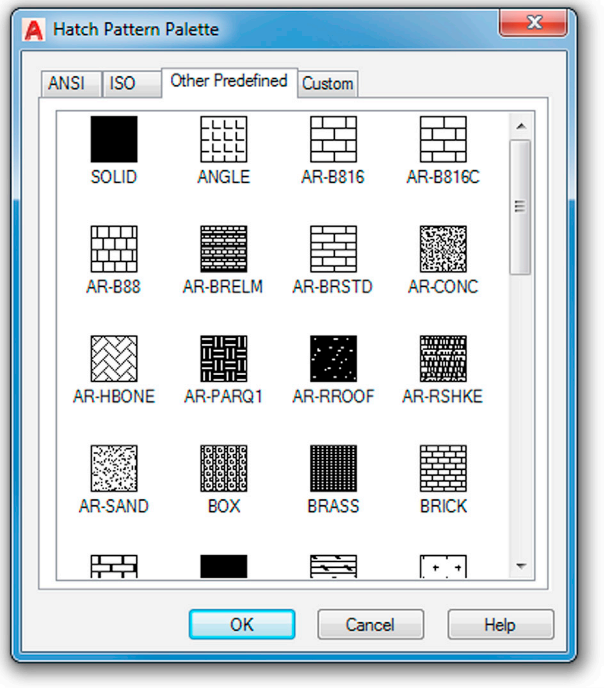


FIGURE 5.3 Other Predefined tab.

a collection of connected lines defining an area, then the best way is to pick a point in the middle of that area; and indeed this is the more common situation. The pattern then behaves like a bucket of paint spilled in the middle of the room. It flows outward evenly and stops only when it hits a wall. Once again, no holes or gaps are allowed yet; that is addressed later.

In the Boundaries section of the Hatch and Gradient dialog box (top middle), notice the two choices just discussed—Add: Pick points and Add: Select objects. Choose either one to try. The AutoCAD procedure for both is outlined next.

Add: Pick Points

If you choose this option, AutoCAD says:

```
Pick internal point or [Select objects/remove Boundaries]:
```

Click somewhere *inside* the object, and AutoCAD says:

```
Selecting everything…
Selecting everything visible…
Analyzing the selected data…
Analyzing internal islands…
```

Press Enter and you return to the Hatch dialog box with Step 2 completed. Notice that a preview of the hatch is shown to you as you complete this step.

Add: Select Objects

Alternatively, if you pick this option, AutoCAD says:

```
Select objects or [picK internal point/remove Boundaries]:
```

Click on the object itself (not the empty space) and press Enter. You return to the Hatch dialog box with Step 2 completed (Fig. 5.4) and the Preview button active.

Successfully picking a boundary can sometimes be a tricky business. The existence of gaps, no matter how small, can be a source of occasional frustration to designers; and until relatively recently, it was difficult to tell where those gaps were

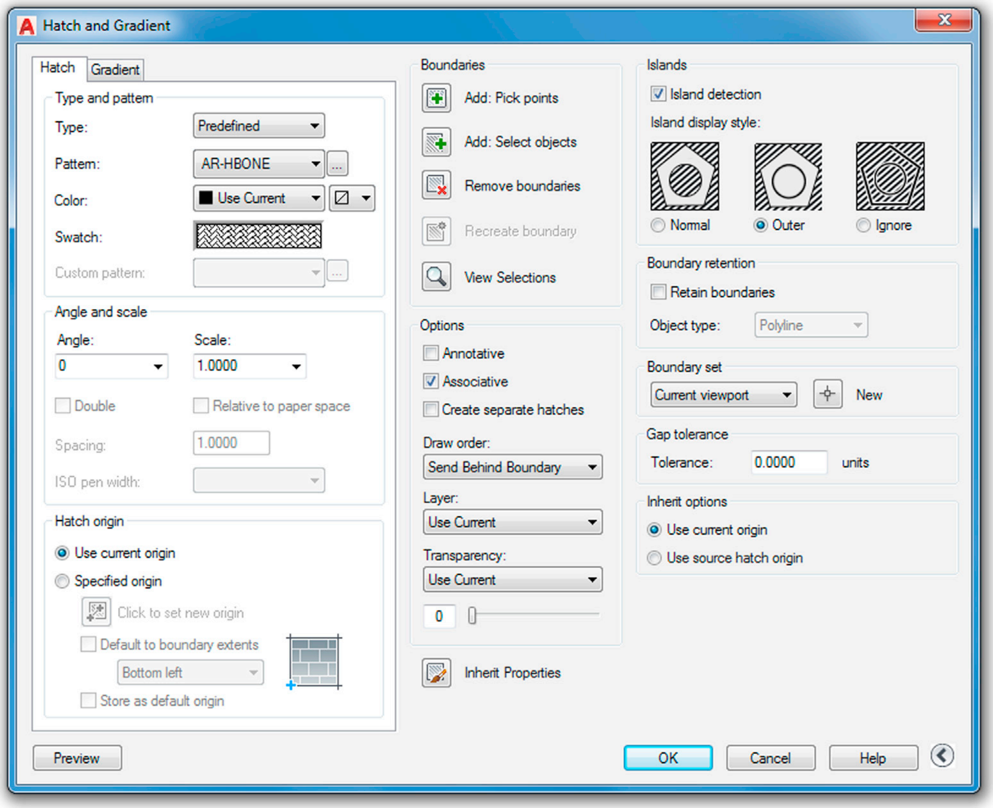


FIGURE 5.4 Steps 1 and 2 completed.

hiding in order to fix them. As of AutoCAD 2010, red circles now appear where the gaps are, aiding you in locating them, but this all can be avoided in the first place by not doing sloppy drafting (i.e., not connecting lines together properly). It is a sign of advanced AutoCAD skills when a complex area hatches right the first time.

In cases where boundary selection is not successful, complex areas can often be broken down to smaller ones by using lines to divide the area into smaller pieces and the nonproblematic portions hatched first, although this is a last resort. A few releases ago, AutoCAD added the gap tolerance command, which ignores gaps up to a preset limit. This is a great tool, which we cover shortly, along with the entire gap issue in general, but it is somewhat of a Band-Aid and still does not address the underlying sloppy drafting but merely allows you to get away with it.

Remember, you get only the level of accuracy that you put in. It is essential to master the fundamentals of drafting early on. The hatch command is an "early warning" to students. If they are having problems using it smoothly, they need to go back and refine their basic drafting (linework and accuracy) skills.

Step 3. Fine-Tune the Pattern by Adjusting Scale and Angle (If Necessary)

You are almost done and, at this point, could probably just press OK and finish the hatch pattern; however, press Preview instead. It is found at the bottom left of the dialog box and is generally a good habit to get into. What you see is your hatch pattern with the 10″ × 10″ square border in dashed lines (Fig. 5.5).

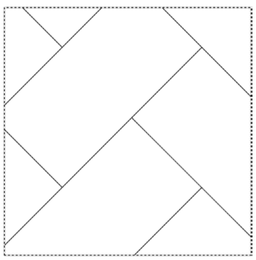


FIGURE 5.5 Hatch preview.

AutoCAD will also say what to do next:

```
Pick or press Esc to return to dialog or <Right-click to accept hatch>
```

Here, you would go ahead and right-click or press Enter. Sometimes, however, the pattern is too big or too small. You can usually tell it is too big by either not being able to see it or seeing a small part of it. If it is too small, the problem is worse, because you may not be able to finish the pattern at all. In those cases, nothing can be seen and AutoCAD tells you the following:

```
Hatch spacing too dense, or dash size too small. Pick or press Esc to return to dialog or <Right-
click to accept hatch>:
```

For learning purposes, let us practice changing the scale as the final step in our hatch creation. To do this, press Esc once and you return to the dialog box. Under Angle and scale (Fig. 5.6), change the scale to a smaller number, such as `0.25`, by typing it in. In some cases where the scale is way off, you may need to do this several times until the hatch pattern is just right. In the same manner, you may adjust the angle of the entire pattern if desired.

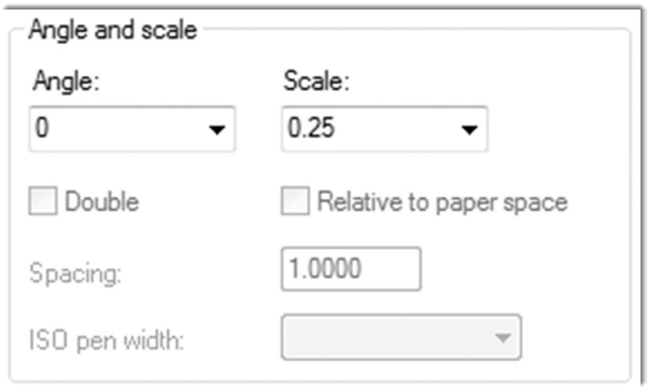


FIGURE 5.6 Angle and scale.

