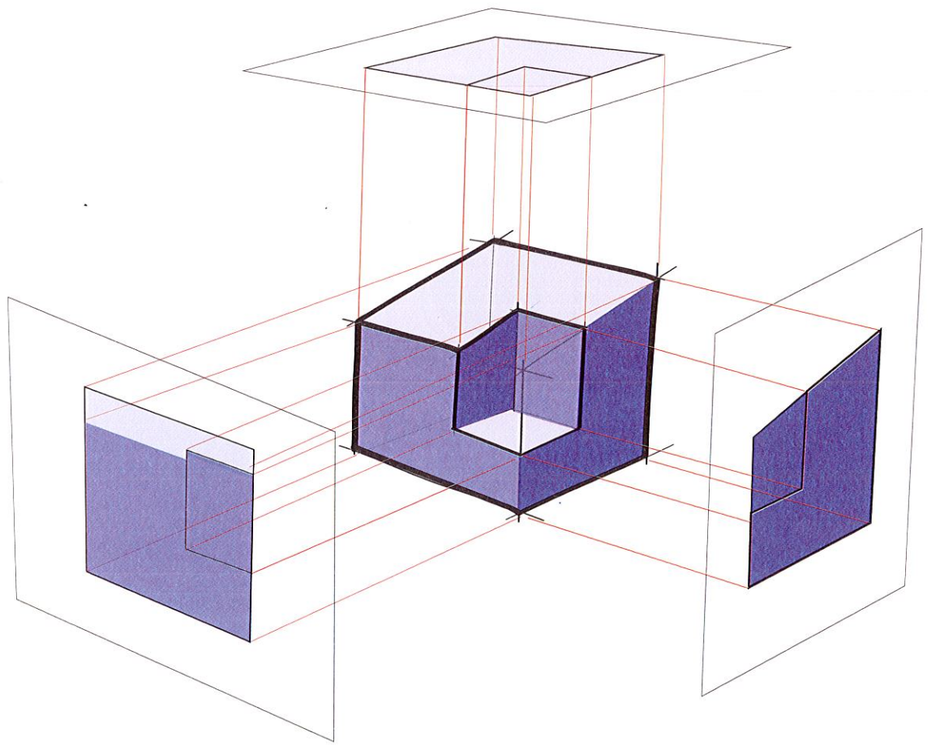
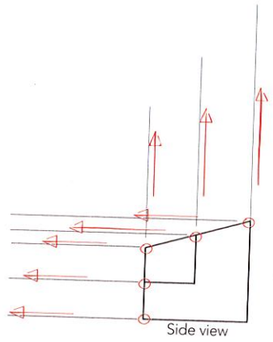
Tutorial

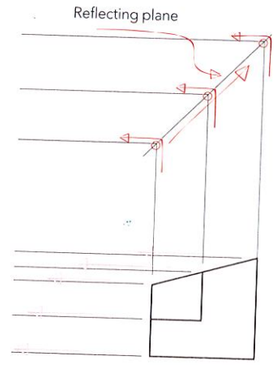
Orthographic projection

Orthographic projection is a network of horizontal and vertical projection lines that intersect to form points or vertices where two lines meet. To begin the process, one view must be known (top, front or side view, for example). The projection process can begin from this known view, moving at 90-degree angles horizontally and vertically. Standard orthographic drawing is laid out with the top view at the head of the page, front view directly below and the side view immediately to the right – which requires a 'reflecting plane' set to a 45-degree angle to translate the geometry over and down to the lower right quadrant of the sheet without distortion.

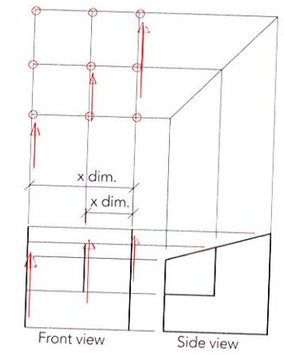




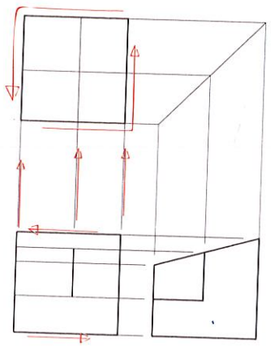
1. Begin with the dominant view of the object – in this case the side view. Project lines from vertices (end points) in both the vertical and horizontal directions. These projection lines 'drive' the placement of geometry in the other views once there is a sufficient network of intersecting lines.

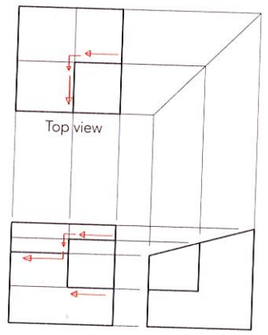


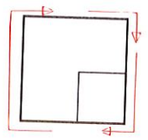
2. Lines projected vertically need to be reflected (rotated) 90 degrees to establish critical edges in the top view. To do this a reflecting plane set at a 45 degree angle is sketched. Angle is important because it's half of 90 degrees, thus eliminating distortion like the mirrors in a camera lens.



3. The dimensions of the front view must be determined beforehand. Sketch vertical lines to meet existing horizontal projection lines from the side view. Don't be concerned about the final appearance at this point. Sketch projection lines upwards to meet the reflected lines.

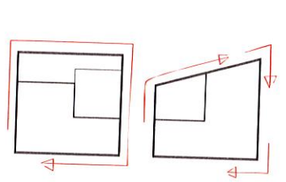




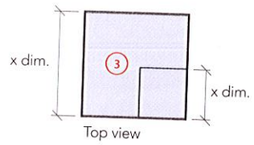


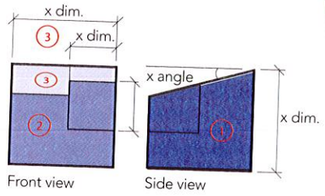
4. Sketch the perimeters of the top and front views defined by the intersecting vertical and horizontal projection lines. The remaining network of intersecting lines reveals where the last edges are to be placed. Networks like these can be confusing. Reference each view for help.

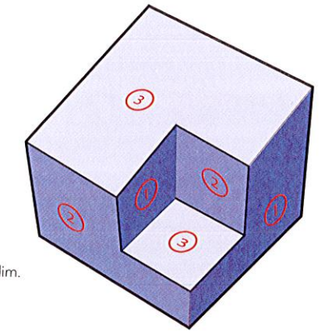
5. With outer boundaries of each view closed, sketch any remaining internal edges to finish the drawing. Mentally moving between the three views helps construct a three-dimensional understanding of the object. Orthographic views are used for dimensioning objects.



6. With darkened (bold) outlines the outside edges stand out. The flatness of orthographic views makes reading them difficult. Their strength comes through the ease of dimensioning. Equally important is the fact that anyone can extract dimensions with a scaled ruler.







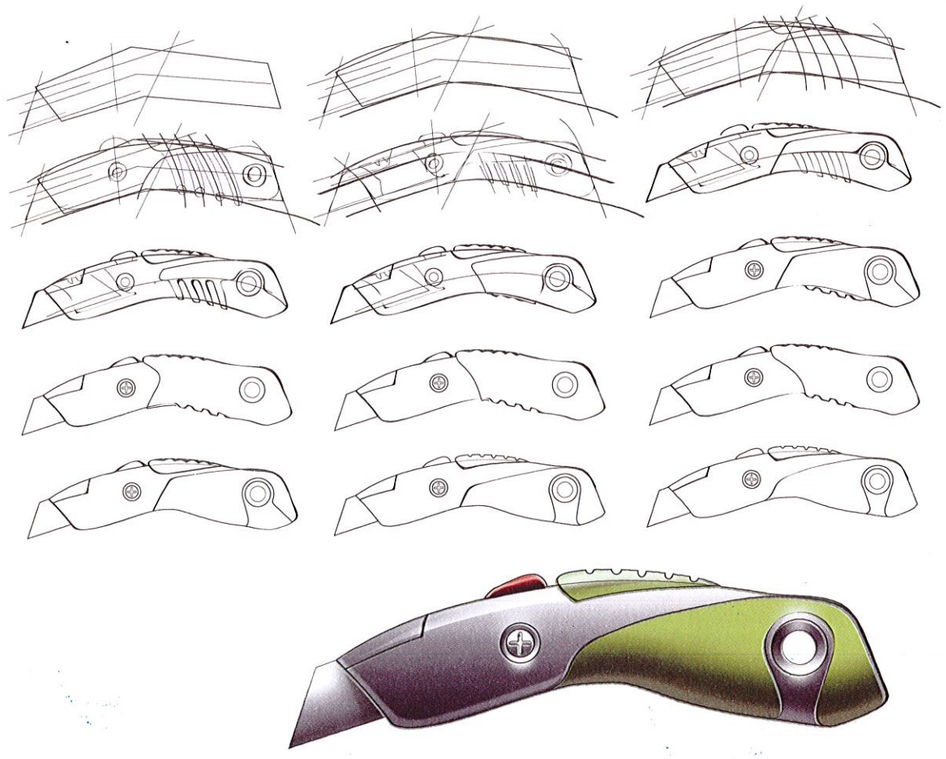
7. Even with the addition of colour, the orthographic view remains very flat because of its orientation – perfectly parallel to the viewer's plane of vision. In the perspective drawing each plane has been assigned a number from 1 to 3 and colour coded according to the view it is associated with. This has been transferred to the orthographic views. Note that only the front view has more than one colour because of the sloping plane. The perspective drawing enables an immediate understanding of the object but is not ideal for dimensioning.

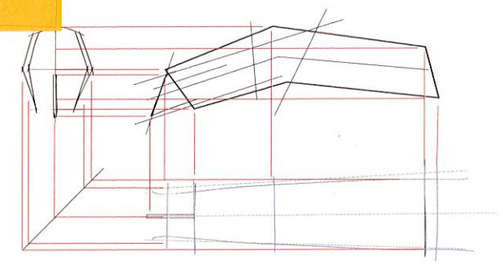
Tutorial

Orthographic sketching

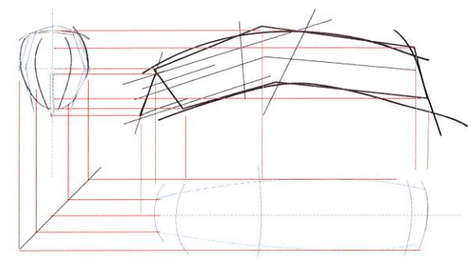
Loose orthographic sketches are one of the best ways to get ideas out quickly. Depending on the complexity of the geometry the process might initially require a single view. Most often designers will develop two views simultaneously; for example the dominant view along with one of the secondary views. In other situations three views are required to really understand the form. In the case of this Stanley knife the dominant view (side view) is the primary focus. Sketching the top view will help the designer with the product's overall form but the focus should be on the side view.

The sequence of sketches below represent a small part of the process of moving from the most basic geometry needed to define the footprint of the product to a more fully refined side view that can then be rendered for greater impact. The range of sketches have been included to show that a designer does not really need to know what the product is going to look like in the beginning but needs to start somewhere and build through iterations. Think of the below as a selection of crucial key frames in a much longer sketch animation. The step-by-step process on the following page shows the projection process for all three views even though a single view or a two-view is often enough.

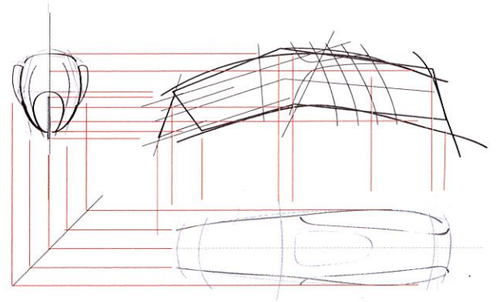




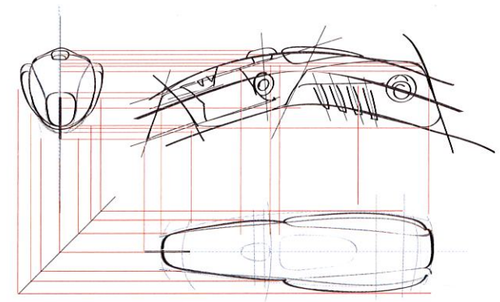
1. Begin with the simplest of layout lines to suggest the overall footprint of the product. In this case, the bend in the body of the product is indicated with straight lines although curves will be sketched over these lines. The projection lines have been drawn with a ruler but usually such sketches are done entirely freehand to keep the process moving. Two views are often enough to get started (front and side view). All three have been included here to clarify the interrelationship between views.



