Model Railroader MAGAZINE

DESIGN YOUR OWN LAYOUT • MAKE ACCURATE DRAWINGS
A SUPPLEMENT TO MODEL RAILROADER MAGAZINE

Workshop tips

Introduction to Track Planning

By Andy Sperandeo

- Learn what really fits your space
- Test your ideas with controlled doodles
- Follow standards for reliable operation

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Introduction to Track Planning

Photo by Jim Forbes

One of the most fascinating parts of model railroading is designing your own layout. It's true that you can build a fine model railroad by following a plan out of a book or magazine, but to get the system you really want there's nothing like designing it yourself.

This booklet will acquaint you with the basic techniques and considerations for imagining a new model railroad and getting your ideas down on paper. Some basic mechanical drawing is involved because the only way to know for sure that your plan will fit is to draw it to scale with a reasonable degree of accuracy. Even if you move on from pencil-and-paper to computer-aided layout-design software, you'll still find it helpful to understand the geometric exercise of making a scale drawing.

Drawing your layout space to scale

The beginning of any model railroad design is knowing where the layout will be built. You can build your model railroad in a spare room, a basement, an attic, a garage, or even a purpose-built separate structure. Wherever it may be, your train room is probably not exactly like any other. An accurate scale drawing of your space will define the size and shape of your railroad and the obstacles it must cope with or avoid.

The example drawing shows a basement with all its features delineated. Notice the distinction between walls that track will be allowed to penetrate and those that may not be pierced. This is essentially a matter of choice – some areas of this basement are reserved for activities other than model railroading.

The amount of detail included is also a matter of choice, and you don't necessarily need to include all the dimensions shown in the example. The heights of stair treads would be useful only if you want to run tracks under or even through them. If you'd like your railroad to pass above or behind any appliances, you need to show their heights also.

Getting it down on paper. Start by making a rough sketch of the room, basement, garage, or other space. Include all the details that will affect the location of your railroad, even if you can't show them in exactly correct places or proportions.

With the help of a friend or family member, use a tape measure to determine the dimensions of your future train room. Measure every wall, wall segment, and offset, as well as doorways and windows. Make two measurements at right angles to determine the location of free-standing columns, pipes, or other such objects. As you take these measurements, write them in on your sketch as a guide to your scale drawing.

Drawing tools

Architects' scale – for drawing and making measurements in scale feet and inches

Compass – a sturdy tool with extra divider and knife points is best

Drawing board – a portable, tabletop board will be fine

Erasers

50-foot tape measure

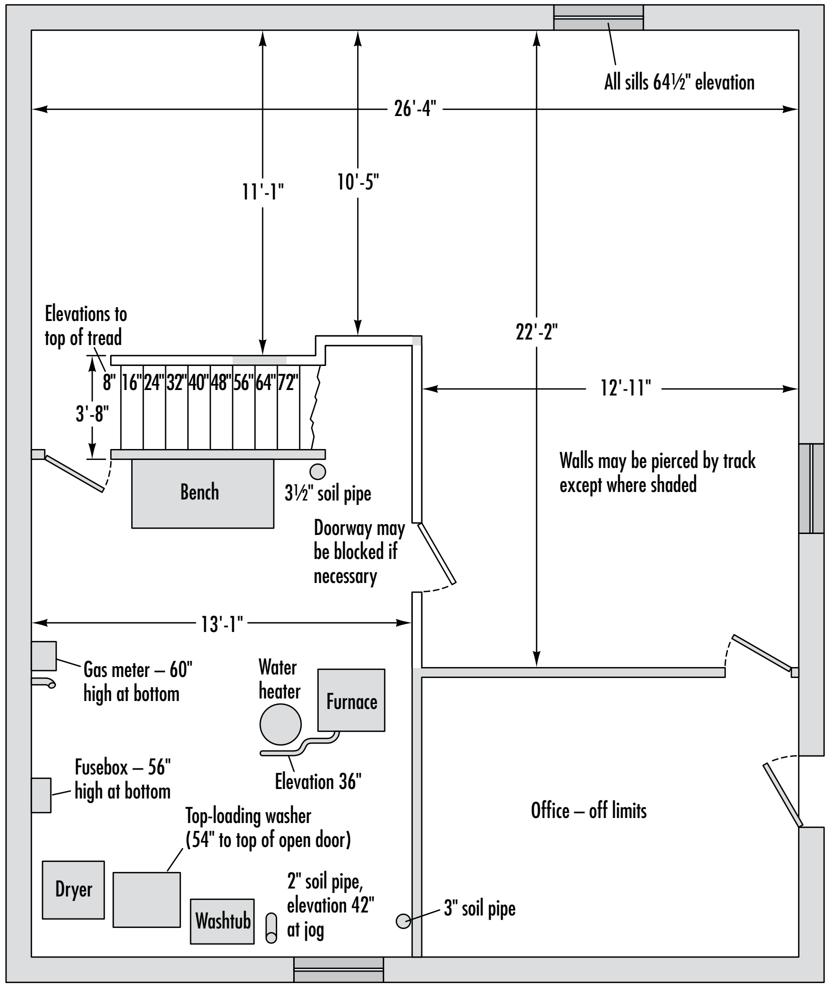
Sharp pencils – keep the sharpener handy, and use fine sandpaper to make sharp chisel points for drawing fine lines

Straightedge or rule

Triangles in various sizes

T-square

Typical layout space diagram



Illustrations by Rick Johnson except where noted

If you're having a new home built, you might want to start planning your railroad with the contractor's drawings, but it'll be best not to finalize your plan until you can get into the room and make your own measurements. Houses don't always match the drawings exactly. Likewise, if you'll be adding wallboard or other interior walls in an attic, basement, or garage, the dimensions after the room is finished are what you need.

Accurately and in scale. Choose a scale for your drawing, one small enough to fit on a handy sheet of paper but large enough to include the necessary details. Generally, it will be easier to produce an accurate drawing in a larger scale. Small layout rooms can be shown in a relatively large scale such as 1½"= 12", while medium-size rooms may work better at a scale of ¾" = 12". Avoid smaller scales except for very large plans because at ⅜" or ¼" to the foot it's harder to maintain accuracy. On the other hand, the bigger the layout the more a "fudge factor" applies, so a small degree of error can be tolerated.

Start by holding a T-square tightly against the edge of your drawing board or pad and draw a baseline across the paper. Use the scale to mark off the length of the longest wall on this line. Put the T-square back on the baseline and rest the base of a triangle against it to draw the perpendicular end walls. Make those lines a little longer than necessary, then measure and mark the end wall lengths exactly with your scale.

If your layout room is rectangular, draw another line connecting the end walls at the marks and you have the space defined. For irregular rooms you'll need to draw in intermediate walls, but always use the triangle and T-square to keep the lines square with the baseline. As much as possible, make all your measurements from the baseline as a guarantee of consistency and accuracy.