Step 4. Preview the Pattern and Accept It If OK

Finally, you are done. Do one more preview and press OK. If you followed the previous steps and used a rectangle, the AR-HBONE pattern, and the scale suggested, then you should get Fig. 5.7 or something reasonably close.

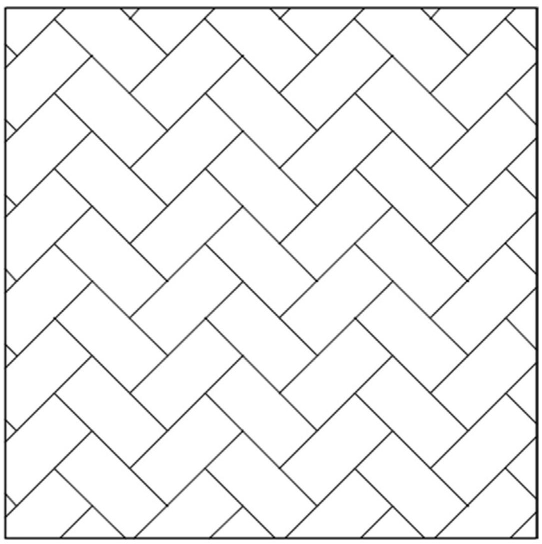


FIGURE 5.7 Final hatch pattern.

5.3 WORKING WITH HATCH PATTERNS

In this section, we mention some of the additional tools and concepts that pertain to hatch patterns. First of all, the most basic question at this point is: How do you edit a hatch pattern after you have created it? It is very easy: To edit a hatch pattern, simply double-click on it. Make sure you get one of the lines of the pattern, not just empty space. You will see a grip and the QuickProperties palette (Fig. 5.8); here, you can change whatever you need to. You can, of course, use the full Properties palette if needed as well (recall how from chapter: Layers, Colors, Linetypes, and Properties). This is different from older releases of AutoCAD, where you were taken back to the Hatch dialog box. The thinking was that the Hatch dialog box was too big and covered up your work, so a sleeker QuickProperties (or even Properties) palette was a better option. If you are using the Ribbon, to be discussed shortly, you need to click only once to edit the pattern.

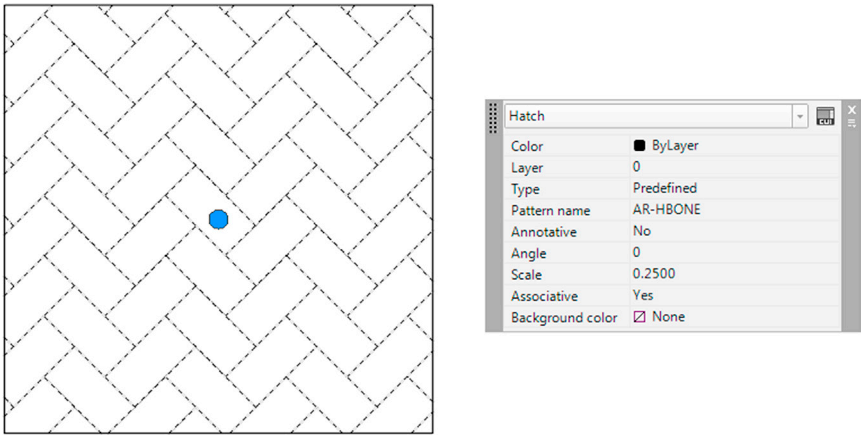


FIGURE 5.8 Editing the hatch pattern via the QuickProperties palette (no Ribbon).

Exploding Hatch Patterns

This may be one of the worst things you can do. Never explode hatch patterns; depending on the size, they turn into hundreds of pieces that cannot be put back together again in the same editable form. All the reasons designers give for exploding hatch patterns (making them fit, trimming them, moving the containment border, etc.) can be addressed with additional hatch tools.

Hatch Pattern Layers and Colors

Hatch patterns should be on a generic A-Hatch layer or whatever layer name best describes what the pattern represents (A-Carpet, M-Cross-Sec, C-Gravel, etc.). Choose any color you want for the hatch patterns, though you should not go with anything too bright, as it may overwhelm the design. Shades of gray are common for cross sections in mechanical design, as are various shades of rusty orange for brick. As a side note, hatch patterns can be easily erased by the usual erasing methods. The patterns can also be moved, copied, rotated, and mirrored, although there is rarely a reason to do so.

As of AutoCAD 2011, you can assign a color directly to a hatch pattern regardless of what layer and associated color, it is on. You can also assign a background color (solid, not a gradient). To do this when first creating the hatch, you can select both the hatch color and the background color (Fig. 5.9) from two drop-down menus at the top left of the Hatch dialog box. The same steps can be performed with the Ribbon, as shown a bit later. One sample result of assigning a hatch and background color is shown in Fig. 5.10.

Advanced Hatch Topics

Here, we summarize some additional advanced options available for working with hatches, including a more detailed discussion concerning the gap tolerance feature. You should explore these on your own as well; this is an important part of learning AutoCAD and greatly enhances your confidence with the software.

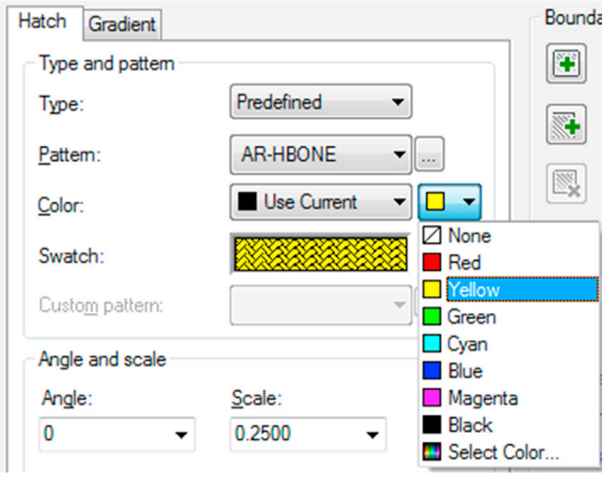


FIGURE 5.9 Hatch (Blue) and background (Yellow) color selection.

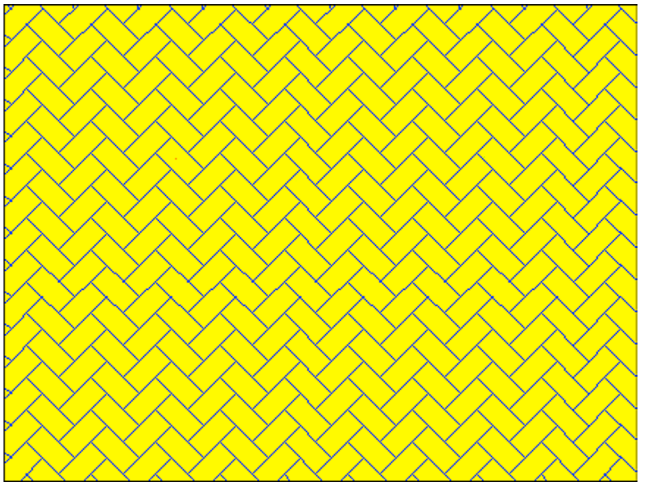


FIGURE 5.10 Hatch with a background color assigned.

Hatch Origin

This allows you to begin hatch patterns from a precise location (origin) as opposed to a random fill-in. AutoCAD chooses the origin on the pattern itself, and you get to choose to what point on the object that origin is aligned. Try it out.

Options

- *Annotative*: This will not be covered until Level 2.
- *Associative*: Keep this checked. This simply means that, if you move the border, the hatch moves with it, very useful in case of future updates.
- *Create separate hatches*: If there are multiple separate areas to hatch, this option keeps them separate; sometimes useful, sometimes not.
- *Draw order*: This is exactly what it sounds like; it gives you options on how you want to stack the hatch and its boundary. Check out the options in the drop-down menu.
- *Inherit properties*: This option lets you borrow the features of another hatch pattern and use them in a new pattern you are creating, saving you some effort and time in picking out a pattern from scratch.

Islands

This gives AutoCAD guidance on how to interpret boundaries inside boundaries (e.g., a chair in the middle of your floor). It simply tells AutoCAD to ignore them or, if not, how to deal with them. Try drawing another rectangle inside your first one and running through the options represented by the pentagon shapes.