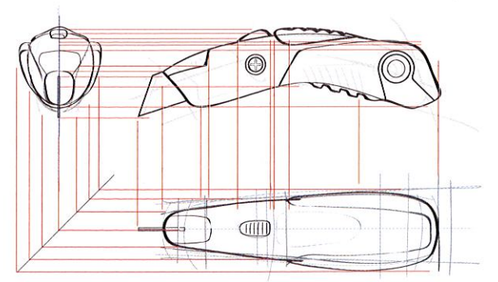
2. The first lines should be sketched as lightly as possible. They are there to help define the boundaries (envelope or footprint of the product). Over these more expressive lines or arcs can be accurately sketched. The projection lines help to register the geometry in the various views while assisting the designer in accurately shaping the product from multiple vantage points. It's not necessary to complete a single view before moving to the next view. They can be developed together.



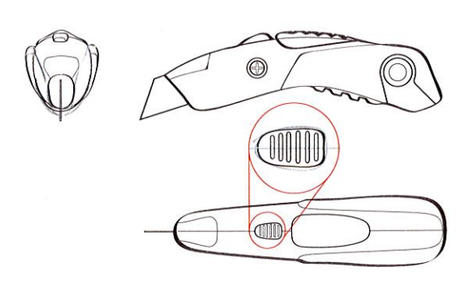
3. Secondary detailing can begin once the overall volume of the product is established. Much like the initial layout lines, secondary details like the grips in an overmoulded handle can be lightly and quickly sketched for possible placement. The whole point of this approach is to quickly place geometry knowing that it can just as quickly be changed or altered. This is not intended to be a control drawing but rather a quick and flexible concept; 20–30 drawings like this would be typical.



4. Now that the front and side views are developed somewhat it's time to move on to the top view. Note that not a single view is complete at this point: all three views are slowly being built and cross referenced. In reality, the top and side view would be the best candidates for sketching as they reveal the most about the product's overall geometry. Additional details like the blade release button and the blade carrier assembly are sketched to help accurately locate other components.



5. Line weights need to be adjusted. In this case a new sketch would be started with the original sketch as an underlay to help facilitate the process. In this process the details can be clarified. The outline is the darkest line and should serve to unify the body. Internal details like the overmoulded handle will be slightly lighter (thinner) and the fine details like the ribs on the release button will be the lightest (thinnest). Ghost lines can be left (like the blade assembly) or removed entirely.

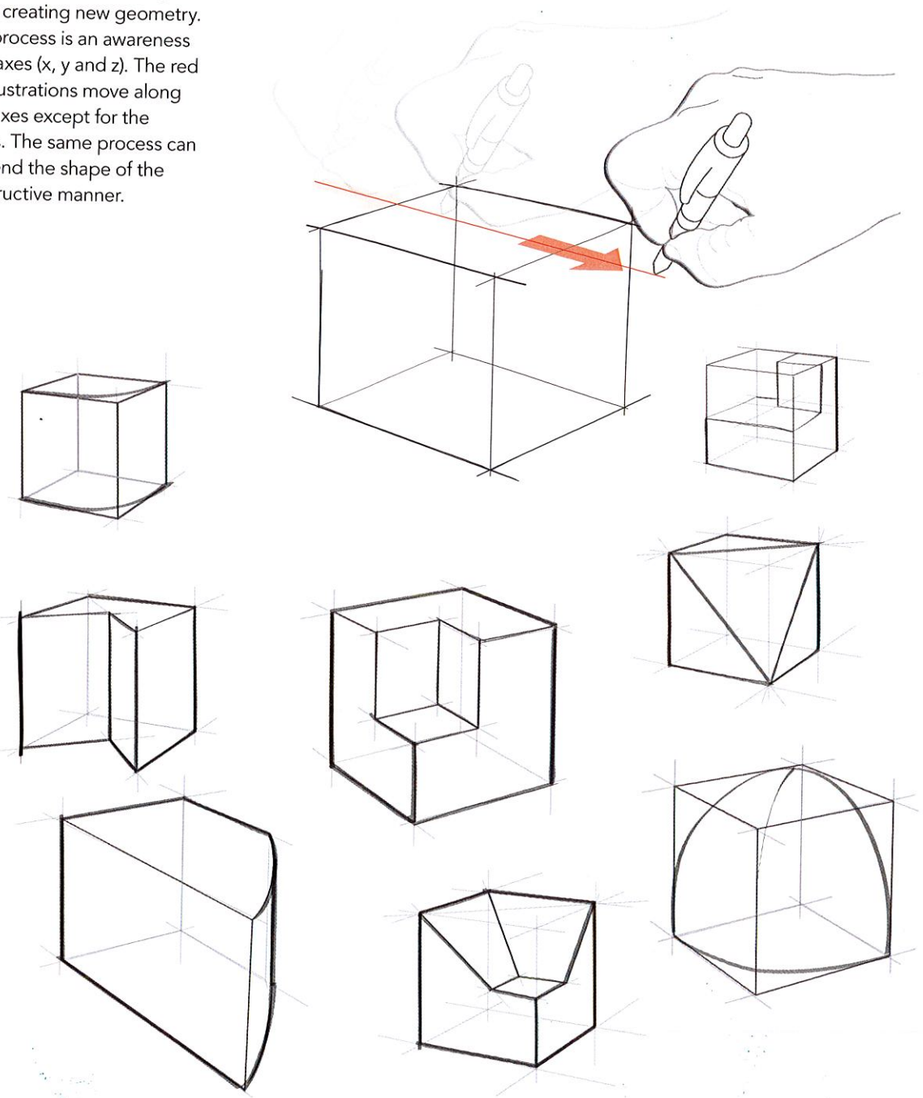


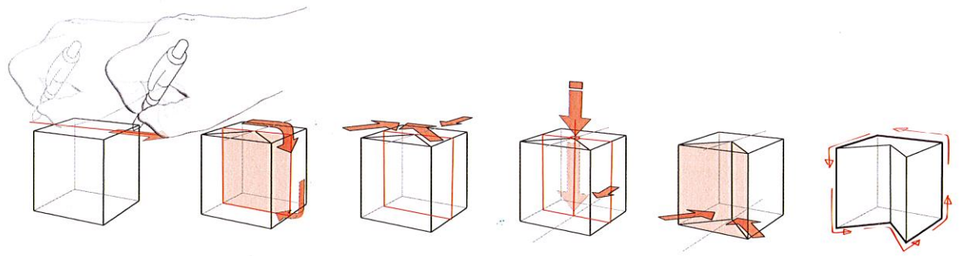
6. Details like the grips on the button are added to the top view where they are easily read. Once the projection lines are completely removed the three views are much less obstructed. The front view has not been completely cleaned up. It is by far the hardest view to sketch accurately and less useful than the other two views given the extreme foreshortening. Nevertheless, any work done of any of the views makes perspective sketching that much easier because the geometry is familiar.

Tutorial

(De)constructing the cube

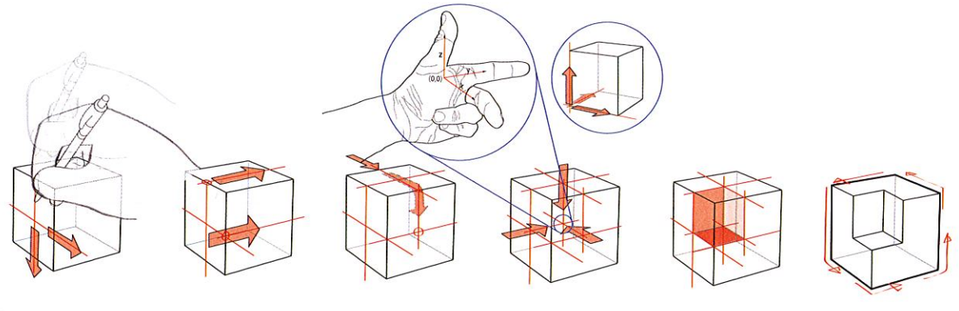
This exercise helps emphasize the power of projection. It involves dynamically deconstructing simple cubes into more elaborate forms. The various faces, edges and vertices of the cube provide references for cutting away as well as creating new geometry. Crucial to this process is an awareness of the primary axes (x, y and z). The red arrows in the illustrations move along these primary axes except for the diagonal edges. The same process can be used to extend the shape of the cube in a constructive manner.





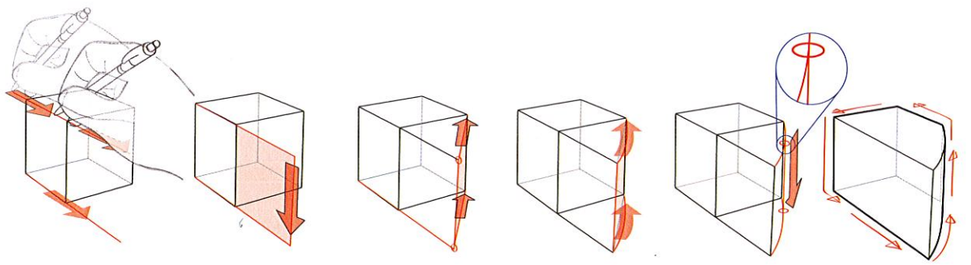
1. Begin with a simple cube sketched in perspective positioned to show three faces. Sketch a line across the top of the cube parallel to the front and back edges on the top surface or face. Project another line downwards along the side face and then along the bottom face and back up the opposite side to close the sketch and create a plane (red). Sketch a line to divide the top surface and sketch two diagonals on the top face to meet at the centre.

2. This initial network of lines makes it easy to add more sketch lines to further divide the internal space within the cube. That first set of lines created a plane that cuts through the centre of the cube. Sketch a line down along this new plane to the bottom face of the cube. This line establishes the centre axis of the cube and provides a point for a new set of diagonal lines to meet on the bottom surface. The cube now has a wedge defined within (red). Darken the outline to complete the sketch.



3. Now we will sketch a vertical line on one of the side faces. Sketch a second line perpendicular to that first line. I've circled the point where the lines intersect the edges of the cube. From here more sketches can be projected back in space. The goal of this exercise is to roughly subdivide the cube into eight smaller cubes and to remove the top front corner of the cube. This will require additional sketches projecting into the centre of the cube which will all meet to form a Cartesian node.

4. The Cartesian coordinate system is defined by the x, y and z axes, which define height, width and depth. Look at any of the corners on this cube – they are all Cartesian nodes defined by three intersecting axes much like the centre set of intersecting lines (circled in blue). With the planes defined it is simply a matter of darkening the overall outline and adjusting the internal line weight of the cutout as well as the internal lines at the back and bottom of the cube. Line weight helps greatly to diminish ambiguity.

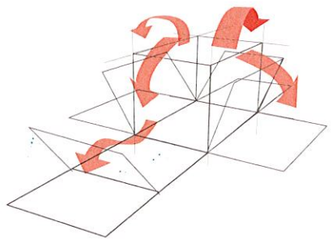


5. Now extend the top and bottom edges on the left face of the cube to build out in space, then project a vertical sketch line downwards to complete the plane (red). This plane is an extension of the existing surface. From the two vertices project lines back to the respective vertices on the front face. These sketch lines create a flat plane (red) that closes the new form, however we will use these sketch lines as references for two arcs that will create a curved surface.

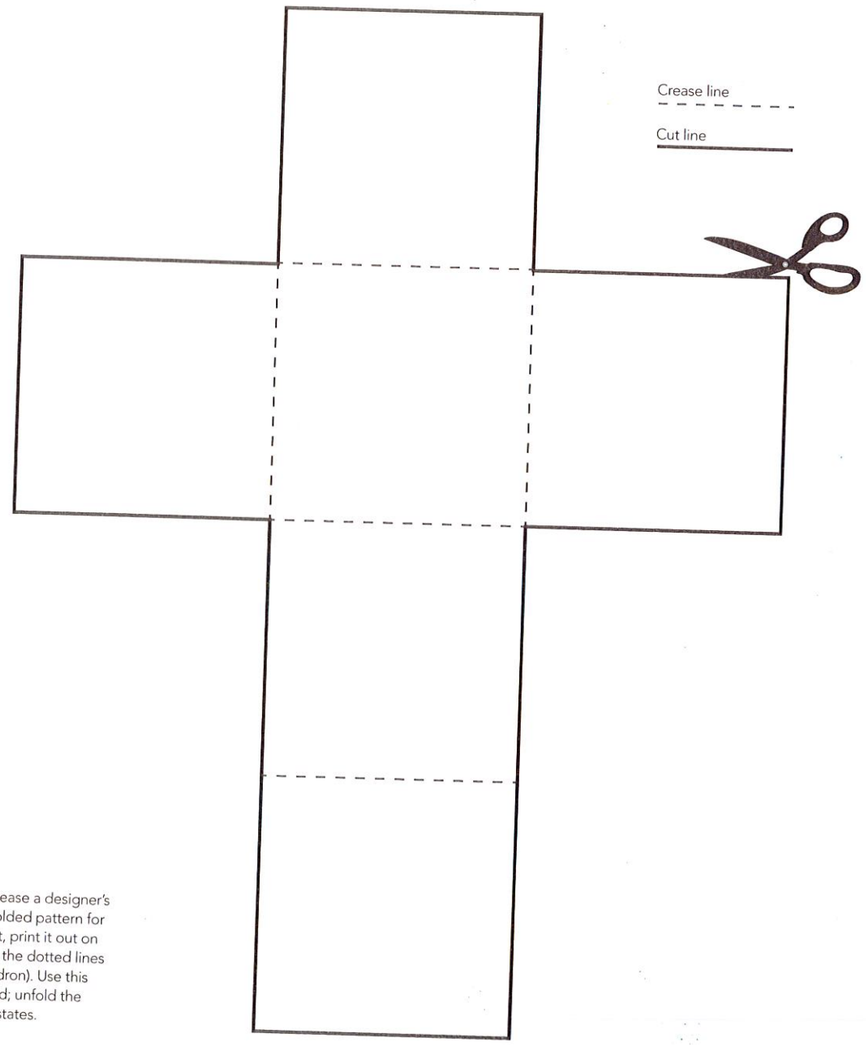
6. The arcs that form the top and bottom segments of the curved surface are sketched similarly to the lines: they connect the vertices and close the surface (red). Because this surface doubles back on itself it would disappear from sight so another line must be added for greater clarity. That line must be tangent to the arcs (red circles) as it represents the outer edge of the curved surface. The final step is to darken the outline.