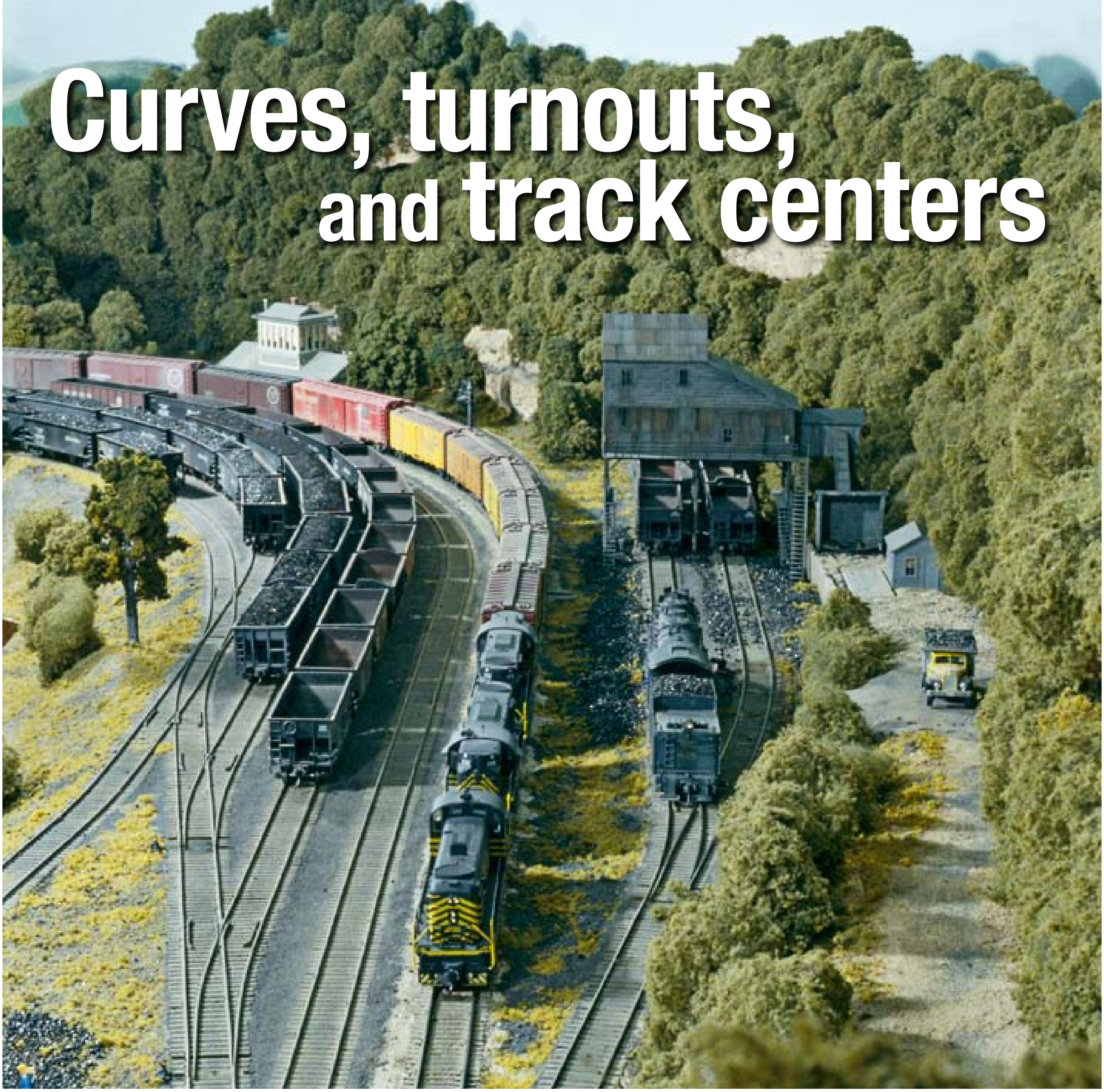
Adding the details. When the outline of your room is complete, use the measurements you recorded on your sketch to fill in the details. Include everything you think you'll need to know to fit your railroad into the shape of the room and around any obstacles or obstructions. It's better at this point to include as much information as you can because you never know what creative leaps you'll be able to make once you start designing.

When you think you have your space drawing finished, take it back to the layout room and use the tape measure to verify what you've drawn. It's better to spend some extra time checking your measurements now than to waste time later on a good idea that doesn't actually fit because of an inaccuracy in your drawing.

Using the drawing. You can use the accurately scaled representation of your layout room in at least a couple of ways. One is to make multiple copies and start sketching in main lines and benchwork shapes right on the copies. I'll have more to say later on controlled doodling or sketching in scale, but obviously this can be a good way to try out different concepts.

For making an accurately scaled track plan, I like to tape the room drawing to the drawing board and work on a sheet of tracing paper laid over it. I find I can quickly trace in the room outline and whatever details I need, then draw the tracks and aisleways in scale.

Curves, turnouts, and track centers



Curve radius, turnout size, and track spacings are standards you need to set before starting to draw a track plan. Tony Koester photo

Among the first choices you'll need to make in designing your model railroad are the sharpness of the curves, and the angle and length of the turnouts (track switches). Curves are defined by radius and turnouts by the number of the frog. Or you can look at it another way and decide what the longest cars and engines you want to run will be. You pretty much end up in the same place either way because your rolling stock will require a certain minimum radius and corresponding frog size to operate reliably. In fact, your trains will look even better on curves and turnouts larger than the minimums they need.

The sectional track in a typical HO train set forms curves of 18" radius. That's measured from the center point of the curve to the center line of the track. Equivalent N scale track sections have a radius of $9\frac{3}{4}$".

In both scales these sharp curves are best suited to smaller steam locomotives, older-model four-axle diesels, and cars of 50-foot scale length or shorter. Nevertheless, many larger engines and cars made in both HO and N are engineered to operate on these extremely sharp curves. Experienced modelers have learned to keep curvature and equipment in proportion for the best operation and most realistic appearance.

The box "Curvature by scales" recommends minimum radii based on types of rolling stock in different scales. It classifies curves as "sharp," "conventional," and "broad" for convenience, but feel free to use whatever in-between radius is appropriate for your track plan. With flextrack you can make curves of whatever radii you need. Of course larger curves are always better, assuming you have room for them.

Turnouts. These are usually specified by the angle of the frog, where the two diverging lines cross – see the "Turnout parts" illustration – stated as a number. In a no. 4 frog or turnout, the legs of the diverging angle will be one unit apart four units from the apex of the angle, also referred to as the point of the frog. This way of determining angles comes in handy when you want to draw turnouts on a track plan.

"Turnout" is an engineering term that we prefer in model railroading to avoid confusion with electrical switches and because it describes the whole track assembly where two lines diverge. Strictly speaking, a "switch" is only the moving parts of a turnout.

The larger the frog number, the longer the turnout and the broader the curvature of its diverging leg. Longer turnouts are good, but they take up more layout space, both in themselves and for arrangements like yard ladders and passing sidings. Just as with curves, we often have to compromise on the shortest turnouts that will handle the equipment we want to run.

Number 4 turnouts are about the sharpest normally used. They may be okay as the standard for very small layouts, but on larger systems it's best to restrict them to industrial spurs where only smaller cars and engines will run. Number 5 turnouts are good for layouts with sharp curves and for yards on layouts with conventional curves. Layouts with broad curves will usually have at least no. 6 turnouts and may use no. 8s in crossovers to avoid S-curve problems.

"Wye" or equilateral turnouts are a special case, as both legs diverge equally from the center line. A wye turnout of a given number is equivalent to a standard turnout with a number twice as high, so the curvature in both legs of a no. 4 wye is the same as in the diverging leg of a no. 8.

Track centers. Along with the size of curves and turnouts, also decide how close you'll put parallel tracks. The minimum is the distance at which trains can pass without touching and with sufficient clearance for reliable operation. Tracks can be closest when straight, but when they start to bend they have to be farther apart to allow for rolling stock overhanging both inside and outside the curve.

The recommendations in the "Track centers" box are conservative and allow a margin for error in track planning. Railroads might put tracks in a yard as close together as 13 feet on center, about 1 13/16" in HO. Parallel main lines might be 15 feet on center or 2 1/16" in HO. After experimenting with the equipment you want to operate, you may find you can use closer centers in construction than you allowed for in your drawing.

When you've decided on minimums for curve radius, turnouts, and track centers, you'll have the basic information you need to start planning your model railroad.

Curvature by scales

Radii in inches

	N	HO	S	O
Broad curves	17"	30"	41"	58"
Conventional curves	14"	24"	32"	46"
Sharp curves	11"	18"	24"	35"

Matching rolling stock to curvature

Broad: almost all motive power including most articulated steam engines, full-length passenger cars, and scale 89-foot freight cars

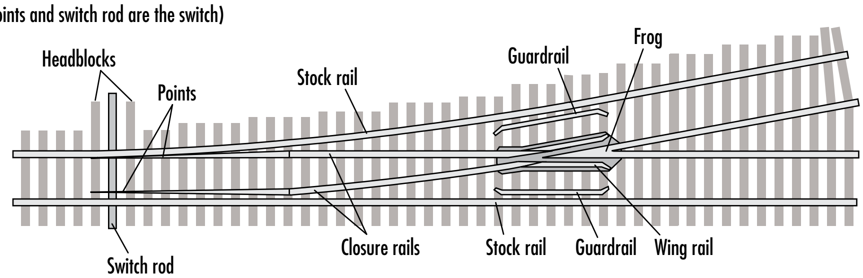
Conventional: medium-size steam engines (2-8-2, 4-6-2), six-axle diesels, full-length passenger cars only with easements and modified running gear, and all freight cars except 85- and 89-footers

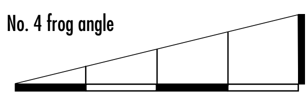
Sharp: small steam engines (2-8-0, 4-6-0), most four-axle diesels, short (60-scale-foot) passenger cars, and freight cars under 60 feet in length

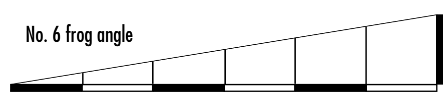
For more-detailed recommendations for matching rolling stock and curves, see National Model Railroad Association (NMRA) Recommended Practice RP-11, at www.nmra.org/standards/rp-11.html

TURNOUT PARTS

(Points and switch rod are the switch)







Track centers

N scale				
Radius (inner track)	9¾"	13"	16"	Straight
Track centers	1½"	1 7/16"	1⅜"	1¼"
HO scale				
Radius (inner track)	18"	24"	30"	Straight
Track centers	2⅜"	2¼"	2⅛"	2"
S scale				
Radius (inner track)	24"	36"	42"	Straight
Track centers	3¼"	3⅛"	2⅞"	2¾"
O scale				
Radius (inner track)	32"	42"	54"	Straight
Track centers	4⅜"	4⅛"	3⅞"	3⅝"

For more-detailed recommendations for track centers, see NMRA Standard S-8, at www.nmra.org/standards/s-8.html

Sketching by the squares

It's fun to sketch layout concepts as they occur to you, and you never know when you might have a breakthrough idea. It might take a lot of time to try a new concept in a scale drawing, but fortunately there's a faster way to learn if your great inspiration will really fit. Master layout designer John Armstrong invented a method of controlled doodling that can be used to quickly test track planning ideas. It's called sketching by the squares.