Gap Tolerance

This is basic hatching aid that was mentioned earlier. Create a new rectangle with values close to what you did earlier, then create a gap in one of the sides, such as what is seen in Fig. 5.11. To do this, you can use a trim command or the new break command (which we officially introduce in chapter: Advanced Design and File Management Tools). Then, if you try to fill this shape with a hatch pattern, you get what you see in Fig. 5.11. Note that the red circles may or may not be present. If they are, they can be removed via the regen command.

Close the alert and press Esc to continue. Then, returning to the main dialog box, set a value for the gap tolerance (you can use 10 for starters) and rehatch the area. You get another warning, which can be eliminated from future occurrence by checking off *Always perform my current choice*, as seen in Fig. 5.12.

Select *Continue hatching this area* and AutoCAD temporarily closes the gap to continue the hatch command. After successful completion, the gap shows again but the hatch remains, as seen in Fig. 5.13. Some designers have used the command to ignore door openings when hatching carpeting in floor plans. You can try this as well on your floor plan later.

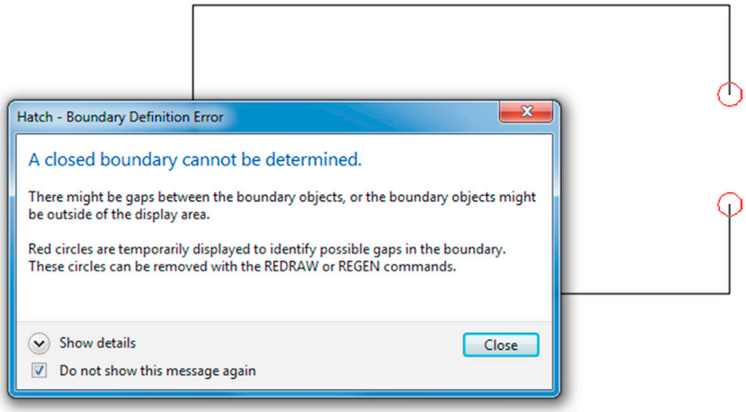


FIGURE 5.11 Boundary not closed alert.

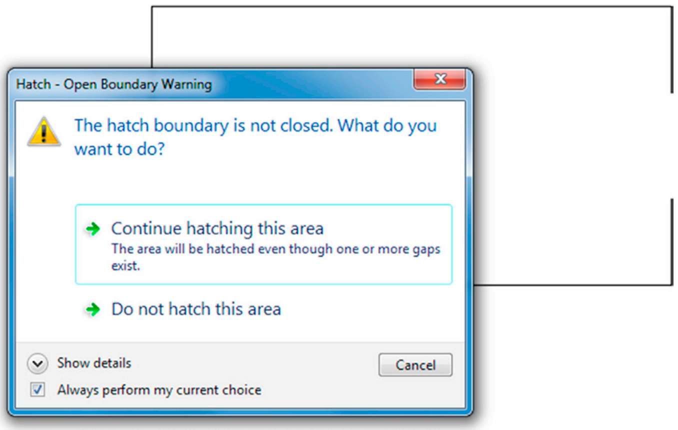


FIGURE 5.12 Open boundary warning.

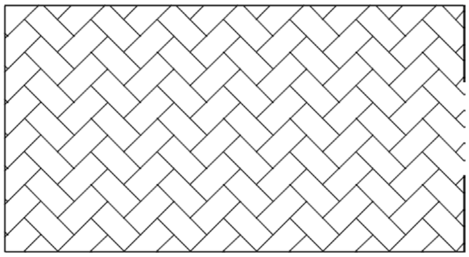


FIGURE 5.13 Hatch with gap tolerance.

5.4 GRADIENT AND SOLID FILL

At the top left of the Hatch and Gradient dialog box, click on the Gradient tab. The left side of the box changes, while the right-hand side stays essentially the same, as shown in Fig. 5.14.

The gradient option is just a solid fill with some flair. You can choose the desired pattern, in one or two colors, and adjust the Shade, Tint, Orientation, and Angle of the gradient. The rest of the steps are similar: Pick point or Select object, Preview, and done.

Shown in Fig. 5.15 is a possible use for gradient in rendering a brick wall. A brick pattern is created and a brick-colored fill tops it. Note that you may need to use Tools→Draw Order→Bring to Front from the cascading menu to position the brick above the gradient fill (or the gradient fill behind the brick, depending on what you pick first). Try it.

Solid Fill

This fill is the first choice (black box, top left) in the Other Predefined tab and deserves special mention as our final topic. This solid fill is similar to a gradient but with no fancy color mixing, just one color. It is very handy as a fill for walls, some types of cross sections, or any location where you want a dark area.

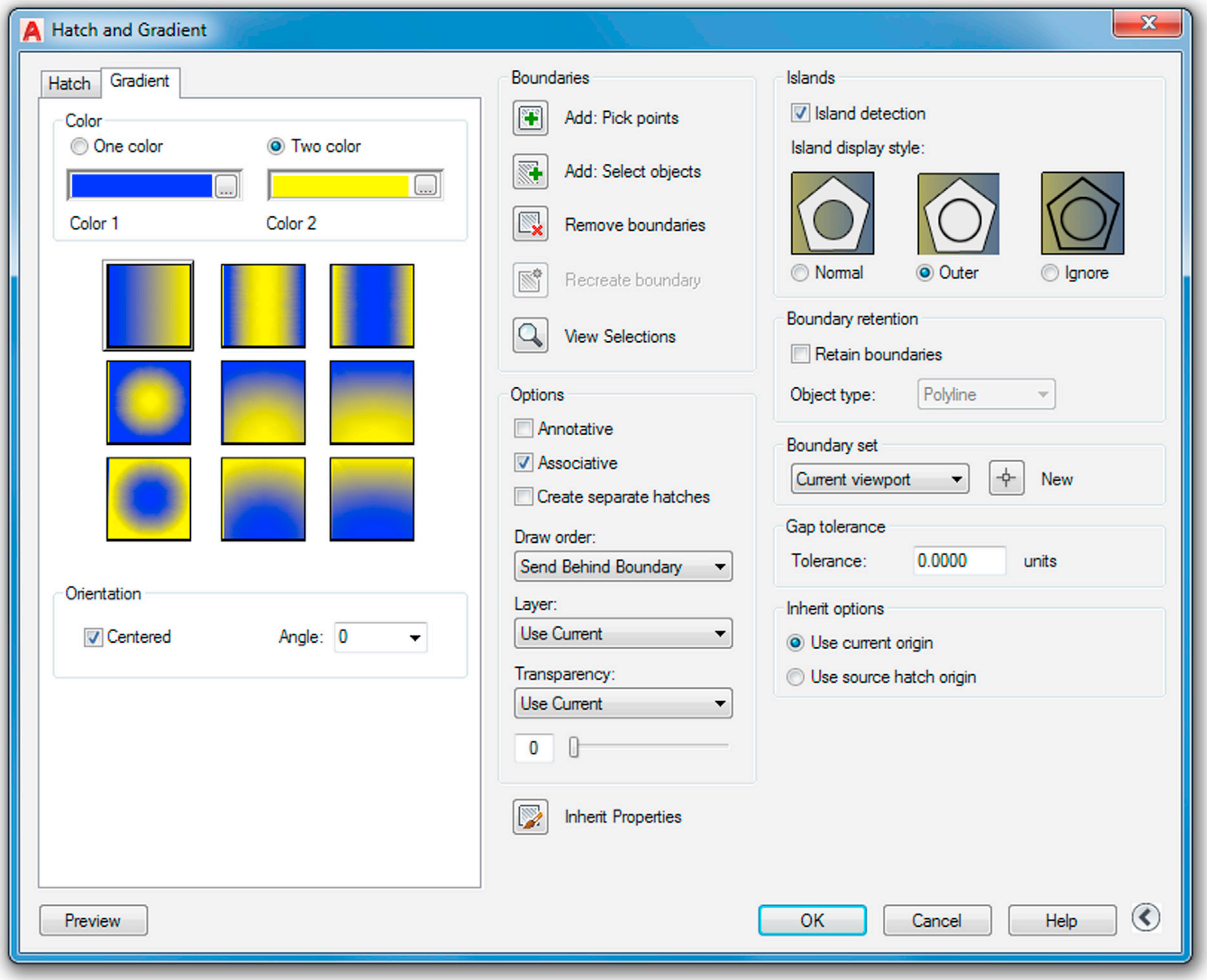


FIGURE 5.14 Gradient tab.