Tutorial

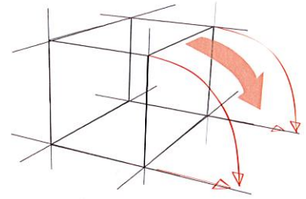
Unfolding geometry



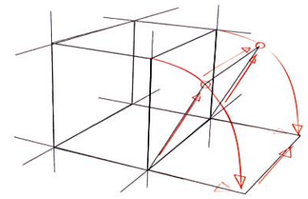
Learning to systematically deconstruct polyhedra is a great way to begin thinking in 3D space while also visualizing cause and effect. Because vertices and edges connect every polyhedron, unfolding the various faces provides an excellent opportunity to think about planes, folding lines and distortion as the faces tilt away. Being able to visualize a simple polygon as a flat unfolded pattern will make creating three-dimensional objects on the fly much easier.



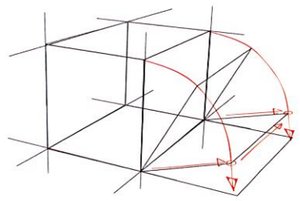
Exercises like unfolding can increase a designer's visual sensibilities. Take the unfolded pattern for a cube and photocopy or scan it, print it out on heavy card stock and fold along the dotted lines to create a simple cube (polyhedron). Use this physical model as a sketching aid; unfold the cube and sketch it in its various states.



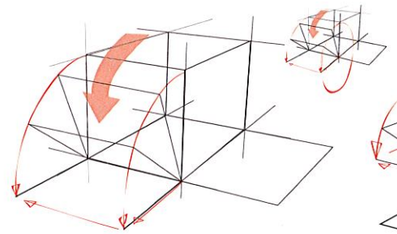
1. Quickly sketch a cube making sure to 'sketch through' so that all occluded (hidden) edges are visible. Determine which face to unfold first and sketch a quick set of arcs (1/4 circle) to determine approximately where the face would land when unfolded to the ground plane.



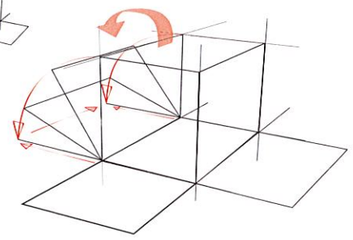
2. Sketch in several steps of the unfolding process for practice. Think of it as lifting weights for your sketching muscles. Use the quarter circles as references for where the plane would necessarily fall. If the arcs are sketched in perspective, they will help position everything accurately.



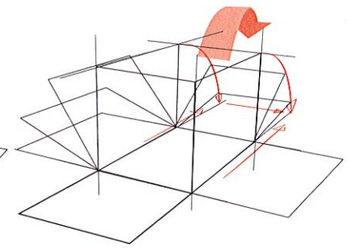
3. Continue sketching additional steps of the unfolding process by referencing the arcs and 'chasing' the lines from vertex to vertex to form the closed flat plane. This method builds muscle memory by reducing the process to a mechanical and repeatable procedure.



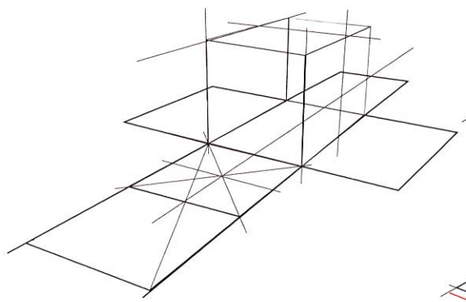
4. The biggest challenge in this process is sketching the arcs with reasonable accuracy. Think of them as partial ellipses sketched around a centre point and axis which is the bottom edge of the cube (see small detail above). If necessary, sketch in the full ellipse lightly.



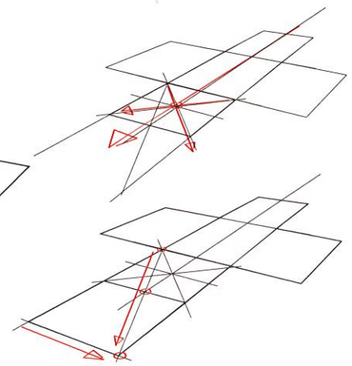
5. Pay close attention to the receding lines of the cube while sketching the unfolding panels or planes. The cube is perspectival so every line recedes to a vanishing point. In this sketch, however, there is no horizon line or vanishing point – everything is approximated.



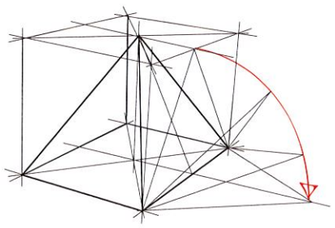
6. At this stage nearly every plane has been unfolded if we count the base plane, which is already sitting on the ground plane. But a cube has six planes or faces, which means there is a top to the box that needs to be added. For this we will take a different approach.



7. Referencing the front plane, project or extend lines forwards in space to create a new plane or face. The problem is knowing where to end the plane. A simple procedure for proportionately extending planes in space involves sketching a centreline and projecting a new line that originates in the uppermost corner and passes through that centreline.



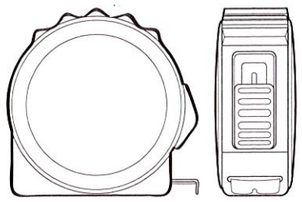
8. Here we see the process in two steps: first the centreline is sketched through the existing flattened pattern (note that the diagonals help to accurately find the centre). Next a line is projected from the uppermost corner that passes through the centreline and intersects with the projected line to determine the length of the plane. Finally the line is connected.



9. Any polyhedron can be placed inside a cube to help with the referencing required to sketch the unfolding process. In the example above a pyramidal form is loosely sketched. The centres are determined by diagonals and lines are projected across the face. The side view of the form is projected on the side of the cube and projected down.

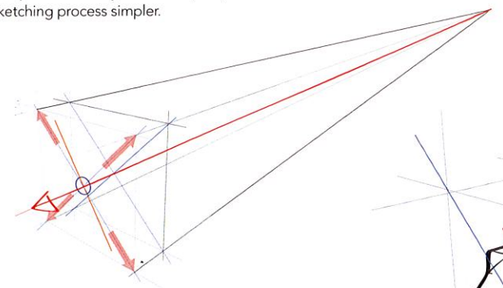
Tutorial

Sketching a tape measure

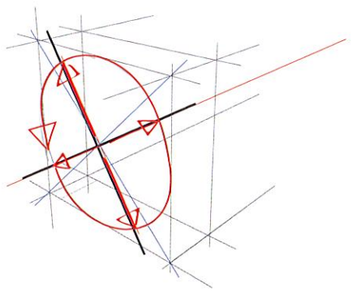


Understanding the object from a two-view perspective already makes the perspective sketching process simpler.

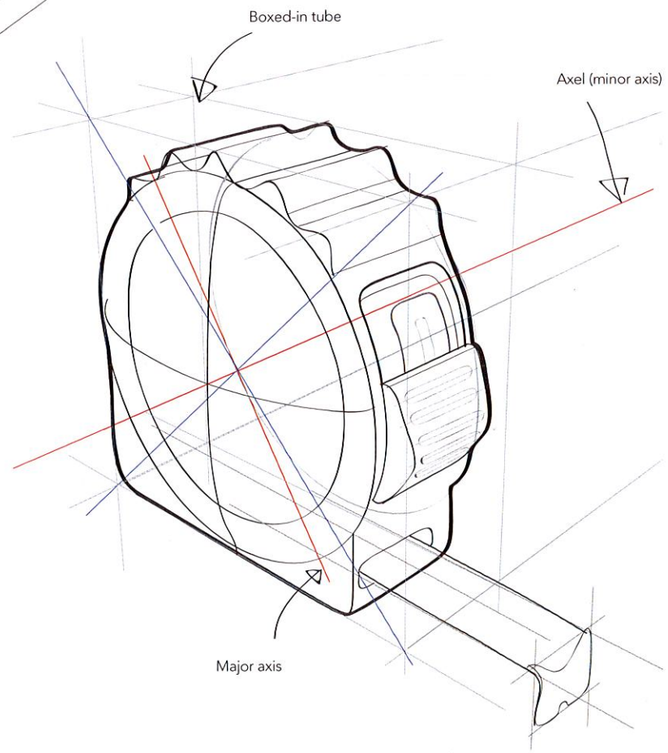
Sketching a tape measure is a perfect way to start working on basic forms in perspective. The form's low-relief, three-dimensional qualities pose some fundamental challenges for beginners. The goal here is to move through the process quickly and methodically, building the shape in steps while referencing the initial geometry laid down earlier. The most difficult part of the exercise is the ellipses. Be aware that there are two centres in a circle viewed in perspective: the centre defined by the diagonals (geometric) and the centre as perceived by the human eye (optical).

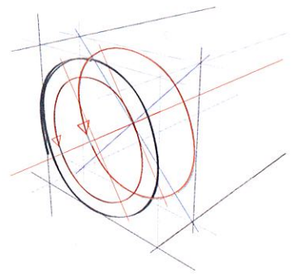


1. To create an accurate ellipse, bisect the face of the cube with diagonals to find the centre. From here project a line back to the vanishing point. This line can be thought of as the axel around which the wheel spins.

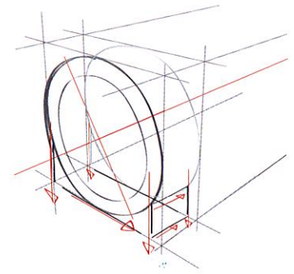


2. Next draw a line perpendicular (90 degrees) to the axel to create the major and minor axes of the ellipse around which the sketch is symmetrically drawn. Note that the original diagonals and the new axes do not coincide.

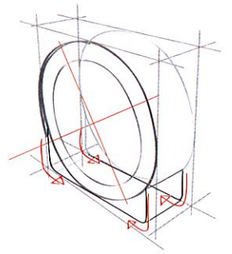




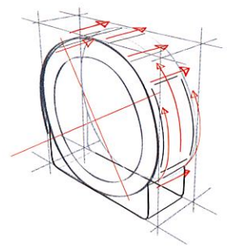
3. Create the second ellipse by repeating the first steps or sketching a slightly smaller parallel ellipse on the back of the cube. Sketch the small internal ellipse using the same major and minor axes.



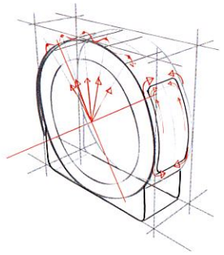
4. Now the most difficult part of the sketch is done (the ellipse), begin building around it. Referencing the front view orthographic, project a series of lines to roughly box-in the base of the tool.



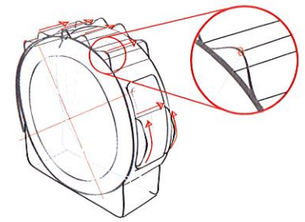
5. With the base lightly boxed-in there's a reference for sketching the radiused corners. Experienced designers will sketch the base with the radiused corners in a single sketch but for the beginner the boxing-in method is useful.



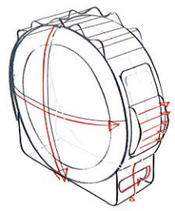
6. Project a series of light lines from the front profile to the back profile to eventually position the grip. Sketch a series of arcs on the face of the tool as reference for the locking mechanism and slot. These will be radiused in the next step.