This method is based on a unit of area called a square, determined by your minimum radius and track centers. See the "Definition of a square" illustration at the upper right. (Illustrations here are adapted from *Track Planning for Realistic Operation*, by John Armstrong, from Kalmbach Books.) Once you've set the size of a square for your layout, you can divide your layout room into a grid of squares.

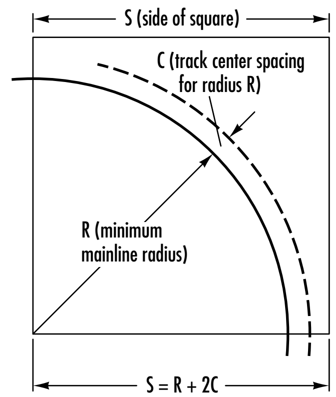
As an example, suppose you have a 12 x 18-foot room for an HO scale layout and want to use a 27" minimum radius and 2" track centers. That makes a square 31" on a side – 27" + (2 x 2") = 31" – and the room size in squares comes out to about 4⅔ x 7 – see the illustration below.

Use tracing paper to lay out this grid over your room drawing, then make as many copies of the grid drawing as you want and use them to sketch layout ideas. With tracing paper, you can always try a different-size square based on a different minimum radius by laying out a new grid over your original room drawing.

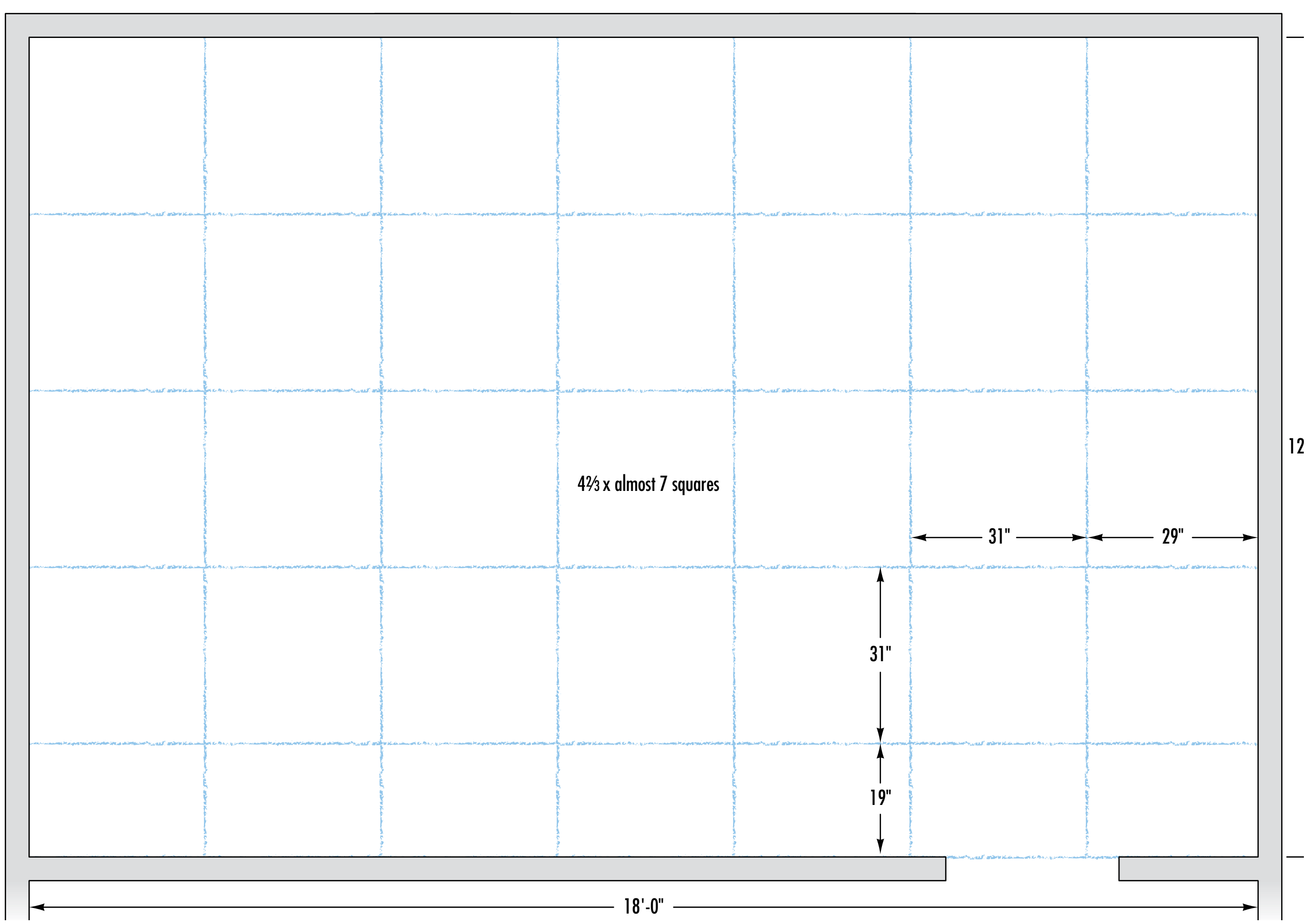
And if an idea comes to you when you don't have one of those copies, all you have to do is draw a rough grid of 4⅔ x 7 squares on whatever paper is handy and start sketching. The grid doesn't need to be drawn to scale or even be exactly square to be useful. Keep in mind a rough idea of where doorways and obstacles are in relation to the grid so you can add those features whenever you want.

What fits in a square. The key to this method is knowing what fits in the squares. This is shown in "What will go in a square?" on the next page. Keep your sketching within those guidelines and you can be sure that your ideas will work when drawn to scale.

Definition of a square



12 x 18-foot room divided into 31" squares



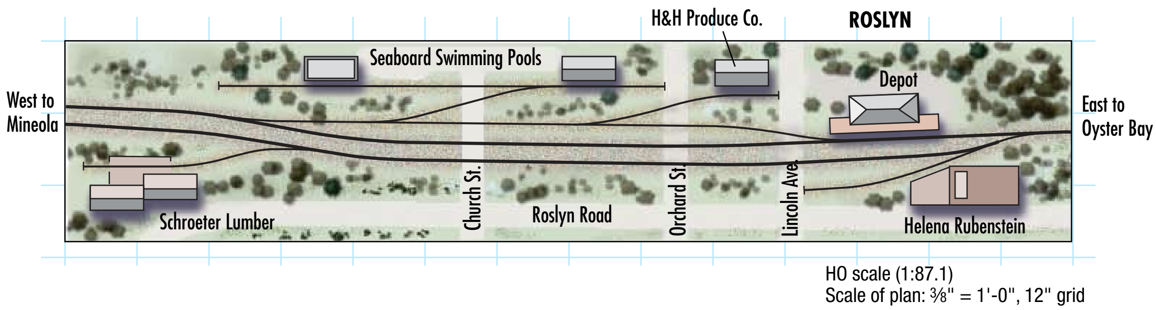


Illustration by Bob Wegner

Layout Design Elements

A good way to design a model railroad is to incorporate track arrangements and scenes based on the real thing. Tony Koester, editor of *Model Railroad Planning* magazine, calls these Layout Design Elements, or LDEs for short. For a small railroad you can pick one LDE as the focal point and design everything else around it. In a larger system you can string LDEs together – a yard, a station, a major industry, and so on – joined by segments of main line.