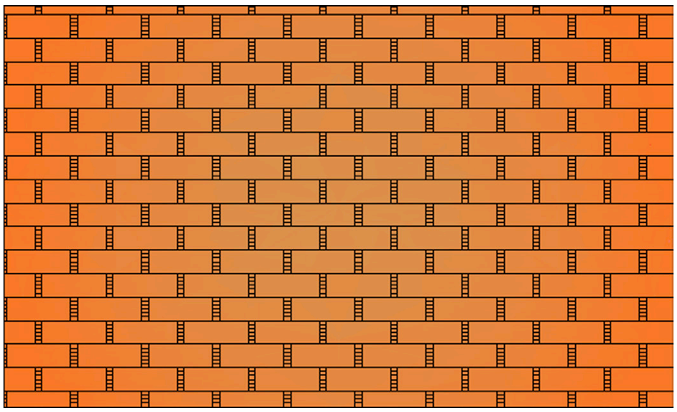


FIGURE 5.15 Brick wall created with Hatch and Gradient.

It becomes even more useful when paired up with a lineweight feature called *screening*, which is discussed in detail in Chapter 19, Advanced Output and Pen Settings. It has to do with being able to fade out (or screen) the intensity of any color, typically down to 30%, and is perfect for indicating "area of work" on key plans, some types of carpeting, and even pavement on civil engineering drawings.

A way to mimic this now without screening is to change the solid fill's color to Gray 9; the soft gray haze then seen is distinct and visible, yet not overwhelming. If you are wondering how the walls were filled in on the apartment drawing, this is how.

5.5 HATCHING USING THE RIBBON

The previous steps using the Hatch dialog box are essentially duplicated using the Ribbon. Bring it back by typing in `Ribbon` (or Tools→Palettes→Ribbon via the cascading menus). Draw a shape to hatch and begin the command in the same manner as before; you see the Ribbon switch to Fig. 5.16. Here, you still have to pick the pattern by dropping down the menu, as seen in Fig. 5.17. Note how all the hatch patterns are present and you do not have tabs anymore.

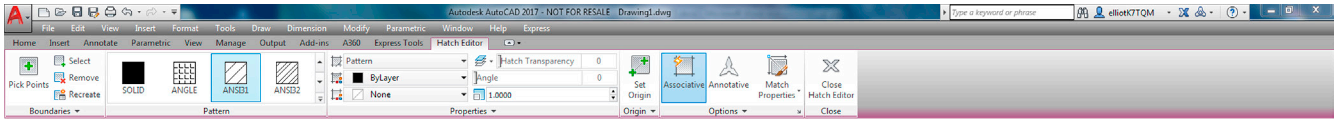


FIGURE 5.16 Ribbon—Hatch creation.

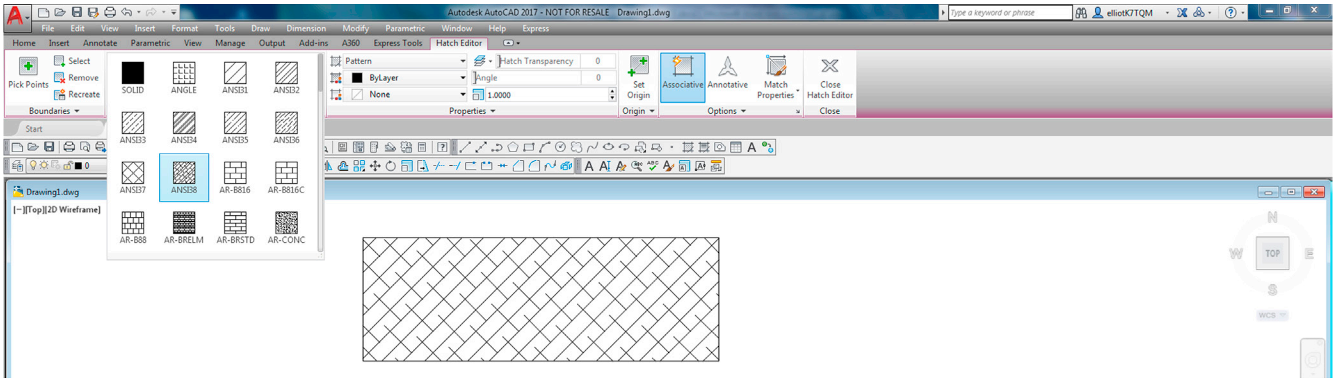


FIGURE 5.17 Selecting patterns.

You can then hover your mouse over the area and see an instant preview of the pattern to get an idea of what you have. When you move the mouse away, the pattern disappears. Selection of boundaries is all the way on the left, under Boundaries, and the fine-tuning is in the middle of the Ribbon under Properties. Here, you can select the Scale, Angle (with instant rotation via a slider), and Background Colors. The rest of the features, such as Gap Tolerance, Origin, and others, are found under Origin and Options on the right.

Which method you use is entirely up to you, although if you have the Ribbon up all the time, it makes more sense to continue using it for the hatch command.

5.6 IN-CLASS DRAWING PROJECT: ADDING HATCH TO FLOOR PLAN LAYOUT

We continue work on the floor plan and add hatch to the rooms and walls. Some tips follow:

- To add hatch to rooms, freeze the A-Doors layer and instead draw *temporary* lines closing off the door entrances. After hatching, remove the lines. You may also be able to use Gap Tolerance set to at least 3 feet, but that is not recommended.
- Make sure the hatch patterns are on the proper layers, whatever they may be (Carpeting or just Hatch_1, Hatch_2; you decide). You do not have to pick the hatch patterns shown, but make sure they are reasonable and at the proper scale.

To fill in the apartment walls, freeze everything except the A-Walls and the Hatch layer. Then, use the solid fill, color Gray 9, as described earlier. If you created everything properly, there should be no gaps or breaks in the wall islands. Check to make sure the windows are drawn correctly, meaning the wall has to have an actual closed gap, into which the window is inserted. Fig. 5.18 shows what everything should look like prior to wall hatching (1) and right after (2). One possible approach to hatching the apartment is shown in Fig. 5.19.

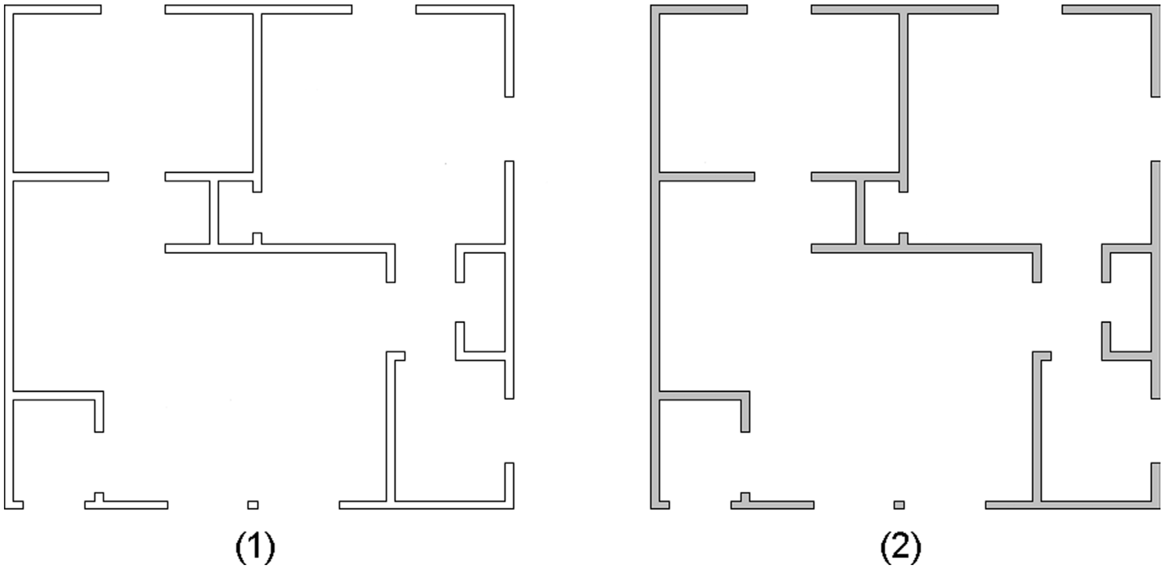


FIGURE 5.18 Wall hatching before (1) and after (2).