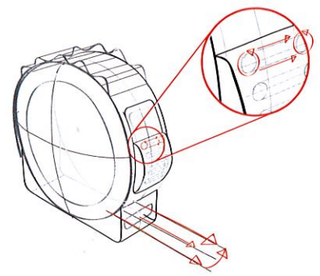
7. Project lines from the centre of the major and minor axes that intersect with the previous projection lines. These will be used to help sketch the grip. Radius the opening for the lock mechanism. Sketch in the interior slot.



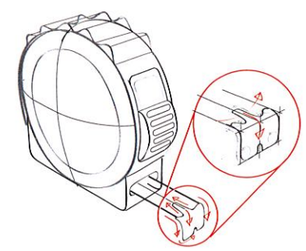
8. Sketch the profile for the grip on both sides of the product and project lines across to connect the high and low points of the profile (see detail). Lightly sketch the profile for the lock mechanism and project lines across to connect the profiles.



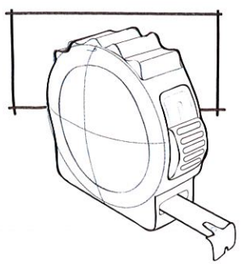
9. Sketch two contour lines across the face of the product to suggest the convex surface. Extend the centreline that was originally used to sketch the lock mechanism. Off that centreline sketch the opening for the metal tape. Project lines for the grips on the lock mechanism.



10. Lightly sketch in small ellipses on either side of the projected lines – these will help define the grips on the lock mechanism (see detail). Project two lines to define the width of the metal tape through the newly sketched opening.



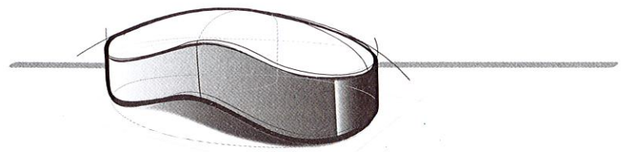
11. Detail the sliding hook at the end of the metal tape by projecting lines to rough in the geometry. Follow this with a series of quick ellipses (if necessary) to help define the radiused edges. Sketch lightly and darken later.



12. A sketch like this can be endlessly tweaked with more detail and colour added. The main thing is to add line-weight differentiation. Begin by sketching a bolder outline around the perimeter of the product. Sketching the edge that defines where the grip meets the body of the product will help differentiate the various surfaces. In the final sketch there are at least three to four line weights (note the parting line that cuts the product in half down the middle and the vignette).

Tutorial

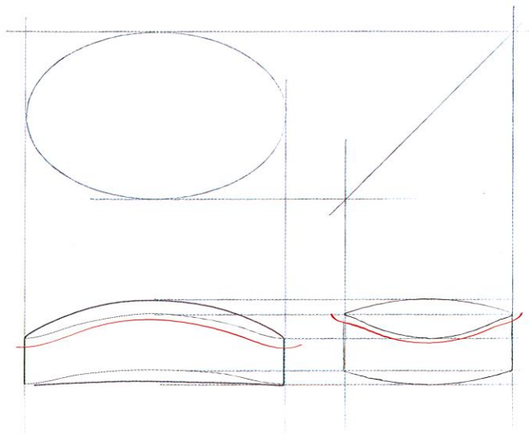
Sketching a contoured bar of soap

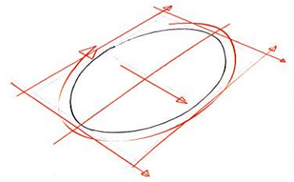


Note how different the sketch above looks from the tutorial on the following page. This is because the vantage point is different. In the sketch above, the vantage point is much lower, making the object appear rounder. Choosing a good orientation is essential to a successful sketch.

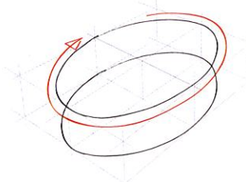
The step-by-step tutorial opposite focuses on the creation of what are commonly referred to as compound curves – curves that bend in two opposing directions. An easy way to accurately sketch compound curves is to use points plotted on the centrelines of varying planes within a volume. A compound curve often defines the boundary of a compound curved surface (a surface that bends in two opposing directions like the soap bar above). This is also known as a double curved surface. Contemporary products often have compound curvature. Sketching such products can be a challenge for a student, but once the process is clearly understood and practised it should become second nature.

Understanding the orthographic view of such an object is essential for sketching it in perspective. The curve that defines the side profile slowly doubles back on itself. The drama of the compound curve is more noticeable from the front view.

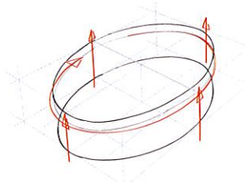




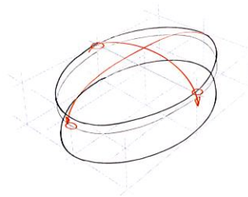
1. Begin by sketching a base plane on which the top view (ellipse) is placed. Pay attention to the symmetrical placement of the ellipse: the major and minor axes will correspond to the centrelines of the plane. Sketch in the ellipse. This will be used as a reference sketch throughout.



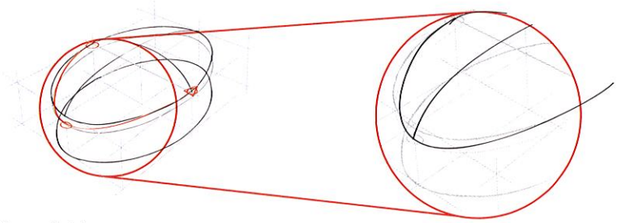
2. Box-in to create a top plane for accurately sketching a second ellipse. This represents the orthographic top view redrawn in perspective on the top plane. These flat ellipses are necessary references for the beginner to sketch the compound curve.



3. Sketch a third ellipse just below the top plane. This too will serve as a reference for sketching the compound curve. Having multiple sets of centrelines is essential and will serve as contacts for the compound curve as it swoops from one plane down to the next and back up to the first.

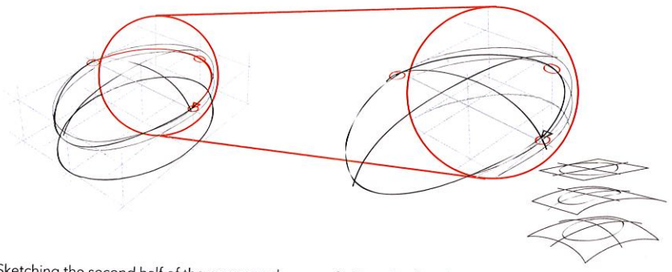


4. Sketch a set of arcs that correspond with the centrelines and the major and minor axes on the top plane. These arcs will become contour lines later on but will serve for now to indicate that the top surface is a compound curved surface.



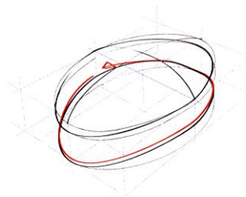
5. The small circles in red indicate the nodal points that the compound curved path must take. Start at any one of these and sketch an arc that curves in two directions: one that follows the path of the ellipse while also moving down to the lower ellipse to connect with the nodal point there.

6. This compound curve should be as smooth and fluid as possible. Begin by sketching only one half of the full curve. Over time the full compound curve can be sketched without the aid of the lower ellipse, as the student will start to 'feel' the curve as it moves in both directions.

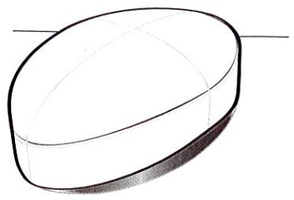


7. Sketching the second half of the compound curve is identical to the first half. Select a nodal point on a centreline and sketch the curve, simultaneously following the elliptical path while also moving downwards in space to connect to the nodal point on the lower ellipse. Transition the second sketch into the first.

8. Note the thumbnail sketches above: an ellipse sketched on a flat plane will remain flat; an ellipse sketched on a single curved plane will curve in a single direction; an ellipse on a compound curved surface will follow both curves and be slightly wider in the middle and more pointed at the tip.



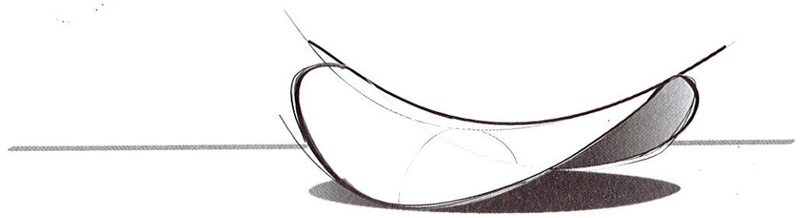
9. For the lower compound curve I've eliminated the extra reference ellipse and sketched the curve in one smooth continuous motion. This is the desired method because it is faster and more intuitive. Learning to feel the movement of an elliptical path as it traverses a compound curve enables minimal scaffolding and greater speed.

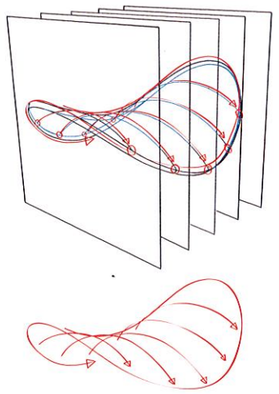


10. The final step is to differentiate the various line weights. Sketch a continuous outline merging the outer edges into one continuous curve. Use a heavy line weight to help hold the object together so that it can be read as a single object. Use a slightly thinner line for any distinct edges. Finally, use a very thin line (or a light grey line) for any contours. In this case the top surface will not be read as convex without contour lines. A drop shadow and cool grey can be added to suggest a light source.

Tutorial

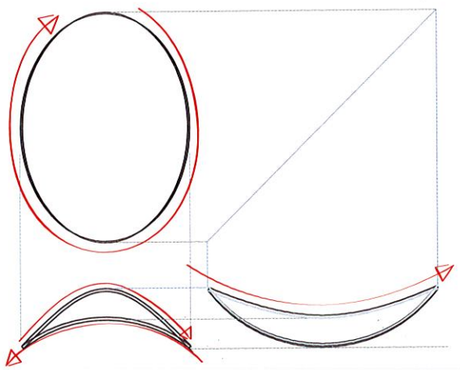
Sketching the Pringle potato crisp

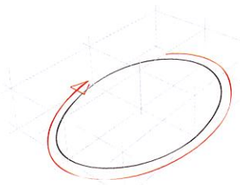




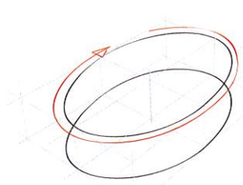
A compound curved surface like a saddle sliced at even intervals will result in a series of simple arcs aligned along a curving spine.

The Pringle potato crisp is a compound curved surface often referred to as a 'saddle' because of its resemblance to the riding accessory. It is very difficult to draw this form in perspective without understanding the dominant arcs that drive its shape as seen in the orthographic view (below). These provide critical centre points and end points, which define the limits of the surface's boundaries. Such an example clearly illustrates again the importance and power of understanding form in orthographic view before proceeding to sketch it in the more challenging perspective view. The compound curved surface is defined by a continuous compound curve much like an old-fashioned roller coaster. The biggest challenge with a surface like this is to sketch the compound curve in one fluid stroke. Another way to think about this surface is as series of sections that are connected by a continuous compound curve (see illustration left). On the following page are two examples of how to approach such a form.

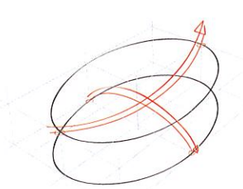




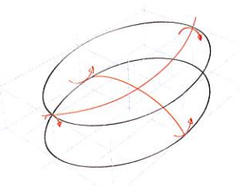
1. Box-in the basic envelope – the cubic volume the full object occupies in space. Sketch the top view ellipse on the bottom plane, being careful to position the ellipse so the centrelines pass symmetrically through it. This serves as a reference.



2. Repeat and sketch the same top view ellipse on the uppermost plane of the product envelope, again ensuring that the ellipse is symmetrical to the two axes. These two ellipses are the upper and lower reference points for the compound curve.

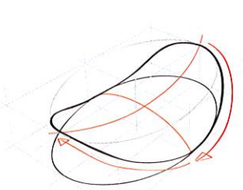


3. Sketch two arcs: one that runs parallel to the major axis and one parallel to the minor axis of the ellipse. These are direct translations of the side and front view – see orthographic drawing on p. 112. Note that one is concave, one is convex.

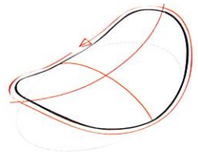


4. This step is not strictly necessary but is useful for beginners. Sketch a series of small arcs to help define the direction of the compound curve at the end points on the two previous arcs. As the compound curve is sketched, these references help direct the process.