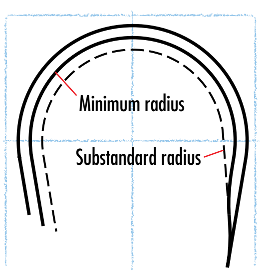
One advantage of LDEs is that they automatically look realistic because they're taken from reality. Another is that your trains will be able to operate like the big ones because the LDE follows a real-life track arrangement.

You can find prototypes to use as LDEs in magazines, books, and railroad historical society publications. Also see Tony Koester's book on LDEs, *Realistic Model Railroad Building Blocks*, from Kalmbach Books. When you find something you like, draw it to scale and convert its dimensions to squares. If you know that the large grain elevator complex you want to model needs ¾ x 3 squares, it'll be easy to work it into your sketches.

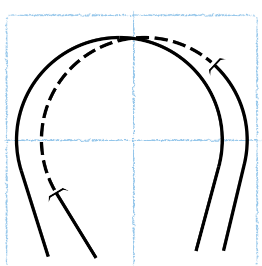
Since everything you sketch by the squares is proportioned to your minimum radius, this method assumes that your rolling stock will be proportional also. With a smaller radius, yard ladders and turntables will be sized for smaller engines and shorter turnouts. As the radius gets longer, the squares accommodate longer turntables and turnouts for larger equipment.

Aisleways for walk-in or walk-around layouts aren't specified in terms of squares. That's because everything in the squares varies with modeling scale, but of course our width doesn't. For HO layouts a comfortable aisle will be at least one square wide – more if the minimum radius is small. For N scale allow a width of at least two squares and about half a square for O scale.

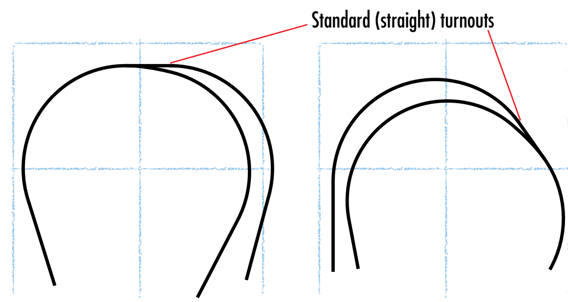
What will go in a square?



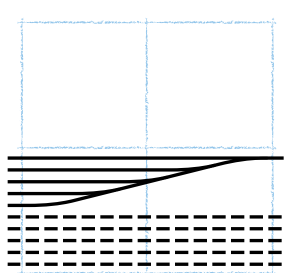
Two concentric semicircles with the inner track of minimum radius will fit in a two-square space. A third track would have to be of substandard radius.



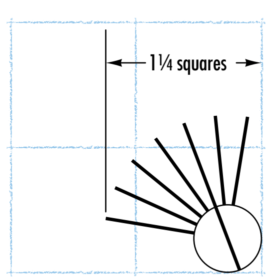
Interlaced single-track main lines will fit comfortably in a two-square width.



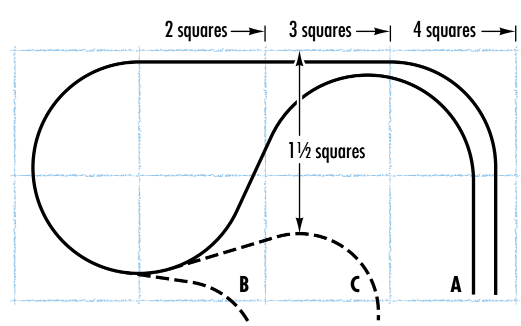
A standard turnout centered in the two-square space will not quite fit. Locating it at an angle will make this alignment practical.



Ten tracks or more will fit side-by-side in one square. However, it takes approximately two squares of length to connect only five tracks with a simple ladder.



A turntable and roundhouse of appropriate size for the class of railroad being modeled will take a space 1¼ squares by ¾ to 1¼ squares, depending on the number of roundhouse stalls.



In highly convoluted alignments, length in one direction can be substituted for another (and vice versa) to some extent. To get the narrow waist of alignment A, a length (left to right of diagram) of almost four squares is required. If length of only two or three squares is available, extra width required for alignment B or C must be provided.

Simple drafting tools will let you draw curves and turnouts with great accuracy.

Photo by Bill Zuback

Drawing curves and turnouts accurately

The essence of drawing an accurate track plan is being careful and correct with curves and turnouts. There are a couple of basic techniques to master and a shortcut to help with the most repetitive tasks. Think of these skills as foundations to support your imagination, and you'll be able to both enjoy the fun of track planning and trust the practicality of your work.

Drawing curves with a compass is easy, and that's mostly what you'll need to do in designing a model railroad. If you've sketched your layout plan by the squares, you already know where the major curves are going to be. Tape tracing paper over your space diagram, trace in the outline of the room, use an architect's scale to set your compass to your minimum radius, and draw arcs of that radius in the locations you've sketched.

Draw the arcs longer, through more degrees of curvature, than they need to be. That makes it easier to accurately connect them with straight lines. You can erase the excess arc after you're satisfied with the location of your main lines.

When you connect the curves with straight lines, align your rule so the pencil point barely touches the outside of the arc at each end. There are two good reasons for this. The first is that you want the line to be geometrically tangent to the arc. "Tangent" means a line touches a circle or arc at only one point, and is therefore automatically perpendicular to a line drawn from the center of the arc or circle to that point. In other words, the straight track the line represents will meet the curve squarely, without a kink of sharper radius.

(This is why railroaders and model railroaders use "tangent" to mean straight track – usually every piece of

Turnout dimensions

Q: Distance from switch point to intersection of center lines

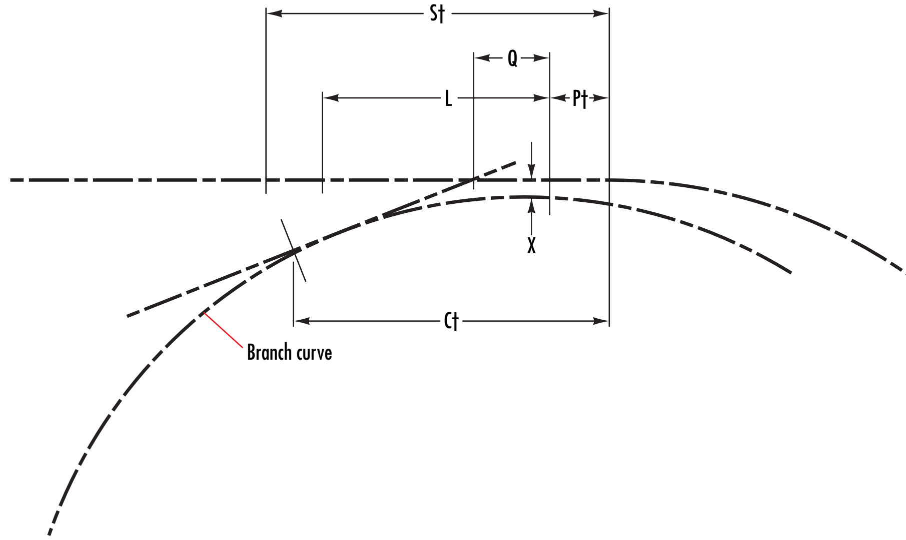
L: Lead, distance from switch point to point of frog

P†: Minimum straight section ahead of switch points

S†: Overall length of straight leg of turnout

C†: Overall length of curved leg of turnout (measured as shown)

X: Offset between continuation of curve and straight leg of turnout



This table gives key turnout dimensions useful for laying out center-line track diagrams to a scale accurate enough to ensure that the alignment can be built in the indicated space. For actual construction of turnouts, see NMRA Recommended Practice RP-12, from which these figures were derived. All dimensions are in inches, to the nearest 1/16".