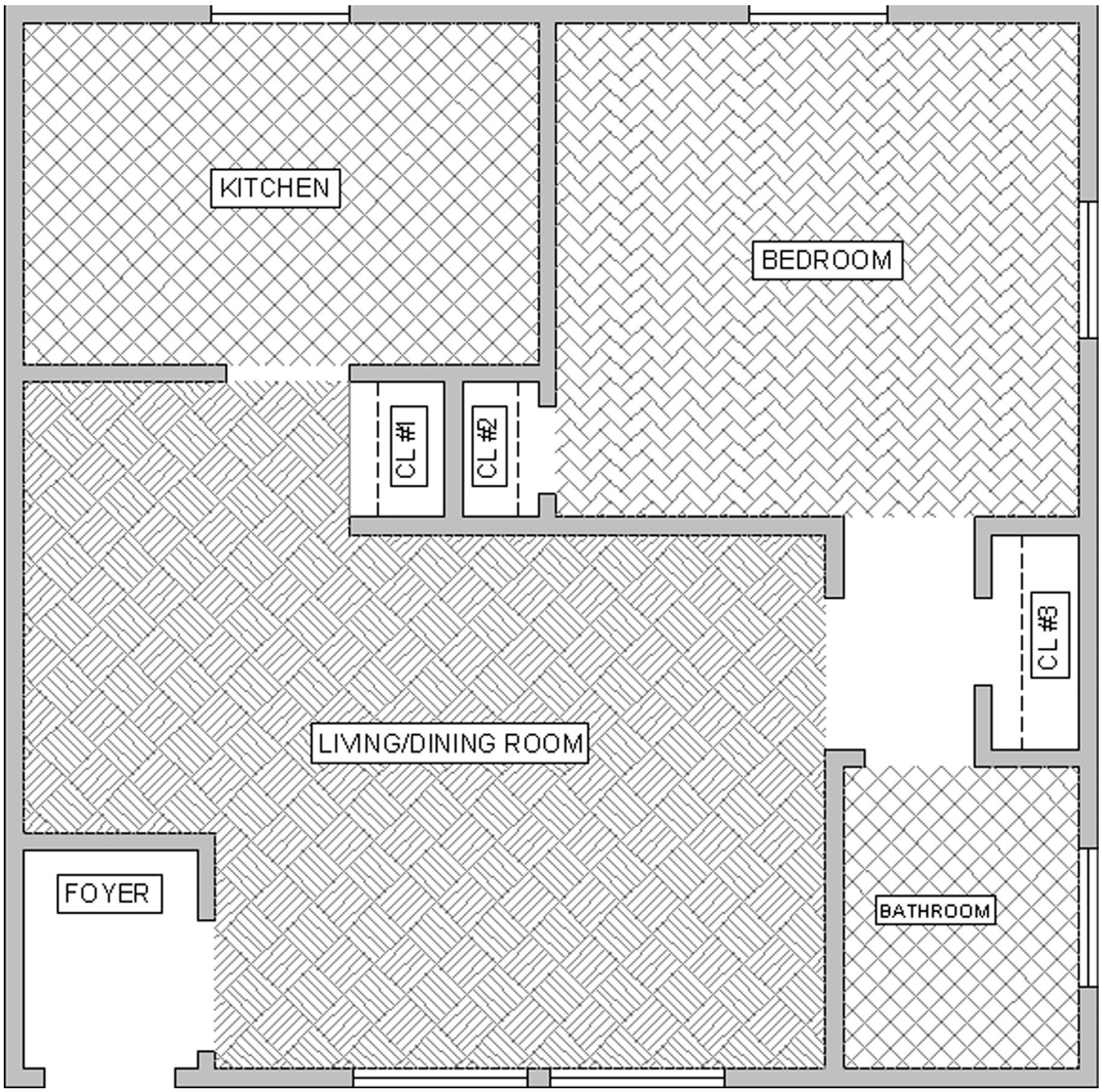


FIGURE 5.19 Floor plan with wall and floor hatching.

5.7 SUMMARY

You should understand and know how to use the following concepts and commands before moving on to Chapter 6, Dimensions:

- Hatch
  - Picking a pattern
  - Selecting area or object
  - Scale and orientation adjustments
  - Preview
- Editing a hatch
  - Double-click
- Additional options
  - Islands
  - Inherit properties
  - Associative
  - Draw order
  - Gap tolerance
- Gradients and fills

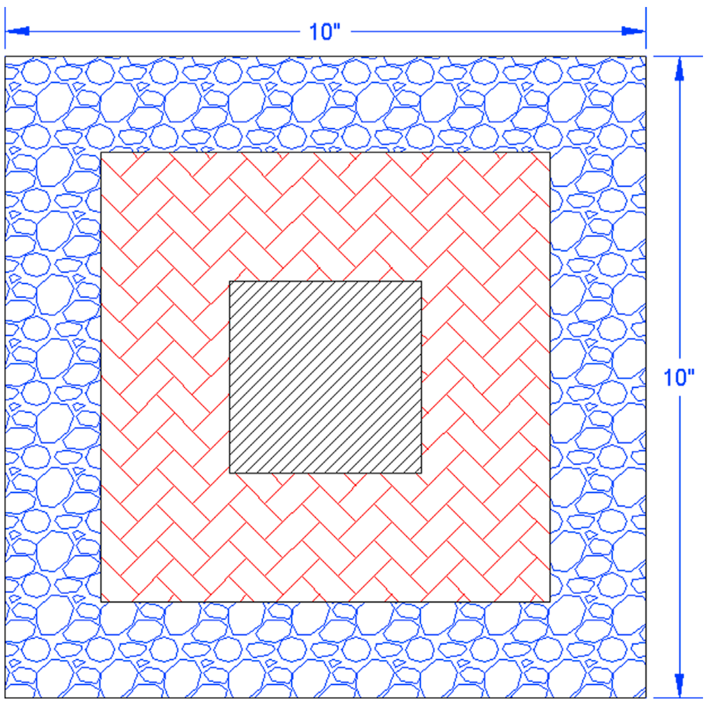
Review Questions

Answer the following based on what you learned in this chapter:

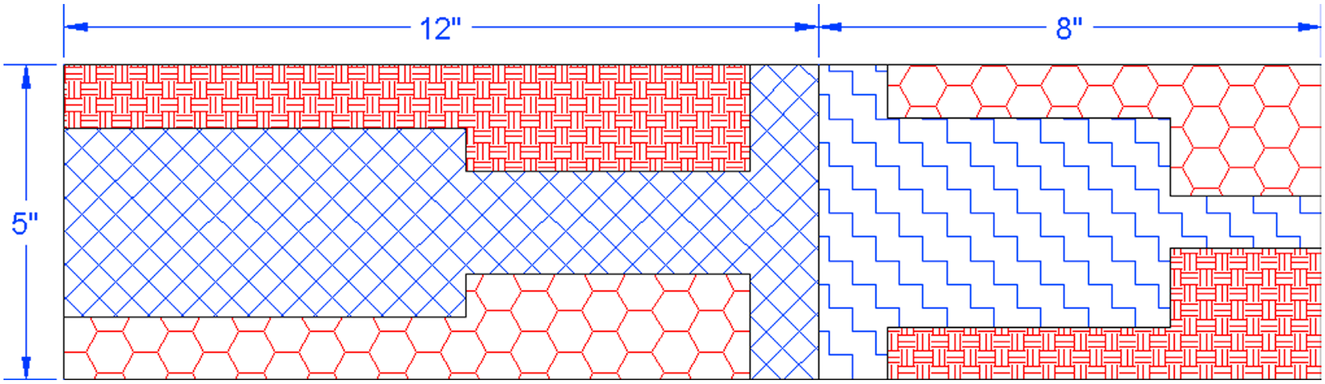
1. List the four steps in creating a basic hatch pattern.
2. What two methods are used to select where to put the hatch pattern?
3. What commonly occurring problem can prevent a hatch being created?
4. What is the name of the tool recently added to AutoCAD to address this problem?
5. How do you edit an existing hatch pattern?
6. What is the effect of exploding hatch patterns? Is it recommended?
7. What especially useful pattern to fill in walls is mentioned in the chapter?