5. While a compound curve should be sketched in one fluid motion if possible, it's been broken down into two steps here for clarity. This is the hardest part of the process and requires the student to literally 'feel' the curving line ride along the ellipse while also moving up and down.



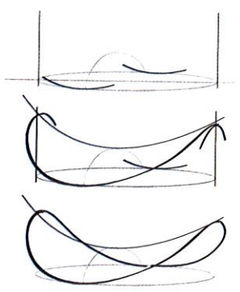
6. A single fluid motion isn't absolutely necessary but often results in a more convincing curve. The earlier scaffolding was created so the compound curve could be sketched with confidence. Feeling the shape of the object while sketching can also build confidence.

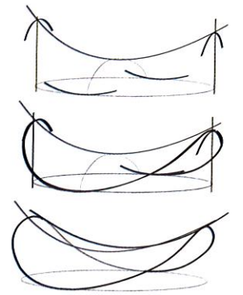


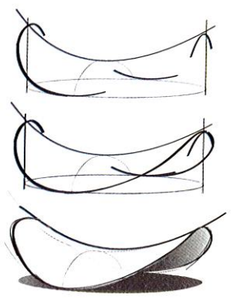
7. A single darkened outline can help make the object pop out in space. As the resulting surface is a compound curved surface, the addition of contours to reinforce the curvature are very helpful. The contour lines are the previously sketched arcs.

8. All objects have thickness that can be conveyed through a second edge. Rather than sketch the entire compound curve again, lightly sketch just a partial second sketch that follows the first edge and disappears naturally out of sight.

9. Use the original elliptical sketch as a reference for casting a shadow. While this is not completely accurate, it helps to situate the compound curved surface in relation to the ground plane. Hatch marks and a blast of cool grey marker will suffice.







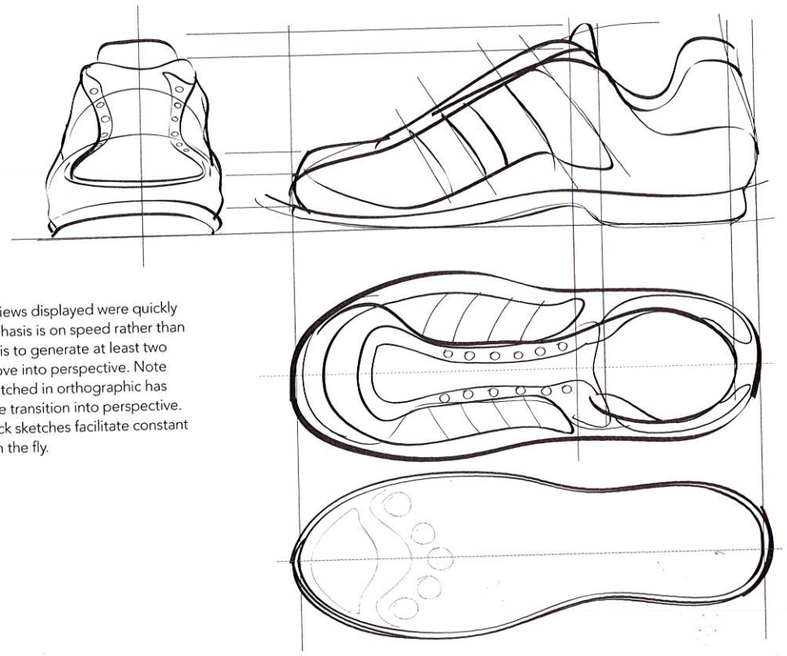
10. The sequence above is more or less identical to the previous one. The main difference is the vantage point (the angle from which the object is viewed). By lowering the vantage point, the nature of the compound curved surface becomes more apparent. When the object is drawn from above, the contours flatten out, making the compound curve that defines the perimeter of the surface less extreme. The choice of orientation when sketching an object can play a big role in how easily the object is understood. Note that the 'envelope' has been intentionally eliminated. The arcs and ellipse suffice as references for quick sketching. Also, the original reference ellipse defines the projected shadow.

Tutorial

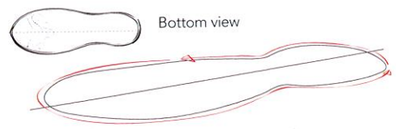
Sketching a trainer

One of the simplest metaphors for rapid sketching is to think of the product's 'footprint', as the starting point for sketching. It makes sense then to practise by sketching a trainer. This tutorial begins with the footprint of the product and proceeds to build the upper and the internal detailing through sections. Finally all the various sketches are united by a single compound curve outline. Many product sketches begin this way as it helps to first establish the overall shape of the object on the base plane (footprint) before building up the necessary sectional sketches (or ribs) to give the form dimensionality. The compound curve (also known as a 3D sketch) when combined with interior contour lines creates the illusion of a compound curved surface or skin.

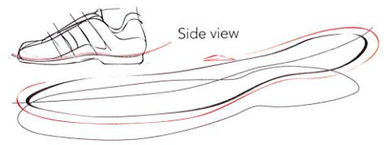
This tutorial is about speed rather than a high degree of detail. The perspective sketch process should not take longer than 15 or 20 minutes when done correctly. Critical to the success of this approach is working out the approximate design in orthographic view before translating it into perspective. The focus should be on the quick proliferation of ideas rather than on a high degree of finish or detail.



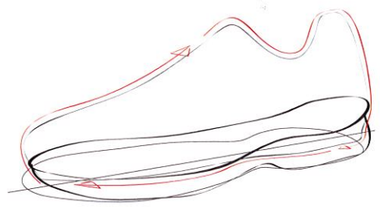
The orthographic views displayed were quickly sketched. The emphasis is on speed rather than accuracy. The goal is to generate at least two views quickly to move into perspective. Note that the design sketched in orthographic has changed during the transition into perspective. These types of quick sketches facilitate constant revision of ideas on the fly.



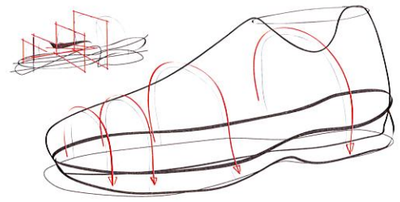
1. Begin by sketching the footprint in perspective. Here it is literally the print the trainer might leave. Sketch a centreline to help in positioning the symmetrical sketch (the front half of the drawing will be larger due to the foreshortening). This sketch represents the orthographic bottom view of the design and will help to position the compound curves that will reference it. The centreline will also be used to position the side profile of the trainer.



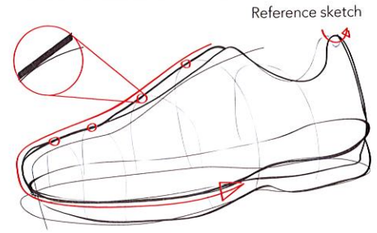
2. The next sketched surface floats just above the footprint and represents the top of the rubber sole. This sketch is a compound curve that simultaneously follows both the footprint and the side-view profile of the sole (see detail). It is helpful to sketch a centreline that mimics the curving side-view profile. Just like a flat centreline, a curving centreline suggests the plane on which the compound sketch sits.



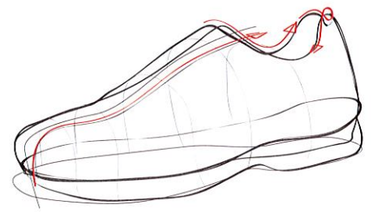
3. Referencing the side view, sketch that profile in perspective on the centre plane (the plane is not actually there but the centreline that references it is). With this profile in place, the trainer now begins to emerge as a 3D reality even though there are few sketches present. The next step is to add in sectional sketches from the front view orthographic to help build out the upper. Note there is not a single flat surface present.



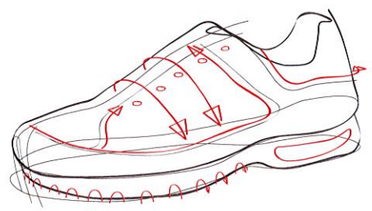
4. Sketch a series of sections (ribs) along the length of the trainer as if they were placed on a series of parallel planes (see detail). The centre point of each sectional sketch should touch the top side of the side profile. While this process is aimed more at speed, it is still important to strive for accuracy. An additional section has been lightly sketched where the foot enters the trainer as a reference point for the compound curves.



5. With the sectional sketches (ribs) in place a partial outline can be sketched. The outline should touch tangent to the sections (circled in red) creating a single compound curve that joins them into one nearly cohesive form. The outline is only partially sketched at this point to provide clarity for the remainder of the sketch. The full outline will be completed when more geometry is placed. Sketching often proceeds in small incremental steps.



6. With the trainer slowly taking shape, sketch the back geometry where the heel tab and heel collar meet the front of the shoe. The geometry for the tab and collar are a compound curve somewhat similar to the Pringle crisp. When sketching it think about the oval opening (top view) combined with the side profile. Finally, with the trainer outline complete, sketch on the compound curved surface of the upper as if it is 3D to add in the details.

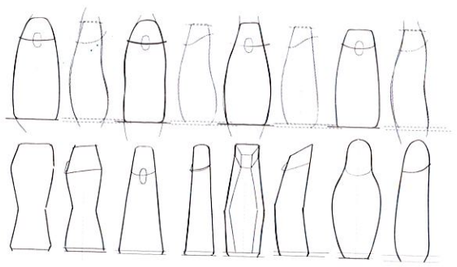


7. The remainder of the process is detailing. With the 3D form fully developed, the sketching process involves lightly sketching on top of it and acknowledging the compound curved surfaces. Once a detail is correct, it can be darkened. It is very important to feel the form of the product while sketching. While the sheet of paper or computer screen is flat, the object is not and all internal contours must reflect this reality.

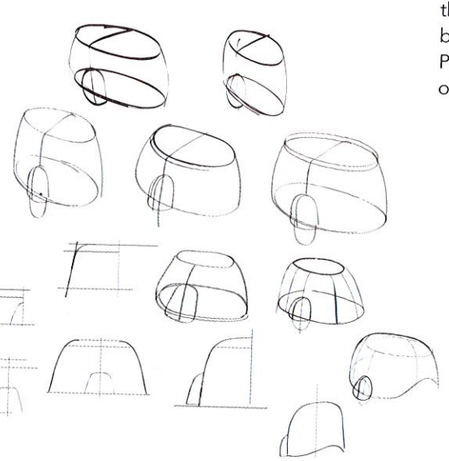
8. This sketch represents a quick 20 minute concept based on orthographic sketches that might have taken an additional 10 minutes to sketch. It could be completed to a much higher degree of detail including material finishes, colour, shade and shadow, but that's not the point. The idea here is to show that even a quick sketch can communicate form very quickly so others can view and give their input before moving on.

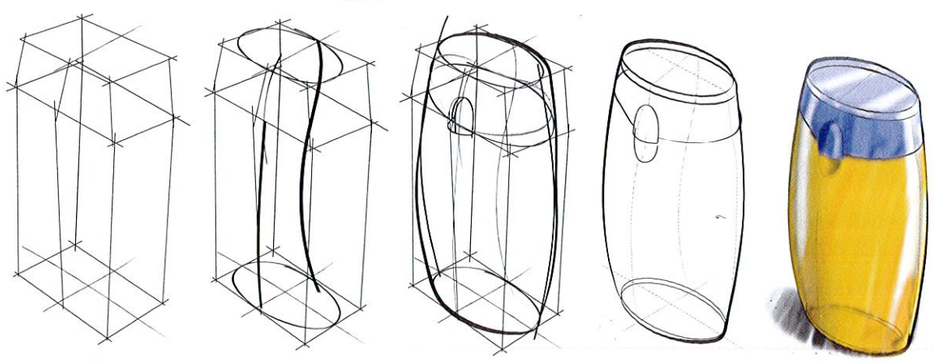
Tutorial

Putting line and orientation together



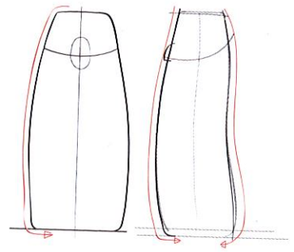
Developing concepts orthographically is quick and allows easy comparison across a range of concepts. Details can be quickly sketched in 3D if necessary (below).



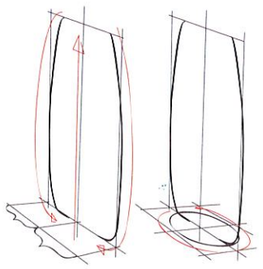


Using the example of a shampoo bottle, we will combine line and orientation in order to understand the design's geometry. The quickest and simplest approach is through a series of front- and side-view orthographic sketches that require the designer to focus on only one view at a time (front, side or top view). Moving from left to right, making either small or large changes is easy and fast and permits broad experimentation combined with the ability to review concepts side by side. Isolating a single component (like the cap) and moving between orthographic and perspective can also be effective.