Turnout dimensions	N				HO					S				O			
Frog #	4	5	6	8	4	4½*	5	6	8	4	5	6	8	4	5	6	8
Q	1 3/8	1 5/16	1 5/16	2	2 1/2		2 7/16	2 3/8	2 3/4	3 5/16	3 1/4	3 1/8	5 3/16	4 9/16	4 1/2	4 3/8	7 5/16
L	2 3/4	3 1/8	3 3/8	4 7/8	5 1/16	5 3/16	5 11/16	6 1/4	9	6 13/16	7 5/8	8 3/8	12 3/16	9 9/16	10 3/4	11 7/8	17 5/16
P†	1/2	9/16	5/8	13/16	15/16	1 1/2	1 1/16	1 3/16	1 1/2	1 1/4	1 3/8	1 1/2	1 7/8	1 5/8	1 13/16	2	2 1/2
S†	3 13/16	4 1/4	4 11/16	6 1/2	7	9	7 13/16	8 5/8	12	9 5/16	10 3/8	11 3/8	15 15/16	12 13/16	14 3/8	15 7/8	22 5/16
C†	3 3/4	4 1/4	1 1/16	6 1/2	6 7/8	8	7 3/4	8 5/8	12	9 3/16	10 5/16	11 3/8	15 15/16	12 11/16	14 4/16	15 7/8	22 5/16
X	3/16	1/4	1/4	5/16	5/16	5/8	7/16	1/2	5/8	1/2	9/16	3/4	13/16	5/8	3/4	15/16	1 1/8

† Dimensions given are minimums; for ready-to-use or kit turnouts substitute actual measurements from turnouts to be used. For example, Atlas HO no. 6: P = 1½", S = 12", C = 10". Most sharp- and conventional-curve N scale ready-to-use turnouts are the curved-frog design, as are Peco Streamline turnouts in all scales. These can best be laid out as arcs tangent to the straight-leg center lines and the actual dimensions C and P.

* Atlas no. 4 HO turnout is actually no. 4½. L, P, S, C, and X are shown for this turnout in the HO columns.

straight track on a railroad is tangent to a curve somewhere.)

The other reason for having the straight line barely touch the curve is to allow for transition, or easement, curves. These are spirals of gradually decreasing radius that allow locomotives and cars to move smoothly from a straightaway into a curve. Easements not only look nice on a layout, they help trains run smoother by compensating for the extreme sharpness of even the broadest model railroad curves.

Easements require an offset between the straight track and the constant-radius curve to allow room for the gradual transition to that radius. That offset is generally some fraction of an inch, however, so the width of a pencil line is usually enough to represent it. (Note that half the length of the easement will extend into the tangent, so allow for that too by not locating turnouts closer to the curve than that distance.)

You'll also need to draw new curves taking off from straight lines. Start by aligning a triangle along your tangent so that the 90-degree corner is at the point where you want the curve to start. Then you can draw a line along the triangle that will be perpendicular to the straight line – the center of the curve will fall along that perpendicular line.

With your compass set to the desired radius, place the point on the perpendicular line so the tip of the lead barely touches the tangent. Then you can swing the compass to draw the arc of that curve.

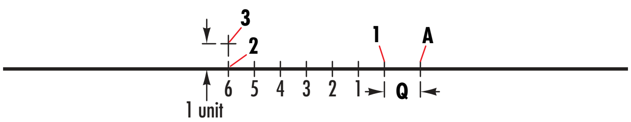
Don't fudge on the relationship between curves and tangents. Accuracy here will pay off in the construction and operation of your railroad.

Turnouts also call for careful drawing, both to construct accurate angles and to mark off relevant dimensions. The "Turnout dimensions" table gives the information you need based on NMRA Recommended Practice RP-12 (www.nmra.org/standards/rp12.html). Not all turnouts necessarily match these recommendations – nor should they. If you'll be using turnouts with other dimensions, such as scratchbuilt turnouts following the specifications of your favorite prototype, use those measurements in your track plan.

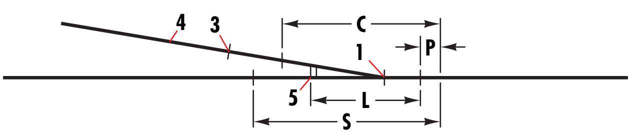
The illustrations on the next two pages show how to lay out turnouts

Laying out turnouts on track plans - 1

To lay out a turnout at a given location on a tangent, points to be at A:



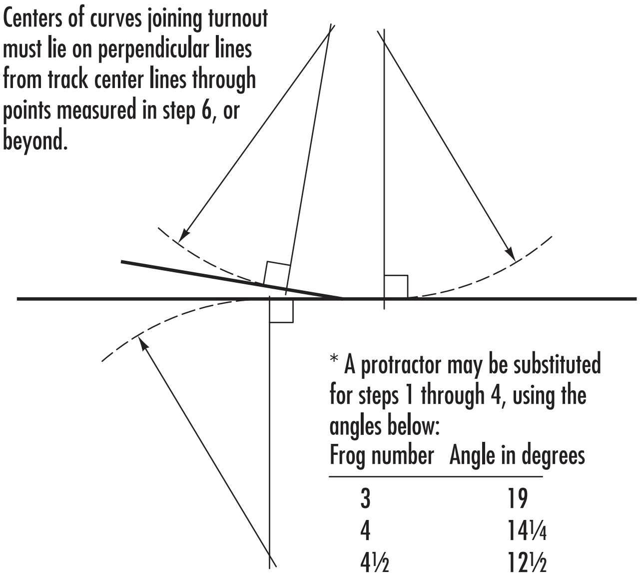
1. *Measure point-to-intersection distance Q from "Turnout dimensions" table.
2. *Measure number of units equal to turnout frog number – units may be of any convenient length.
3. *Draw perpendicular and measure one unit.†
4. *Draw line through points 1 and 3.
5. Measure length L from "Turnout dimensions" table – this locates frog.



6. Measure distance P, then S, and then C for turnout type (NMRA, kit, or ready-to-use). This locates rail joints or other points at which curved track can join turnout.

† For equilateral or wye turnout, measure ½ unit on each side of straight center line.

Centers of curves joining turnout must lie on perpendicular lines from track center lines through points measured in step 6, or beyond.



* A protractor may be substituted for steps 1 through 4, using the angles below:

Frog number	Angle in degrees
3	19
4	14¼
4½	12½
5	11½
6	9½
8	7⅙

step by step and also give turnout frog angles for use with a protractor. Depending on the size of your protractor and the scale of your plan, this can be very accurate, but if you find it difficult to distinguish the protractor's increments, you can definitely rely on the method shown in the illustration.

As with curves it often helps to extend straight lines from turnouts longer than they need to be and erase them later. It may allow you to mark the distance for a frog angle in larger units that are easier to read, and the extended lines can be useful in other ways. To lay out a yard ladder, for example, extend the diverging line from the initial turnout, then draw body tracks parallel to the base line. Where the body tracks intersect the diverging line are points of intersection for the turnouts in the ladder.

Templates are the shortcut for all this drafting. Commercial templates are available, and they're easy to use if you're satisfied with the scale, curve, and turnout choices they offer. But it's not at all hard to make your own templates, as shown in the illustration on the opposite page. Then you'll have exactly the curves and turnouts you want for your layout in the scale you've chosen for your drawing.

If your compass has a knife blade, it's easy to cut the required arcs in clear acetate or styrene. You can do almost as well by scoring with a second point in a compass, but the knife blade will make neater cuts. For the turnout template, use a hobby knife and just score and snap out the wedge across the straight edge of the template. The same template works for both right- and left-hand turnouts – just flip it over.

A deluxe set of track planning templates might include at least three curves: the minimum radius, the radius for the outer track on a two-track curve, and a radius tighter than the minimum that you find acceptable for branch lines or industrial spurs. Similarly, you can include templates for your minimum turnout and two or three larger sizes you can use to avoid potential S-curve trouble in crossovers or just to look nice.

The methods explained here will help you lay smoothly flowing trackwork, like that of the Benton, N.M., yard leads on Eric Brooman's HO scale Utah Belt layout. Eric Brooman photo

Laying out turnouts on track plans - 2

To join a curve to a tangent through a turnout at a given location on a tangent, with the center of the curve at B and tangent to pass through C:

1. Draw curve center lines of radii R and R + X (find X in "Turnout dimensions" table).

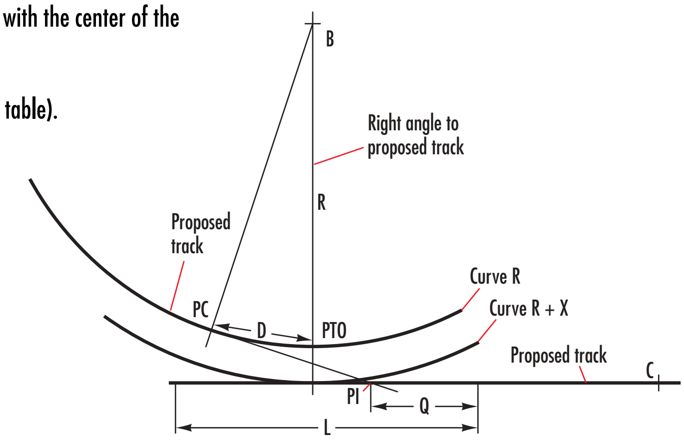
2. Draw tangent from C to join curve R + X.