Exercises

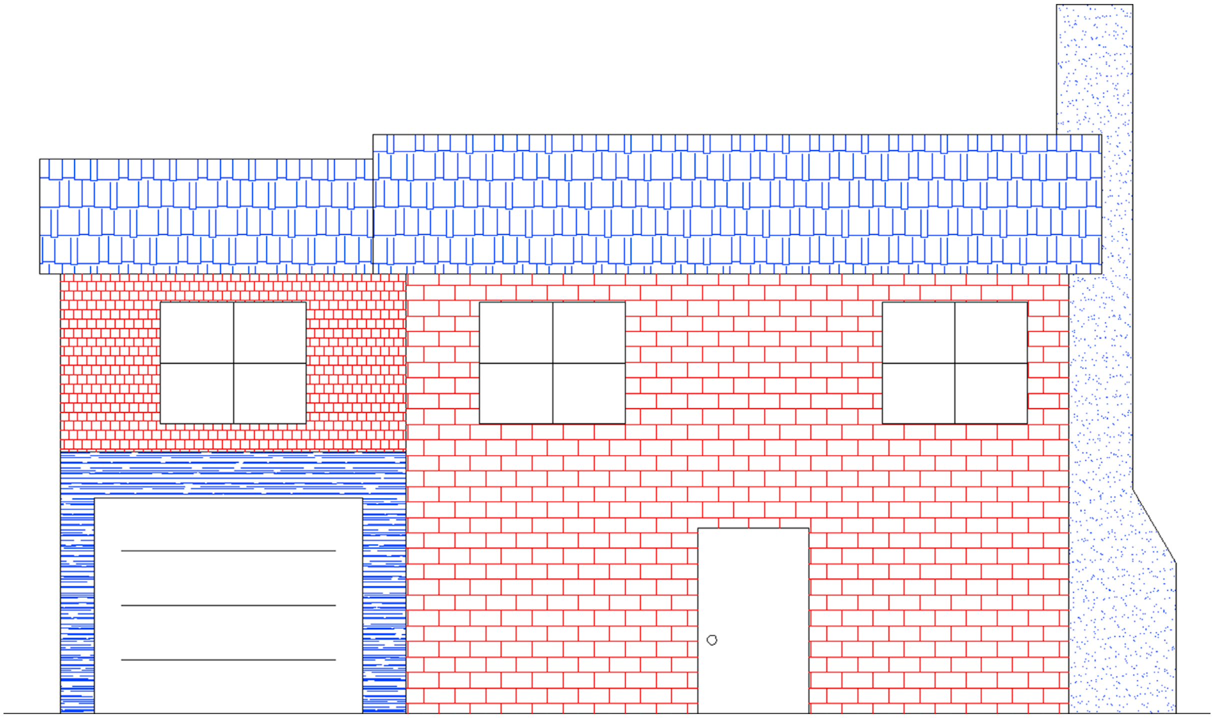
1. In a new file, create the following rectangle, offset to get the smaller ones, and fill them all in with the shown hatch patterns. Do try to duplicate what is shown, including hatch patterns, scale, and angles as closely as possible. (Difficulty level: Easy; Time to completion: <5 minutes.)



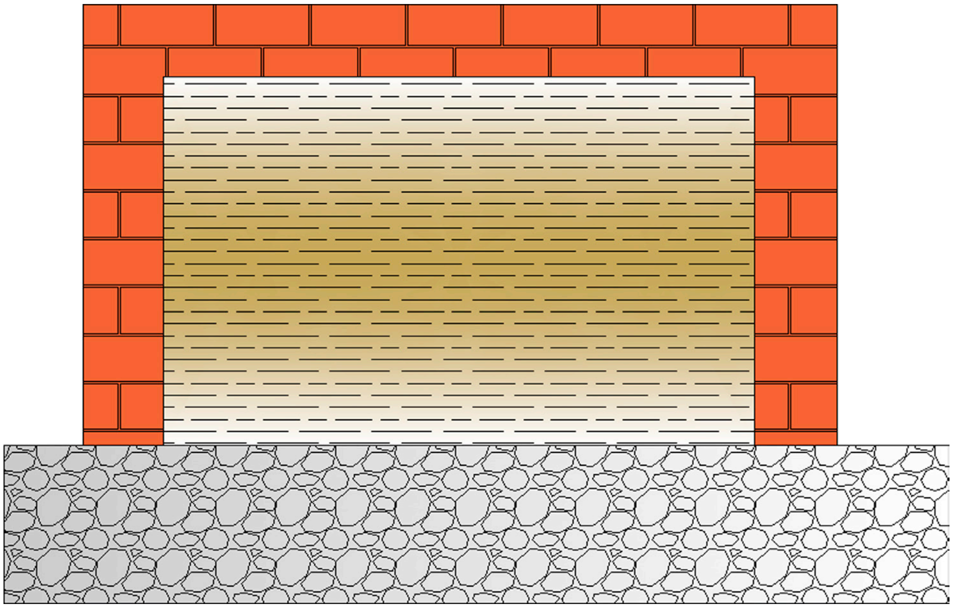
2. In a new file, create the following shapes and hatch patterns. Some overall sizing is shown, but you have to improvise the rest via the offset and line commands. Do try to duplicate what is shown, including hatch patterns, scale, and angles as closely as possible. (Difficulty level: Easy; Time to completion: <5 minutes.)



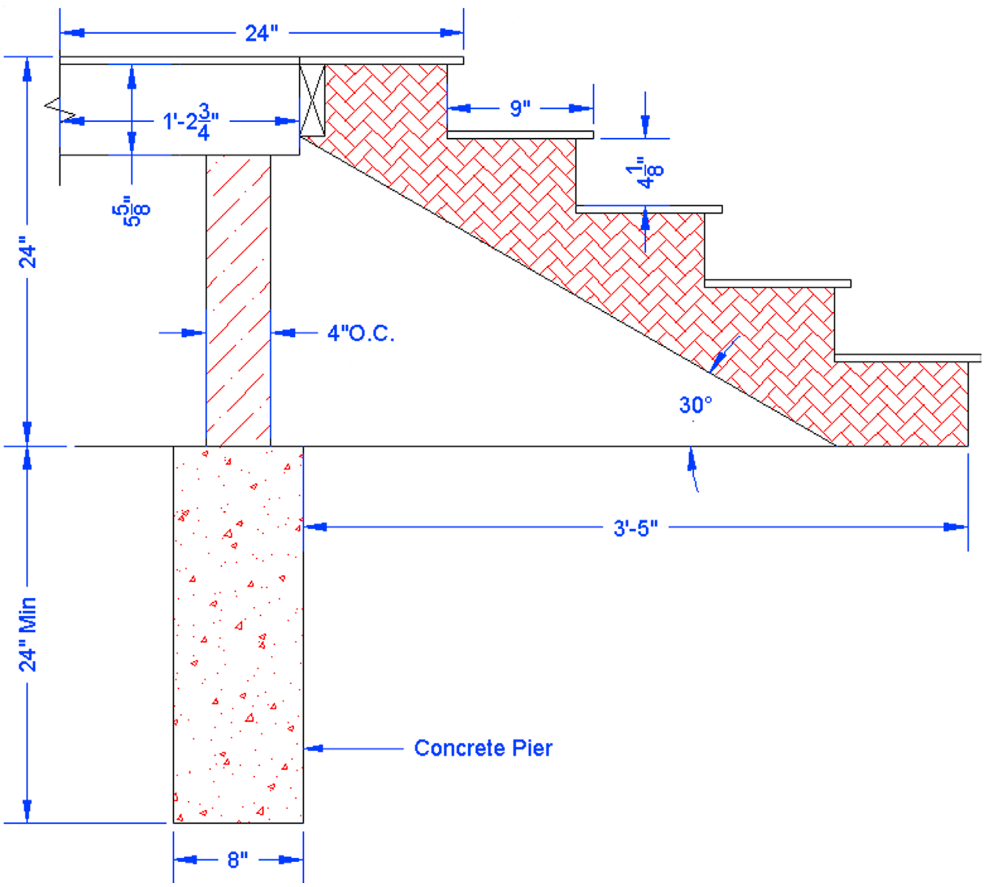
3. Open up (or redraw) Exercise 5 from Chapter 1, AutoCAD Fundamentals—Part I and add the following hatch patterns. Do try to duplicate what is shown, including hatch patterns, scale, and angles as closely as possible. (Difficulty level: Intermediate; Time to completion: 10 minutes.)



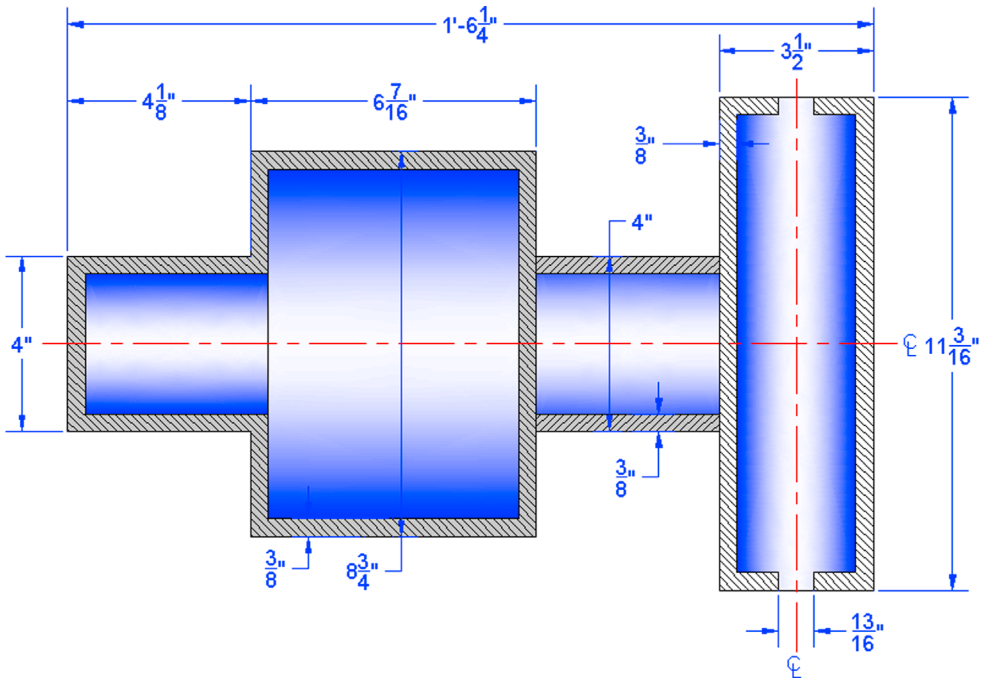
4. Open a new file and set units to Architectural. Create the following brick wall design, a slightly modified version of what is seen on the cover page of this chapter. Note that some of the backgrounds are gradients. Sizing and scale is up to you, but do try to duplicate what you see. (Difficulty level: Easy; Time to completion: <10 minutes.)