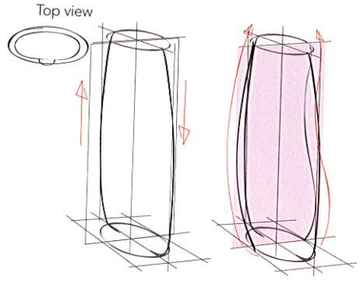
In this sequence, the approximate bottle shape is quickly and lightly boxed in to establish the overall footprint of the form, followed by the most essential curves from the two orthographic views. Details are then added to the basic wireframe. A tight sketch like this can be rendered in Photoshop in less than ten minutes to provide a higher level of fidelity.



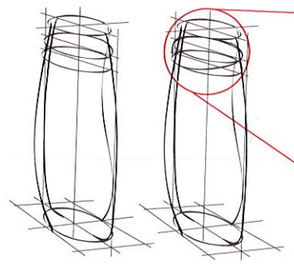
1. Determine which geometry would be most helpful in getting the sketch started. In this tutorial, the box will be eliminated in favour of simple lightly sketched planes. This method makes it faster and less confusing. The seasoned designer needs no scaffolding to sketch.



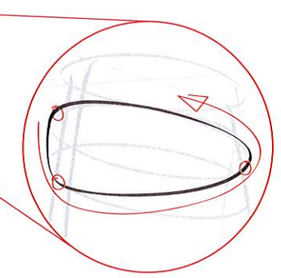
2. Sketch only what is needed – speed is essential. The two primary outlines are sketched on a plane with a centreline for symmetrical placement. The orthographic sketch is truly symmetrical. The back half of the perspective sketch that is further from the viewer is foreshortened. Sketch an ellipse to represent the bottom.



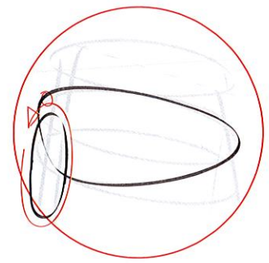
3. Now is a good time to sketch the top view to work out the geometry. Transfer this section (ellipse) into the perspective sketch as a reference for the profile that passes through the centre plane. Using the top section, sketch the profile so that it connects top and bottom sections. The same must be done for the back profile.



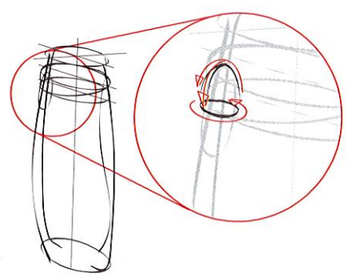
4. With the top section in place, add two additional sections placed accordingly to help place the compound curve that defines the top. These two references will greatly assist in sketching the curve by supplying points of contact at the centreline and side profile curves – much like the compound curve of the Pringle.



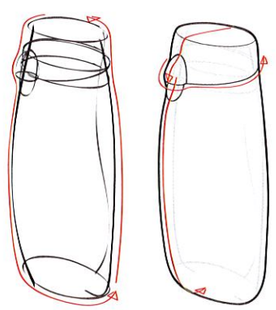
5. With the close-up it's easier to see how the compound curve touches the three points of contact formed by the ellipses as it winds its way around, curving in two directions at once like a roller coaster. Try to sketch this lightly as one continuous curve to achieve a smooth compound curve that does not look choppy.



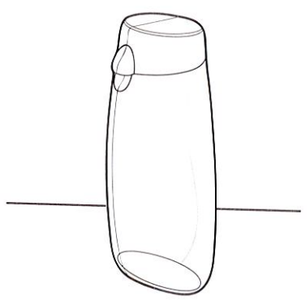
6. Using the centre profile, sketch a quick ellipse (the major axis is vertical). This is just a reference sketch for placing the convex surface that will form the grip for opening the top as well as the concave surface (affordance) for placing the thumb or finger while opening. Make the reference sketch as light as possible.



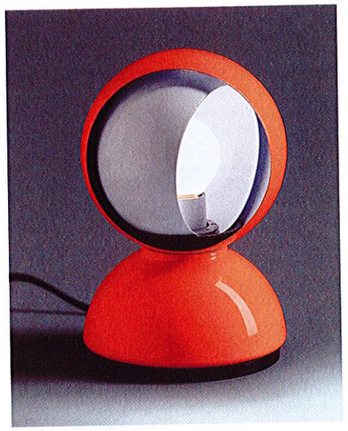
7. Construct the convex surface with three simple sketches: an ellipse that forms the bottom, a centre arc to define the depth and a compound curve that pulls it all together. Keeping these sketches light makes it less likely to get confused when sketching the final compound curve.



8. Sketch the outline in a bolder line weight, careful to touch the various elliptical sections at tangent points. The outline is one large compound curve that creates a boundary which unites all the earlier sketches. Using a lighter line weight add in contour lines to help define the radiused top and bottom and grip.



9. Retrace if necessary to eliminate any unwanted lines and to differentiate the line weight even more. Ghost lines can add volume to a sketch if they are very light otherwise they can confuse the viewer depending on the complexity of the sketch and the amount of scaffolding required to create it. A simple line can add depth.



Sphere

Vico Magistretti's Eclisse Luminaire

Vicco Magistretti's Eclisse light for Artemide is a great example of a 'revolved' shape. The form consists of a semi-spherical base upon which another partial spherical 'diffuser' is placed. Nested inside the diffuser is yet another partial spherical form which rotates within the diffuser to create the 'eclipse-like' effect of the luminaire. As the inner housing is rotated around a vertical axis, more or less light is emitted giving the overall appearance of the moon in its various phases.

Building the model in the computer involves revolving a series of profiles around the same centreline, then cutting them at various points on the perimeter of the sphere. To sketch the form, a centreline is established around which a series of spheres are sketched and then cut. The base sphere is a great example of the circle in perspective (ellipse). It is created by revolving a full circle which is then cut in half and a base is added at the bottom and a collar at the top. The two diffusers are also partial spheres but they are cut beyond the midpoint of the sphere, leaving approximately 60 per cent of the sphere remaining.

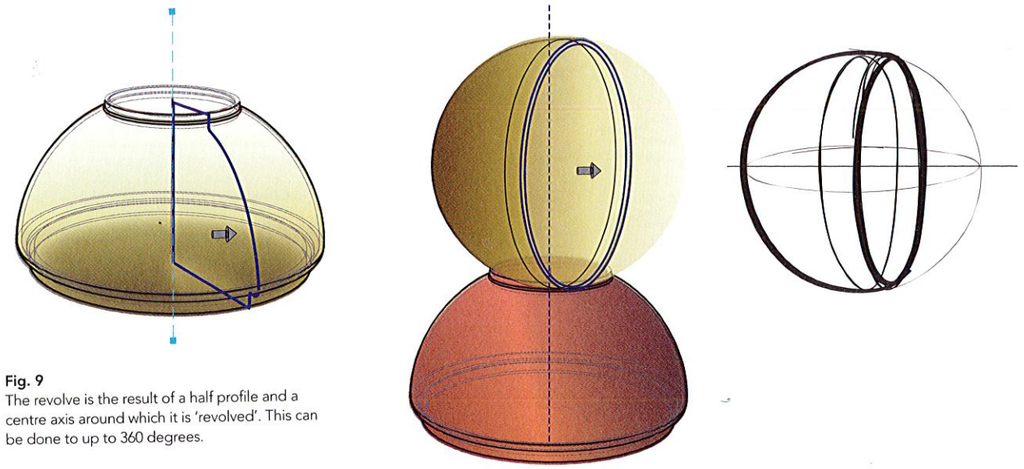


Fig. 9
The revolve is the result of a half profile and a centre axis around which it is 'revolved'. This can be done to up to 360 degrees.

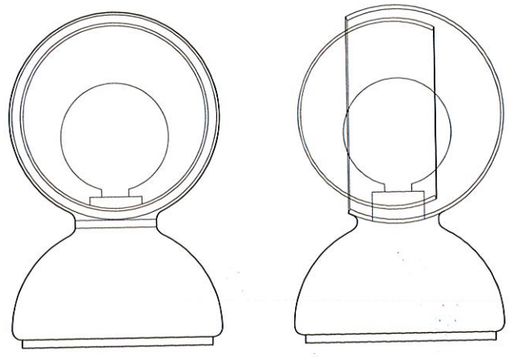
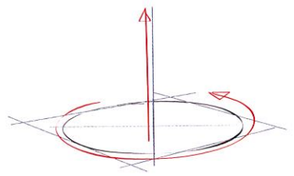
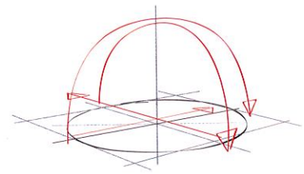


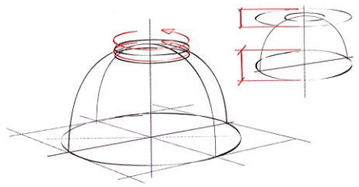
Fig. 10
Once the base has been revolved, the outside diffuser is revolved around the same centre axis. Because of the nature of the geometry, the outside diffuser is revolved 360 degrees creating a full sphere, which is then cut to create a partial sphere beyond the centreline.



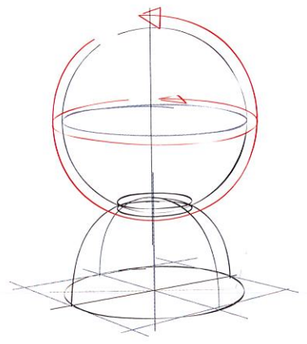
1. The Eclisse lamp is comprised of a series of partial spheres – some nested inside others. Begin with a base plane upon which an ellipse is quickly sketched. Note that the ellipse in this case has its major and minor axes aligned with the vertical and horizontal axes. The minor axis is extended to help centre the other sketches.



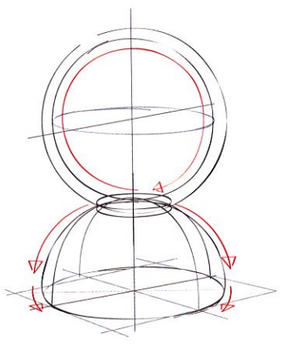
2. Sketch another set of intersecting axes to help subdivide the circular base (ellipse) into equal quadrants. These lines will help position the product so that it is turned slightly away. The end points of these axes will serve as references for projecting the arcs that will define the partial sphere of the base.



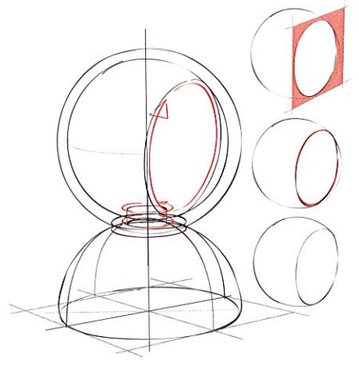
3. Sketch a series of centred ellipses positioned at the top of the projected arcs as references for the neck or collar between the base and the light diffuser. These ellipses are smaller but also flatter (more closed) because of the effects of perspective (see detail drawing).



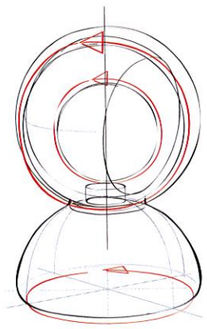
4. Sketch a circle that is symmetrical with the centreline and the same diameter as the base. The circle will intersect with the neck that was previously sketched (refer to orthographic). Sketch an ellipse that passes through the centre of the circle to create the illusion of a sphere. The base and top are now positioned accurately.



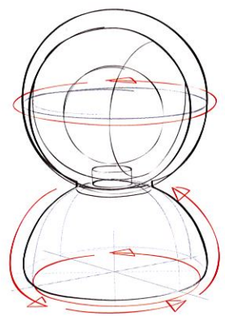
5. Sketch an outline that will unify the base and the collar into one solid surface. This outline must touch tangent to the ellipses. The projected arcs now appear as seams or contour lines and will help the viewer read the form as semi-spherical. These arcs were placed at that angle for this purpose. Sketch an interior circle for the nested sphere.



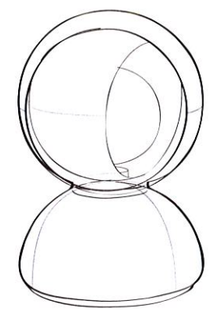
6. The inner nested sphere must be cut or sliced in such a way to create the opening (see the section cut in the orthographic view). A plane has been sketched to provide a reference for the cut (see detail). The resulting ellipse becomes the opening of the internal sphere. Using the collar as a reference sketch in the socket for the bulb.