3. Draw right angle from tangent to B – this locates the point of tangent offset PTO.

4. Measure distance D equal to radius R divided by the frog number – this locates the point of curvature PC. Draw line from B to PC.

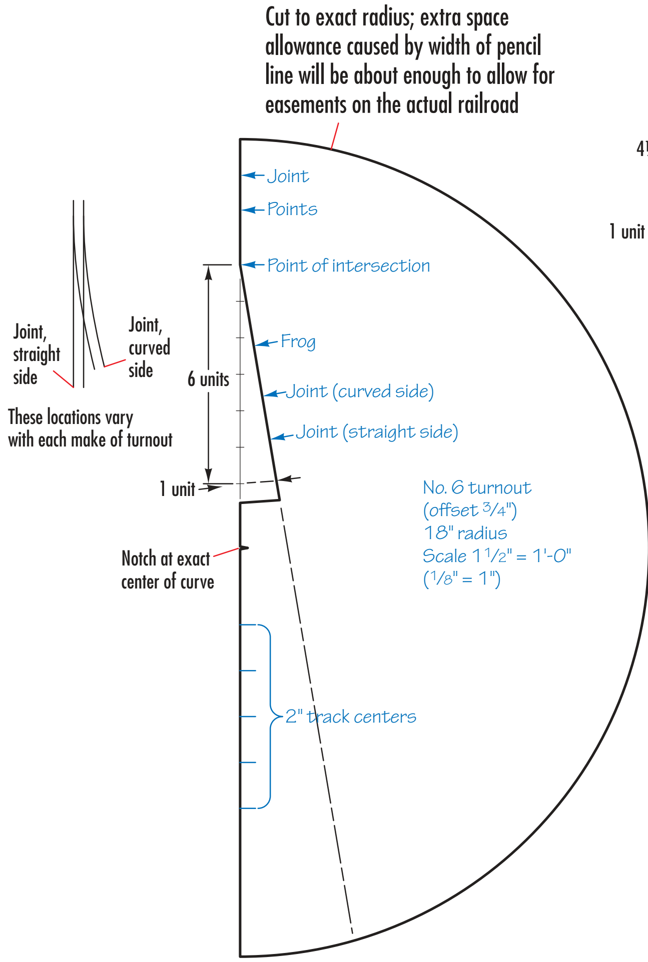
5. Draw line from PC perpendicular to B-PC – where this crosses tangent is the point of intersection PI.

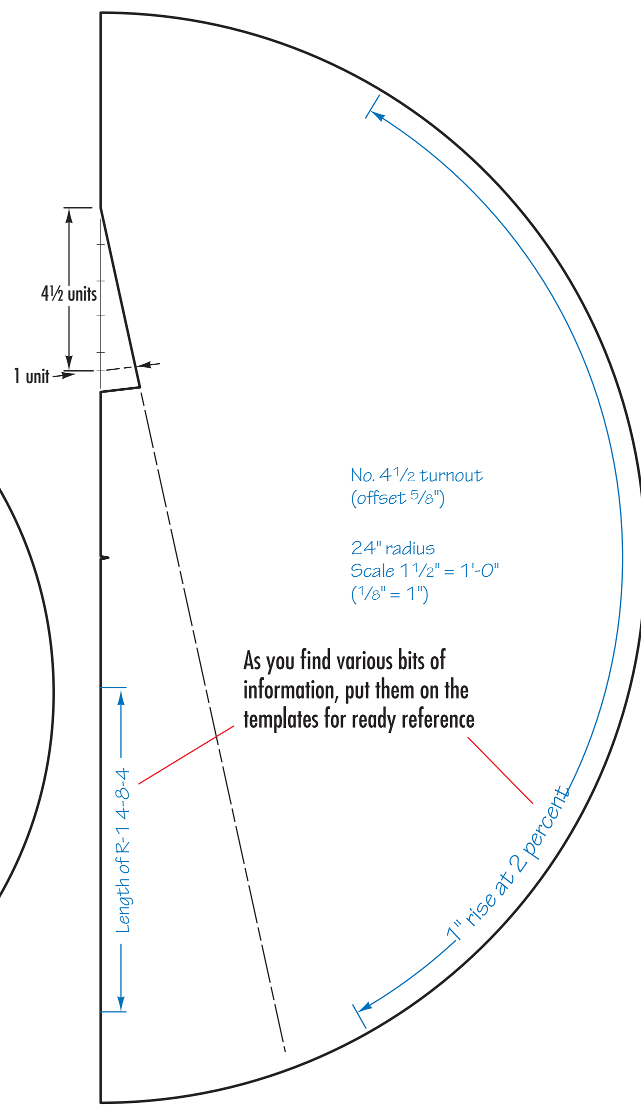
6. Measure distances Q and L to each side of PI to locate point and frog of turnout.



Templates for track planning

Templates will ease the task of drawing a track plan to scale, and can be especially useful in the cut-and-try process of finding the best alignment for key trackwork. The templates can be of any material, but heavy acetate or clear styrene will let you see your previous drawing through the template.





The 3.5 percent grade up to Mahoosic Notch on Jack Ozanich's HO scale Atlantic Great Eastern Ry. adds to the fun by requiring pusher locomotives to help heavy freights make the climb.
Craig Wilson and Jack Ozanich photo

Figuring grades and clearances

Even as you draw in two dimensions you'll want to start thinking of your model railroad as three-dimensional. Whenever you want a track to cross above another track or even over itself, you need to plan on a reasonable grade. Or you may want to build grades for scenic and operational reasons. In the hilly or mountainous country so popular with modelers, trains have to operate up and down grades. You may even want a grade steep enough to require helper or pusher engines, because of the additional operating interest, to represent a favorite prototype, or both.

You also need to provide enough separation so that trains on the lower level can pass under the supporting structure of the upper level track. That supporting structure may be your usual subgrade and roadbed, or it may be a model bridge. The distance between the rails of the lower track and the bottom of whatever supports the upper track is called the clearance, and it must be sufficient for the kinds of trains you want to run.

The steepness of a railroad grade is usually stated by the number of units climbed or descended in 100 units of travel. A slope that rises one unit in 100 is called a 1 percent grade. One that rises two units in 100 is a 2 percent grade, and so on.

On model railroad track plans we often show the lowest track elevation as zero and give elevations above that in inches. Starting from your zero point, you can measure 100 scale inches along the track and mark the elevation at that point for however many inches you wish to establish the steepness of the grade.

Or you can lay out a line climbing to a desired elevation and then measure to determine the percent of a grade. Measure the distance in scale inches along the track between the lowest and highest elevations, divide the difference in elevation by that distance, and move the decimal point in the answer two places to the right.

Suppose you have a rise of 4 1/2" over a distance of 11'-3". Multiply 11 x 12 to convert to inches, add 3, and divide 4.5 by 135. That equals .0333, and after moving the decimal point you can read the result as a grade of 3.33 percent.

That's pretty steep, but if you don't mind running short trains or using helper locomotives it may be okay. If you want to reduce the grade you must have the railroad gain less elevation over the given distance, increase the distance, or manage some combination of the two.

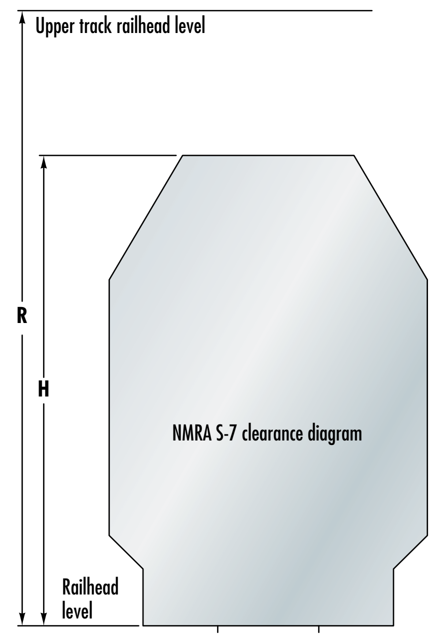
So how do we measure distance on a track plan? Since our tracks are often more curved than straight we're faced with the problem of measuring the length of twisting, turning lines. But you'll usually already have one tool that can do this, your compass. You can use it with the pencil point in place, but it'll be neater to replace that with a second metal point, turning the compass into a pair of dividers.