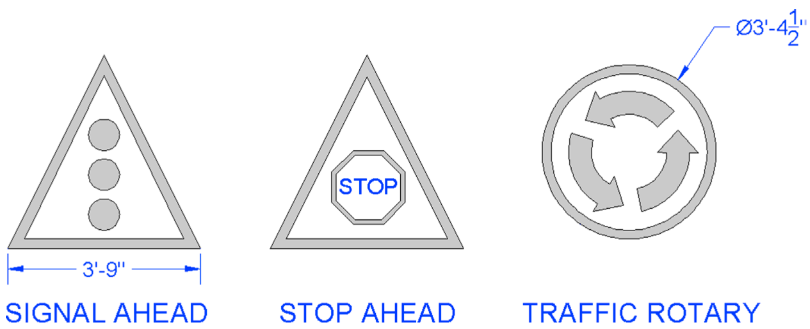
5. Open a new file, create the appropriate layers, and set units to Architectural. Create the following stair layout and hatch patterns. Any sizes and dimensions that are not given can be estimated, as can the scale of the patterns. Add in text where needed. (Difficulty level: Intermediate; Time to completion: 20–30 minutes.)



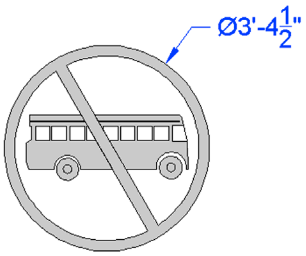
6. Open a new file and set units to Architectural. Create the following layout of a fictional set of cross-sectioned cylinders. Dimensions are provided, but sizing is of secondary importance to creating the hatch and gradient patterns. Notice how gradients are used to depict curvature inside the pipe cross sections, a good trick to add realism to 2D drawings. (Difficulty level: Intermediate; Time to completion: 20 minutes.)



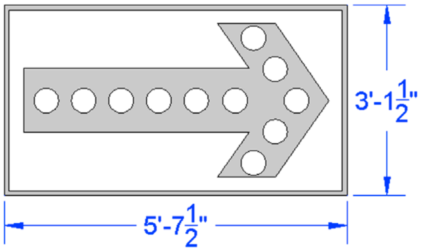
7. Create the following basic road signs using the starter dimensions given. All other sizing is to be approximated off of them. Add solid hatch fill as shown. (Difficulty level: Easy; Time to completion: 15 minutes.)



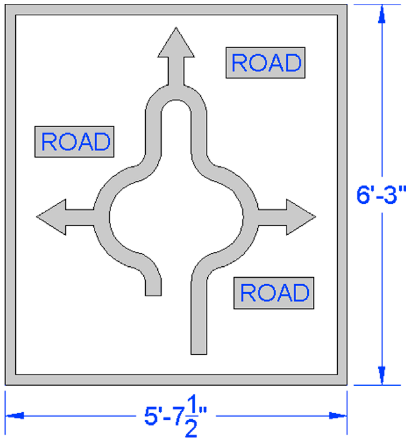
8. This exercise features some additional (slightly more complex) road signs Create them using the starter dimensions given. All other sizing is to be approximated off of them. Add solid hatch fill as shown. (Difficulty level: Easy; Time to completion: 25 minutes.)



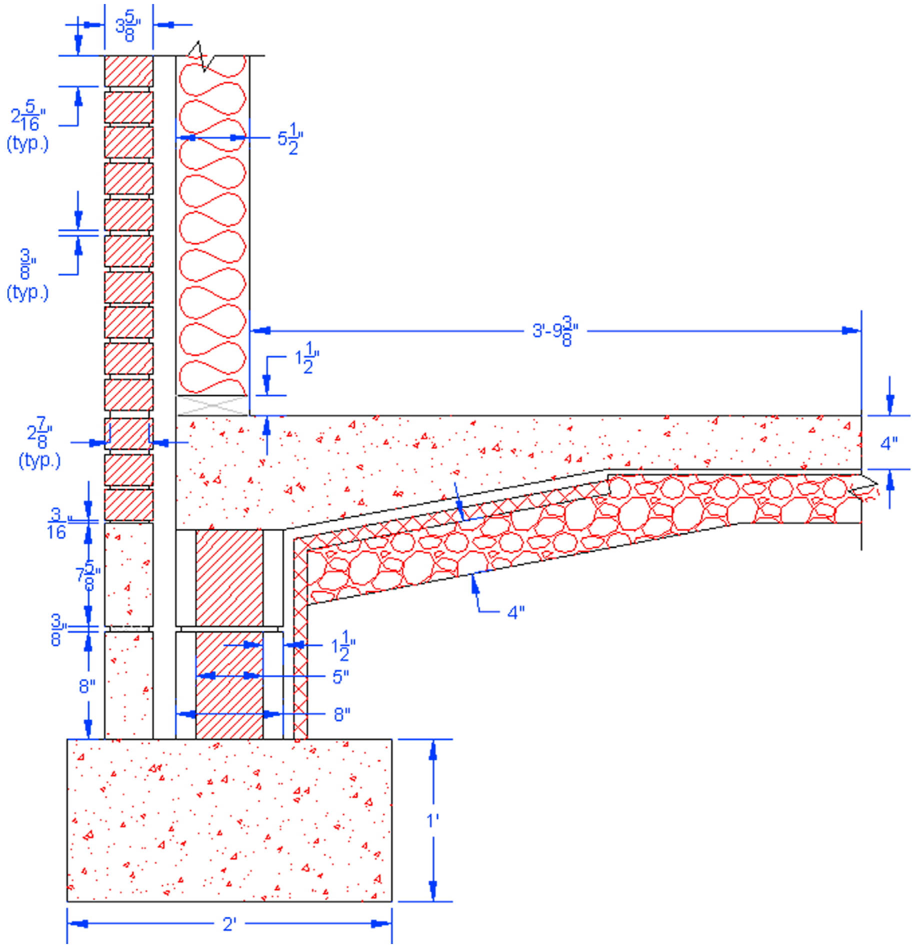
NO ENTRY FOR BUSES



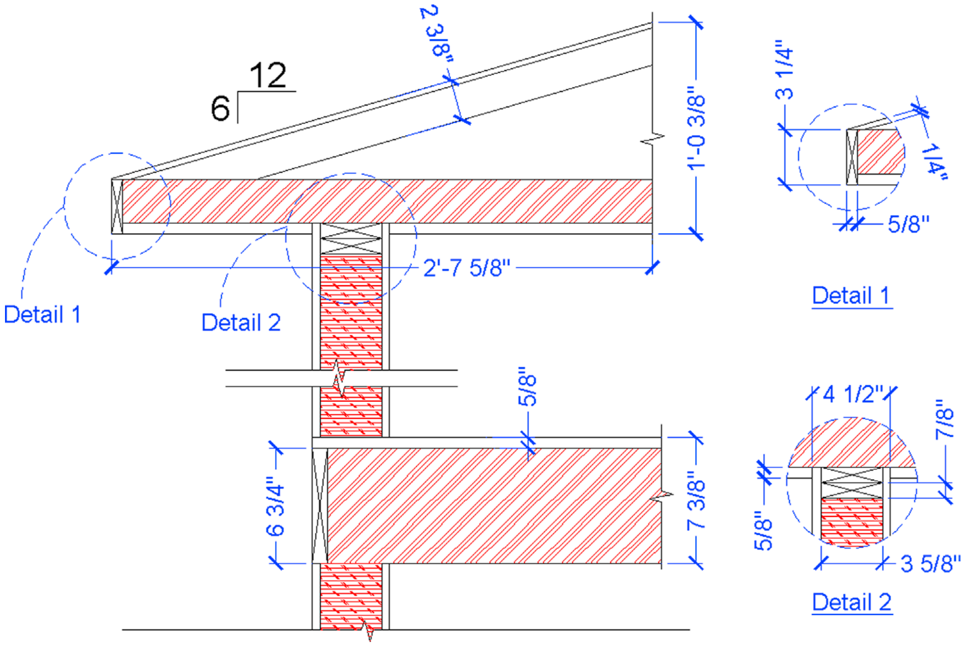
STAY TO THE RIGHT



9. Create the following architectural detail. Many (but not all) of the dimensions are given. Use them as a basis to size the rest. Then, approximate the hatch patterns as shown. The squiggly vertical one is not a hatch pattern but a linetype, called *Batting*, often used to show insulation. Adjust its ltscale until it looks like what is shown. The rest of the hatch patterns should be familiar. (Difficulty level: Easy; Time to completion: 25–35 minutes.)