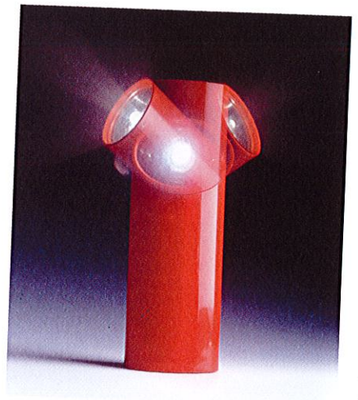
7. Referencing the ellipses that form the socket, sketch the bulb. This is also a perfect circle. Next is perhaps the most difficult part to understand conceptually. The outer sphere, like the inner sphere, is also cut or sliced. This slice will be at an angle different to the other sphere for clarity. Sketch a circle that is slightly offset from the large circle.



8. Sketch another ellipse that passes through the largest circle – this will serve as a contour line to help differentiate the inner and outer sphere. Sketch a final ellipse beneath the base – this will help define the foot. With this sketch in now draw a final outline that cleanly connects the base and outline of the outer diffuser (sphere). This outline helps unify everything.



9. Remove unnecessary lines (construction lines) by retracing the drawing and eliminating those arcs that would be hidden. While the geometry was essential in building the sketch, they are now redundant and confusing to the viewer. With all occluded edges removed, the outlines darkened, and the contour lines sketched lightly, the light fixture is readable.



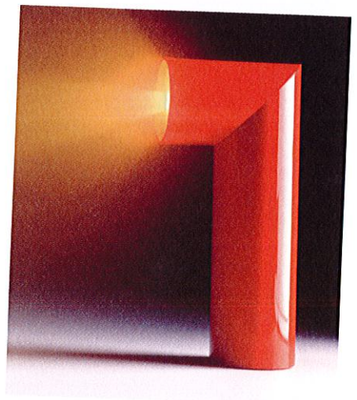


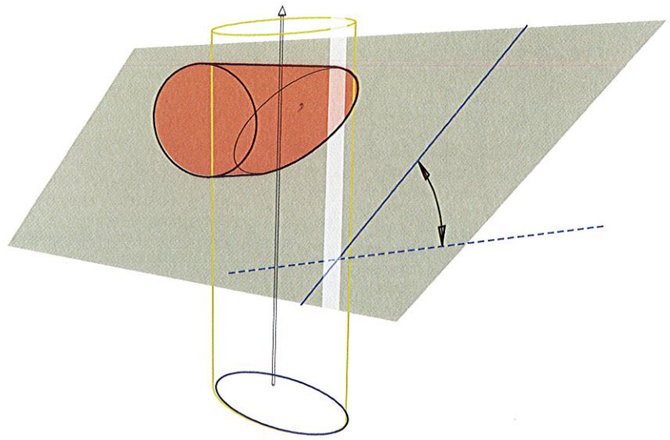
Fig. 11
Bending the torch into an L-configuration means it can be carried easily and, ergonomically speaking, it is more comfortable to the hand and wrist in such a position.

Cylinder

Polyphemus torch

Designed in 1985 by the Argentinian Emilio Ambasz, this light is based on sectioning an elliptical cylinder at a 45-degree angle to create a circle on which a rotating torch head turns. Built from separate male and female parts and then snapped together, the torch can stand or lie on any surface while its light beam is aimed in any direction. Additionally, the torch holds a magnet inside so that it can be attached to a metal surface. The unique shape of the torch utilizes a patented topological principle.

Cylinders are generally thought of as extruded circles but can also be extruded ovals or ellipses as in this torch, which can be fiendishly difficult to sketch despite its relatively simple geometry. While the basic cylindrical form is not difficult, accurately capturing the geometry as the head swivels requires a real ability to imagine, plan and carefully execute. The renderings shown here were built in SolidWorks from approximate dimensions, and involved extruding an oval form the height of the product and cutting that form on a 45-degree angle. The form that results from this cut becomes the head of the light.



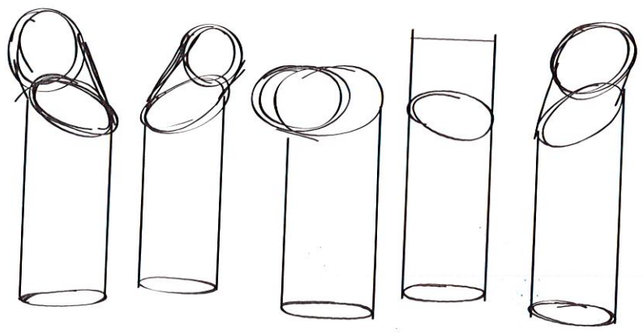
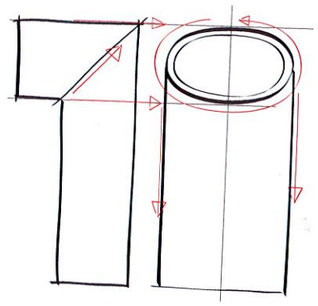
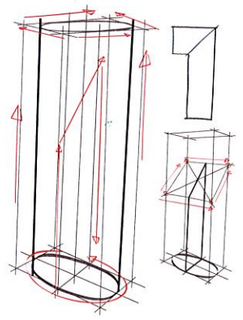


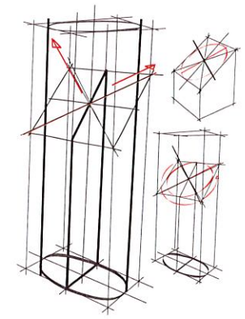
Fig. 12
Sketching the Polyphemus torch represents a unique challenge. Not only is the cylindrical body based on an elliptical profile (section) but the head rotates along a central pivot point, creating possible positions that range from 0 to 360 degrees. The angle between the head and body is 45 degrees. With this information the sketching process becomes easier.



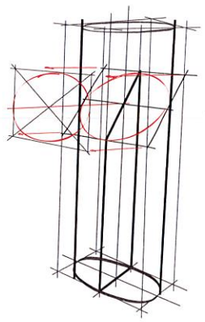
1. Sketch the orthographic front and side views so that they are aligned. Referencing a centreline, sketch the elliptical lens on the front view. While this sketch is simple it will help with the placement of all subsequent geometry and should be referenced throughout the process.



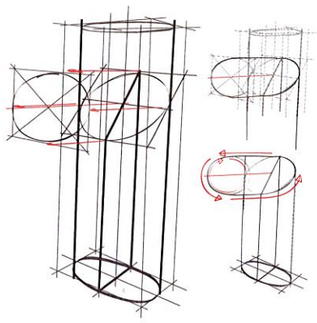
2. Box-in the basic shape of the torch. On the bottom and top faces sketch in elliptical sections and connect to create an extruded cylinder. Along the centre plane sketch the side profile for reference to accurately place the plane angled at 45 degrees for the swivelling lens.



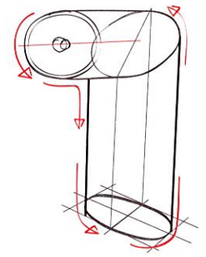
3. On this newly created plane sketch in diagonals to determine the centre point. From here sketch a line that projects at a 90-degree angle from the centre: this represents the axel around which the ellipse will be centred and is approximate.



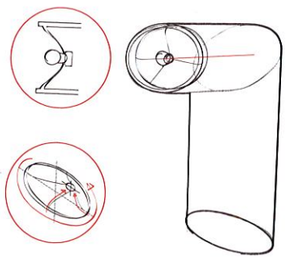
4. From this same centre point project a line forwards at 90 degrees from the main vertical axis. This line will help locate the plane on which the lens sits. Because the horizon line nearly cuts the centre of this plane, the ellipses' major and minor axes will be close to vertical and horizontal.



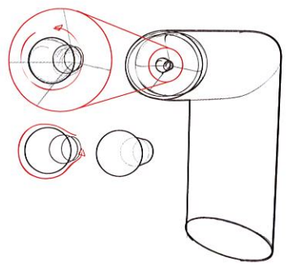
5. With the plane in place the projected line now serves as the axle of the ellipse (the minor axis). Sketch the ellipse to fit the plane (remember the lens is elliptical which makes it seem more distorted than usual). The rest of the extruded cylinder can be ignored from here on out.



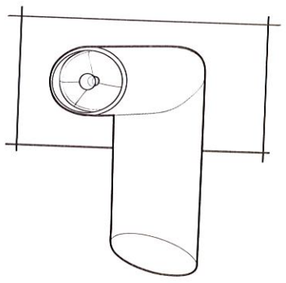
6. This product is a great example for using the original sketch as an underlay. Trace over using a light table or tracing paper. Sketch the outline of the product to unify what has been drawn. It is fine to leave a few of the ghost lines in place as they might be useful later on.



7. Sketch the lens and the bulb. In order to understand the geometry make a thumbnail sketch of a section cut right through the lens housing. Sketch four contour lines at 3, 6, 9 and 12 o'clock and follow the concavity of the housing. The bulb is sketched around the ellipse axle.



8. The three quick circular sketches that represent the bulb, the stem and the base need to be unified with one strong outline. The set back on the lens needs some clarification. As it stands right now it is defined by several additional ellipses which will need to be cleaned up.



9. Using an ellipse template redraw the lens and set back. With a circle template the bulb can be cleaned up and finally the outline can be made more exact with a straight edge if desired. A simple vignette can help a product stand apart from the background.

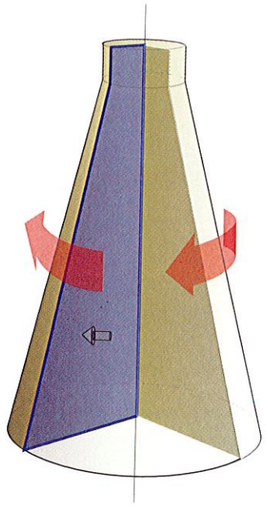
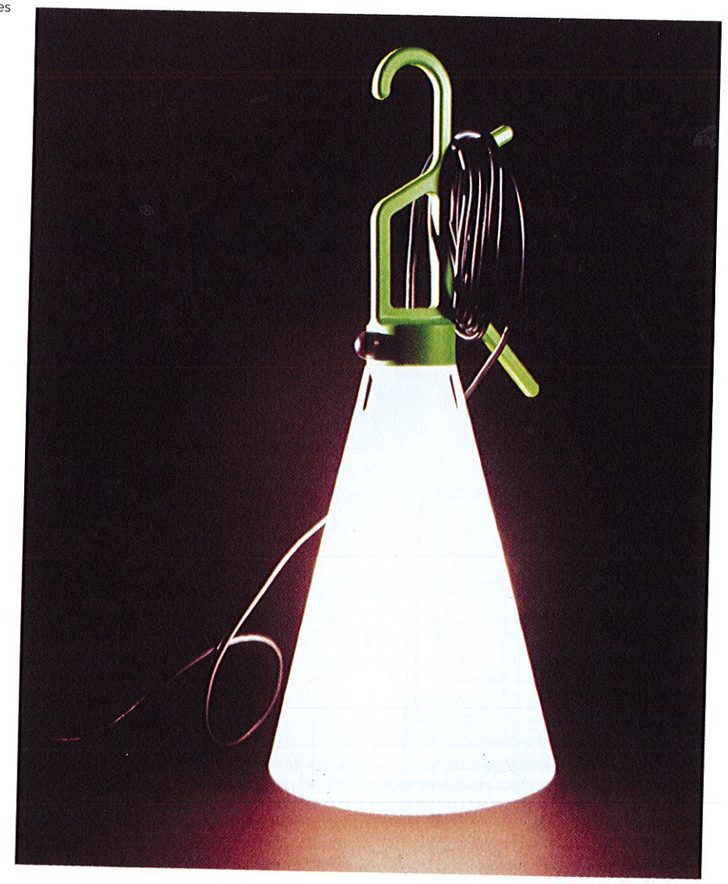


Fig. 13
Modelling the Mayday lamp in a CAD program involves revolving a half profile (half of the cross section) 360 degrees around a central axis. The process of sketching the same form, while not identical, is similar – every sketched ellipse involves a revolution around a centre point and in relation to a major and minor axis.

Cone/Truncated cone

Konstantin Grcic, KGID Authentics and Flos

Konstantin Grcic's work is often characterized as reductive or minimal in its form language. Born in Germany, his design education began at the School for Craftsmen in Wood at Parnham (England) under John Makepeace. He obtained a master's degree in product design at the Royal College of Art in London and worked for Jasper Morrison in London, then returned to Germany to set up his own design firm, KGID, in Munich. Grcic's deep knowledge of furniture and product design history is clearly evident in his attention to detail and proportion, and his desire to push manufacturing as far as he can. KGID is known for a hybrid approach to design development that combines hands-on manipulation of prosaic materials (paper, cardboard, wire, fabric, etc.) with computer modelling and rapid prototyping. His Mayday light for Flos may take its name from the naval distress signal, but the form language is pure Grcic – direct and eminently functional. The form is the very essence of projected light with the practical coat-hanger-like addition for wrapping the cord and hanging the light. It is a piece that Jasper Morrison and Naoto Fukasawa might refer to as 'super normal'.