Using your scale, set the dividers to some convenient measurement, then

Clearance table

	N	HO	S	O
H: NMRA S-7 clearance*	1 21/32"	3"	4 1/8"	5 1/2"
R: Recommended railhead-to-railhead separation	2 7/32"	4"	5 1/2"	7 3/8"

*For more details see www.nmra.org/standards/s-7.html



use them to step off the distance along the track while you count the steps. If you set the dividers to a scale 10", ten steps equal 100" and you can mark an elevation at that point to indicate the desired grade. Or set the dividers to a scale foot and step off the distance to a given elevation in feet. Multiply the number of steps by 12 to convert feet to inches and divide that distance into the elevation to find the grade.

There's a degree of error in measuring curves with dividers – in geometric terms you're measuring chords between points on an arc instead of the circumference of the arc itself – but all that means is that the grade will be a small fraction of a percent steeper than indicated. Usually close is good enough, or you can deliberately mark out a slightly gentler grade than you want to build.

For greater accuracy, a simple length of soft copper wire can be a useful measuring instrument. Bend it to follow the line of your track, put sharp bends at each end of the distance to be measured, then straighten the wire between the sharp bends and measure the straight-line distance with your scale. Or you can use a measuring wheel called an opisometer that you can steer along the line of your track. Usually these have scales in inches and you'll have to convert the measurements to your drawing scale. There are also digital versions that can make scale conversions for you.

Overhead clearance requirements for each scale are given in the clearance table. These are taken from NMRA standard S-7 and represent the ideal prototype clearance of 22 feet above the rail (with some approximation – in HO 22 feet is 3³⁄₆₄".)

Real railroads don't always have this much clearance, and you don't need to either. But if you're going to skimp you should know the scale height of your rolling stock and maintain enough clearance for it. Be aware as well that models are sometimes taller than they should be in scale.

Remember to allow for the structure supporting overhead tracks, whether it's a scale-model bridge or simply the plywood and roadbed combination under your trackwork. Either way it needs to be included in the railhead-to-railhead measurements indicated by track plan elevations. (Where one hidden track crosses over another, you can use short lengths of a thin, stiff material like Masonite hardboard to support the upper track.)

Characteristics of grades

Railroads would avoid grades if they could, because climbing them increases operating expenses by limiting the length of trains and requiring more and heavier locomotives. In reality this is impractical. Even flat-looking country has some slope, and of course there are hills and mountains that have to be crossed. Railroads often follow watercourses to find the easiest path through the terrain, but the streams and rivers wouldn't be flowing if they weren't moving downhill toward sea level.

On a model railroad we may need grades to achieve a desired routing, and we may also use them to help portray particular types of railroading. The descriptions below relate grades to the kinds of railroads that use them.

0 to .99 percent: Except in the flattest terrain, grades as gentle as .3 or .5 percent often require extra earthwork, bridges, and length of run. These expenses may be justified only if traffic is unusually heavy. The former New York Central advertised its New York-Chicago main line as the Water Level Route because most of its grades were less than .5 percent (with the famous exception of the 1.6 percent climb out of the Hudson River Valley at West Albany Hill).

1 to 1.99 percent: A grade of 1 percent, such as on the former Western Pacific line through the Feather River Canyon, is a moderate grade for crossing mountains. The Pennsylvania RR climb through the famous Horseshoe Curve is on a grade of 1.86 percent.

2 to 2.99 percent: When Congress passed land grant laws to subsidize 19th-century railroad construction in the West, it specified that grades on the new lines could not be steeper than then existed on the Baltimore & Ohio. This required the builders of the Central Pacific and Union Pacific to maintain grades of 2.2 percent or less.

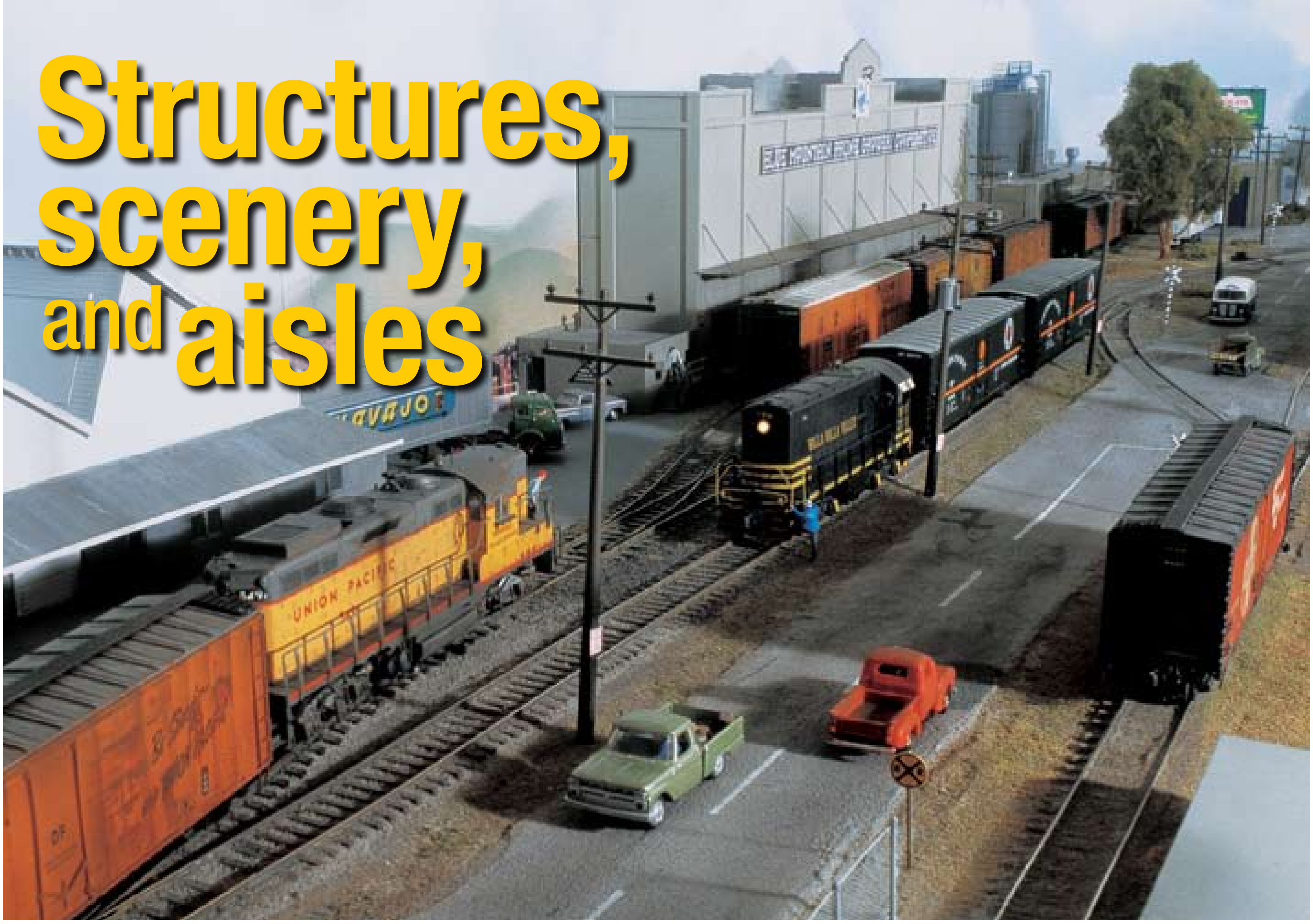
3 to 3.99 percent: Mainline railroads on grades this steep are unusual and found only in rugged terrain. The Santa Fe's line over Raton Pass on the Colorado-New Mexico border was built on a grade of 3.5 percent, leading the railroad to build a second route farther south to carry the bulk of its transcontinental freight traffic on grades not exceeding 1.25 percent.

4 percent and steeper: The steepest mainline grade in the United States is the former Southern Ry. line over Saluda Mountain in North Carolina, at 4.7 percent. It's more common to find grades that steep on cheaply constructed backwoods logging and mining railroads. Seven percent is about the practical limit for normal adhesion and in steam days required special gear-driven locomotives like Shays, Heislers, and Climaxes.

Sand on the rails and the smoke plume from the 2-8-8-4 show what hard work was required to lift Baltimore & Ohio coal trains up the 2.4 percent Cranberry Grade at Terra Alta, W.Va. Gordon R. Roth photo

A scale bridge deck structure can range from about three feet to more than six feet deep, depending on the type and length of the bridge. In HO three feet is ¹³⁄₃₂", and code 83 flex-track is ³⁄₁₆" thick. If you plan for 3" from railhead to railhead where a track passes under a bridge, you're really allowing at most 2¹³⁄₃₂", or a scale 17'-6". That's too little for the biggest modern cars, although older, smaller rolling stock may be okay. The clearance table gives recommended separations for track planning.