10. For the final exercise of this chapter, set up your file with the appropriate layers and text settings and draft the following detail of the roof and support beams. All necessary dimensions are found in either the main detail or the two supporting details. Any dimensions not given can be assumed. Then, approximate the hatch patterns as shown. The 6 and 12 above the roof indicates its slope and may be used to calculate the angle via some basic trigonometry, if needed. (Difficulty level: Moderate; Time to completion: 30–40 minutes.)



Spotlight On: Mechanical Engineering

Mechanical engineering is the science of designing and manufacturing mechanical systems (Fig. 1) or devices (Fig. 2). It is one of the oldest and most widespread engineering specialties and is often the profession one has in mind when thinking of a "typical" engineer. Mechanical engineering is also by far the most diverse of the engineering specialties, and "mechies" can be found working in fields as wide-ranging as aerospace, automotive, naval, rail, power, infrastructure, robotics, manufacturing, consumer products, and much more. It is truly a profession that keeps our society moving.

FIGURE 1

Mechanical engineers need to master a wide variety of engineering sciences, structures, materials, vibrations, machine design, control systems, electrical engineering, and more. They also need to be well versed in business practices, cost analysis, and risk assessment, as design and production of just about anything is closely tied to these. Mechanical engineers have been the driving force behind development of high-end software tools, such as finite element analysis (FEA) for structural work.

FIGURE 2

Education for mechanical engineers starts out similar to education for the other engineering disciplines. In the United States, all engineers typically have to attend a 4-year ABET-accredited school for their entry level degree, a Bachelor of Science. While there, all students go through a somewhat similar program in their first 2 years, regardless of future specialization. Classes taken include extensive math, physics, and some chemistry courses, followed by statics, dynamics, mechanics, thermodynamics, fluid dynamics, and material science. In their final 2 years, engineers specialize by taking courses relevant to their chosen field. For mechanical engineering, this includes classes on structures, controls, vibration analysis, thermodynamics, and machine design, among others.

Upon graduation, mechanical engineers can immediately enter the workforce or go on to graduate school. Although not required, some engineers choose to pursue a Professional Engineer (P.E.) license. The process first involves passing a Fundamentals of Engineering (F.E.) exam, followed by several years of work experience under a registered P.E., and finally sitting for the P.E. exam itself. Mechanical engineering is also an excellent undergraduate degree for entry into law, medicine, or business school. Just some of the careers you can pursue with an engineering bachelor's followed by a JD, MD, or an MBA include patent attorney, biomedical engineer, and manager or CEO of an engineering firm. If you can handle the education requirements, the mechanical engineering undergraduate degree may truly be one of the most useful ones in existence.

Mechanical engineers can generally expect starting salaries (with a bachelor's degree) in the $62,000/year range, which is in the middle of the pack among engineering specialties, behind computer, petroleum, and chemical engineering. This, of course, depends highly on market demand and location. A master's degree is highly desirable and required for many management spots. The median salary in 2014 was $83,060, with the top 25% making $119,950. The job outlook for mechanical engineers is excellent, as the profession is so diversified that there is always a strong demand in some of the sectors, even if others are in a downturn.

So, how do mechanical engineers use AutoCAD and what can you expect? Industrywide, AutoCAD enjoys significant amount of use, even as its share shrinks as companies switch to low-cost 3D solutions such as SolidWorks and Inventor.

In truly high-end design (aerospace, automotive, and naval, for example), the dominant software applications continue to be CATIA, NX, and Pro/Engineer (Creo); and AutoCAD does not compete with these. However, this still leaves many applications where AutoCAD is appropriate, such as small part design, schematics, and overall layout of systems. Many companies also do not manufacture but rather assemble modular pieces into new products; here, too, AutoCAD is the appropriate low-cost solution. Let us take a look at a few examples.

The acronym P&ID stands for piping and instrumentation diagrams, a major mechanical engineering field, commonly referred to as *process control*. Engineers use the principles of fluid flow, material science, and hydrodynamics to design piping and valves that regulate fluid flow. This can be anything from a chemical plant to an electrochlorination system to waste treatment. Usually, systems are assembled out of standard industry parts, so AutoCAD is the appropriate tool to put them together into a design. Fig. 3 shows a typical piping valve profile diagram.

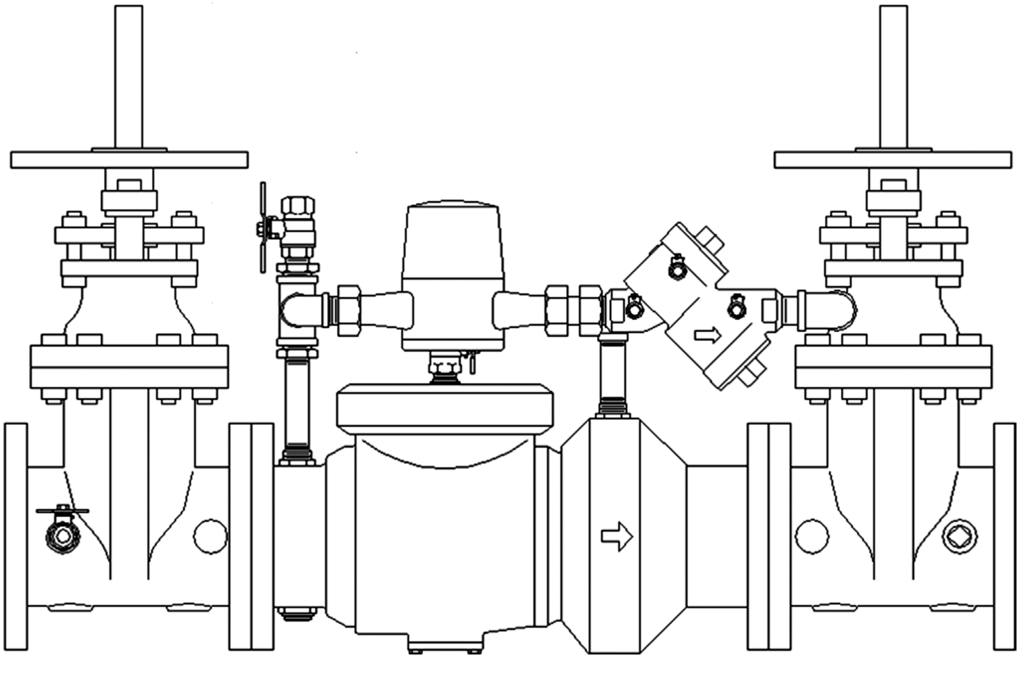


FIGURE 3

Small device assemblies are another example of mechanical design. If the parts are standard and no manufacturing is necessary, only assembly drawings, then AutoCAD can be used to depict the ideas. Fig. 4 shows an AutoCAD drawing of an instrument tuning peg assembly.

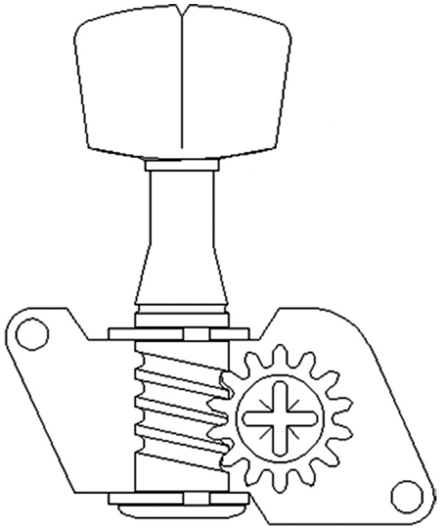


FIGURE 4 Tuning peg assembly.