Structures, scenery, and aisles



Space was at a premium on Blair Kooistra's HO scale shelf layout, a switching line called the Walla Walla Valley Ry. He still left room for roads and structures to show the railroad in the midst of its urban industrial setting. The low-relief buildings against the backdrop give the impression of larger buildings while saving layout area. Blair Kooistra photo

There's more to a model railroad than just the track, and typically you'll want a track plan to indicate the locations of at least the most important structures and scenic features. There also has to be room for people to build and enjoy the layout, or the plan won't be much use. It's easy to account for all this as you're designing a layout – just leave room for other things besides track.

When you draw a structure on a track plan you need to know the size and shape of the building's footprint, and you need to keep it far enough away from the track. The first piece of information is often available from kit makers, in their catalogs or on their Web sites. Kit reviews in *Model Railroader* and other magazines usually specify the footprint also. If you plan to scratchbuild a structure, use the dimensions from the prototype plan. When you draw in a building to scale, you know it will fit where you want it.

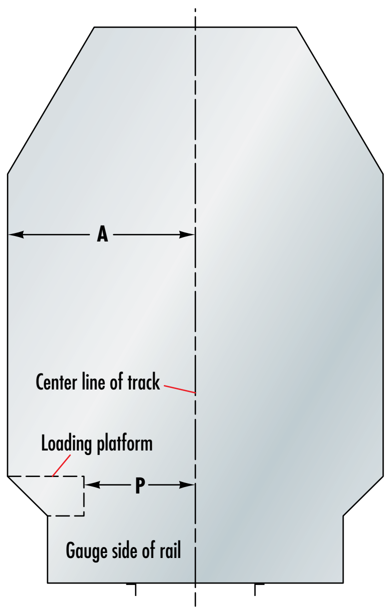
As long, that is, as you allow sufficient clearance from the track center line. It's a trap to cheat on this or simply not to consider that the track represented by a center line is wider than the pencil trace. The trains that will run on the track are wider still. Allow for this as shown in the "Clearance for structures" diagram on the opposite page. You'll need to provide even greater clearance along curved track or where the building is to be set back from the track.

The sloping banks of this creek on Marshall and Mike Skibbe's N scale Chicago Great Western layout help make their rendition of Iowa countryside convincing. Andy Sperandeo photo

Room for slopes can be the key to realistic or at least believable scenery. This can mean keeping a degree of separation between tracks at different elevations. Except when modeling elevated roadbeds through cities, avoid extensive lines of retaining walls between stepped-up tracks.

In open country allow room for the cuts and fills the railroad uses to maintain a steady grade across undulating terrain. Allow for cuts,

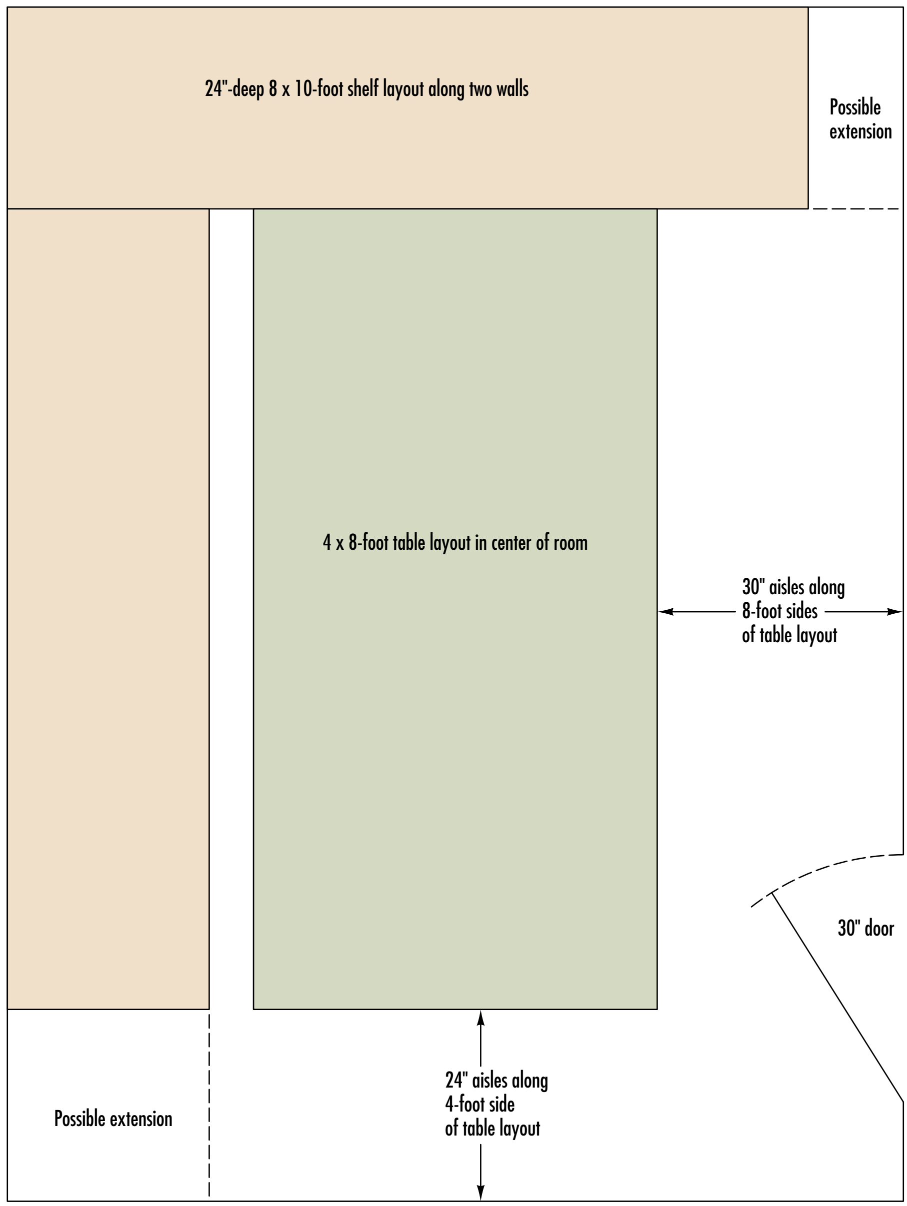
Clearance for structures



	N	HO	S	O
From center of track – **A***	19/32"	1 1/32"	1 13/32"	1 7/8"
For loading platform – **P***	15/32"	13/16"	1 1/8"	1 1/2"

* Allow additional clearance along curved track; for more detail see NMRA standard S-7 at www.nmra.org/standards/s-7.html

Two ways to put a layout in a 9 x 12-foot room



especially as track approaches a tunnel, to keep the actual bore as short as possible.

Slopes are also needed along streams. Outside of very rugged terrain, the banks of a river or creek should have mostly gentle slopes. Even a meandering creek can be a relatively wide feature in the landscape.

Streets and highways can also take more space than you might think. A scale 20-foot width usually looks okay for a two-lane roadway in model scenes, but that's tight for modern vehicles. A 25- or 30-foot width will be more realistic for two lanes. And don't forget to allow for sidewalks in urban settings.

Whenever possible allow room for scenery and even structures between the front-most track and the layout edge. This puts the railroad in the scene instead of in front of it, and seeing trains pass behind some features adds interest.

Room for people is important too. As the 9 x 12-foot room diagram shows, a typical 4 x 8-foot table layout can dominate such a room and restrict the passageways around it. That 4 x 8-foot sheet of plywood or insulating foam can be split down the middle to form an along-the-walls shelf layout that leaves much more free space in the middle of the room.

For walk-in layouts, try to maintain 30" aisles where possible, and allow more width at frequent intervals to make it easier for people following their trains to pass each other.

Aisles of 36" or even 42" width will make building, viewing, and operating the layout much more comfortable. Still wider aisles can be a good idea at yards and other places where operators tend to congregate.

Suggested reading for layout designers (from Kalmbach Books*)

Realistic Model Railroad Building Blocks, by Tony Koester
The Model Railroader's Guide to Freight Yards, by Andy Sperandeo
The Model Railroader's Guide to Industries Along the Tracks, by Jeff Wilson
Track Planning for Realistic Operation, by John Armstrong
Trackside Scenes You Can Model, by Jim Kelly

* Ask your dealer, call 800-533-6644, or go to www.modelrailroader.com.