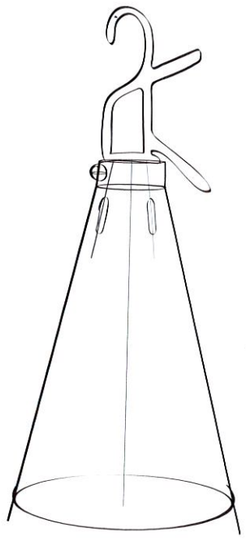
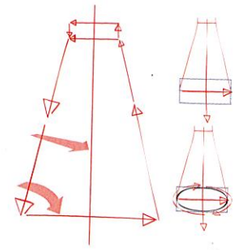
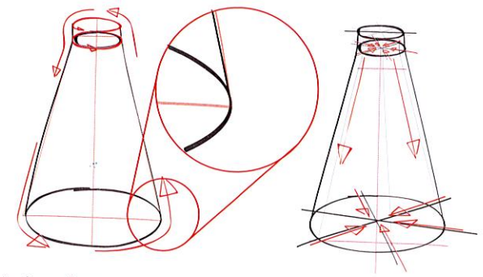


Fig. 14
The diffuser on the Mayday light for Flos is a simple truncated cone. Here the sectional profile has been revolved around a central axis to give an immediate sense of the form.

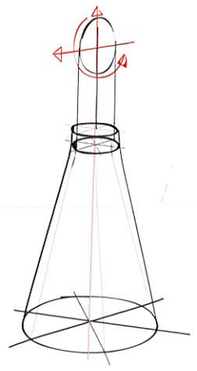


1. Sketch in the full profile (front view) of the product with a centreline. Sketch in the bottom ellipse – an oval perfectly centred on the intersection of the centreline and bottom edge. This serves as the ellipse's major and minor axes.

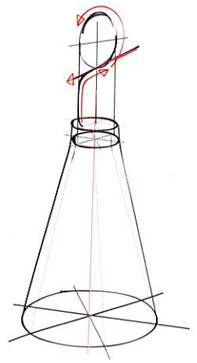


2. Sketch in three ellipses – one for the base and two for the top. Drawn an outline that touches tangent to the outer edges of all the ellipses. This creates a fluid transition (see detail).

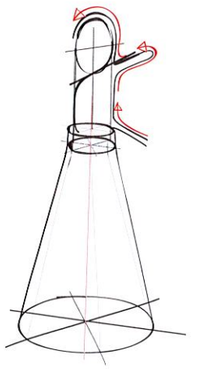
3. Subdivide the bottom and middle ellipses into six even slices. Project sloping lines along the outside of the product connecting the slices into wedges. This is a reference for the vents.



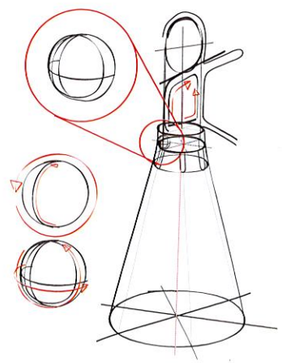
4. Extend the centreline upwards as a reference for the hook. Sketch a line perpendicular to the centreline for the minor axis. This ellipse does not slant left or right because it is at eye level (on the horizon line). Quickly sketch the ellipse.



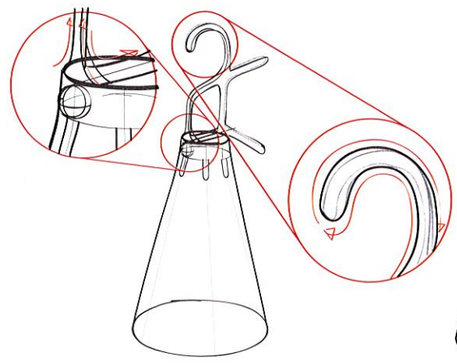
5. Using the ellipse as a reference, sketch in the hook. Sketch in a line just below the hook and angled slightly downwards (review the orthographic sketch for accuracy). Connect the hook and this line into one fluid sketch.



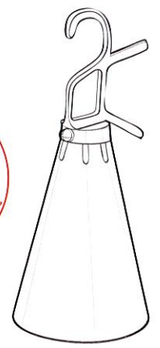
6. Using the completed sketches, double up (offset) the geometry to give the hook dimensionality. Begin adding more details from the orthographic side view to finish the upper assembly of the lamp.



7. Using the existing sketched geometry create the opening. Connect the various sketches to solidify the handle (hook). Using the earlier reference lines, sketch in the vents.



8. Determine which face to unfold first and sketch a quick set of arcs to determine approximately where the face would land when folded down to the ground plane (red).



9. The finished sketch, with line-weight differentiation.

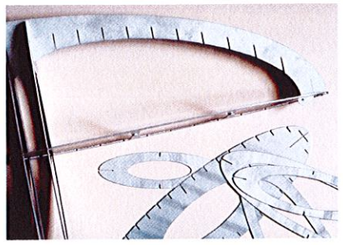


Fig. 15
A close-up detail of the elliptical sections machined and slotted out of aluminium sheet.

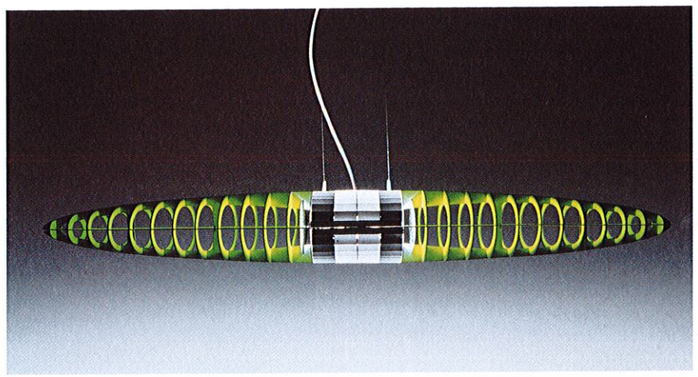
Ellipsoid

Alberto Meda's Titania light fixture

The Titania light fixture, designed by Alberto Meda with Paolo Rizzatto, Luceplan (1984), is a great example of how intersecting planes or sections can create volume. Titania is an example of an early product designed with the aid of computer software. The sections, machined from a single sheet of aluminium, are ovals that are slotted to accept the intersecting pieces that make up the overall form. The blade structure eliminates glare while allowing heat from the lamp to escape. A housing made of polycarbonate encloses the lamp and accepts various coloured filters, which in turn alter the projected light coming from the centre of the fixture onto the ribs.

The ellipsoid poses sketching challenges because the side and top profiles are ellipses and all of the intersecting ribs are ellipses. It is hard to accurately place the geometry without getting lost in a sea of ellipses. The wireframe (fig. 17) was modelled in Rhino. The two profiles are indicated in red for clarity.

Fig. 16
The final constructed light fixture is reminiscent of the elaborate wooden bucks used in the automotive industry for clay modelling.



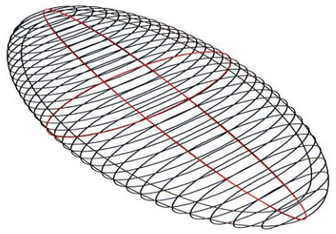


Fig. 17
(Above) Using the CAD software Rhino, an ellipsoid primitive can be generated based on the intersection of only two orthographic profiles. In this case the top view and side view were used.

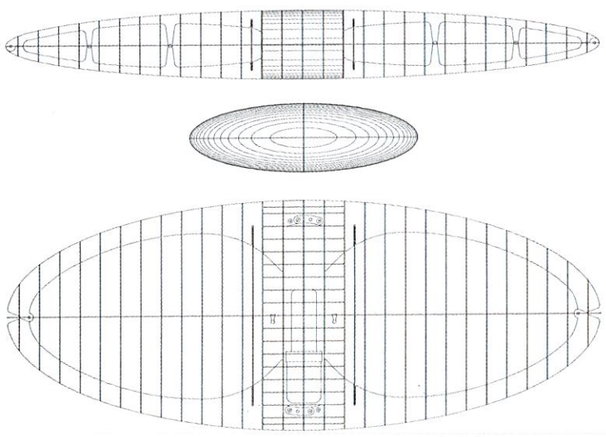
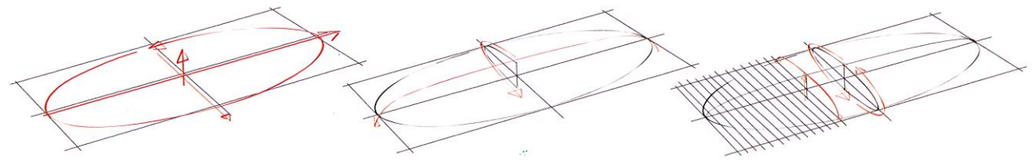


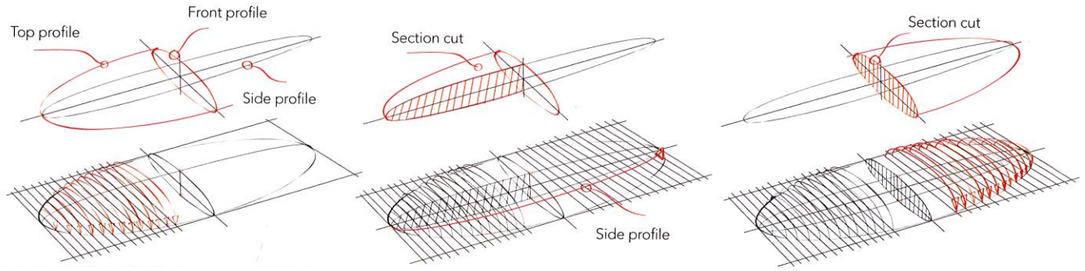
Fig. 18
(Right) Technical drawings for the Titania light fixture, including top, middle and side view (images courtesy of Alberto Meda).



1. Sketch the basic footprint for the top view of the ellipsoid, making sure to add in centrelines. From the centre sketch a line to define the depth (z axis) of the ellipsoid. No centre plane will be created but this axis serves as a kind of proxy for the plane and will help orient the sketch.

2. Sketch the ellipse that will define the front view (middle section) of the ellipsoid. In this example only half of it has been drawn but it is always best when possible to sketch one continuous ellipse. Ghost in the longitudinal section (only the top half has been sketched).

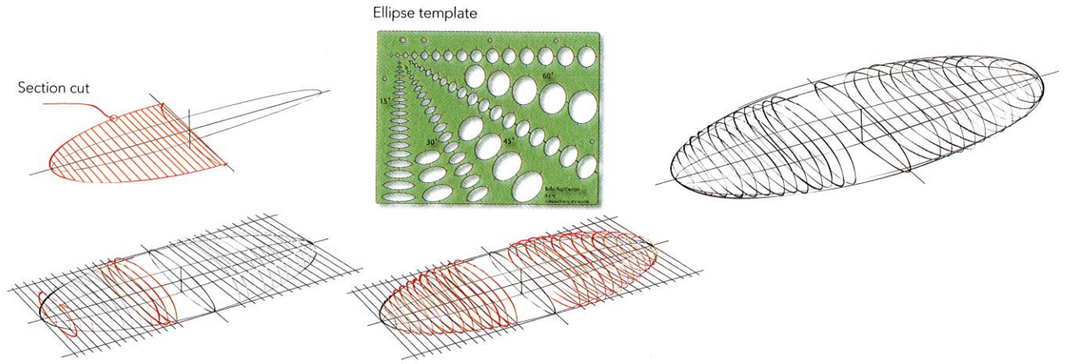
3. There are 13 ribs on either side of the main central housing where the bulbs reside. In order to sketch the elliptical sections, lines have been quickly laid down as references for the various sections. Note: the middle elliptical section has been re-sketched.



4. For this particular example, given the vantage point, only the top halves of the elliptical sections will be initially sketched. Full ellipses will be sketched over these partial sections using them as a reference. The ellipse is a good example of just how crucial the vantage point is for workflow.

5. Sketch the bottom half of the side profile ellipse (in red). Sketch reference lines for the other half of the ellipsoid trying to ensure even spacing in the perspective view. These lines combined with the side profile will serve as guides for sketching the other set of ribs.

6. This type of sketching can be difficult. Reference lines are close together and multiple ellipses are parallel to each other. Thinking in terms of section cuts can be very helpful. Here the various sections have been filled in with hatch lines to better define the surfaces.



7. Using the earlier half ellipses as a reference, sketch full ellipses over all of them. This process is highly repetitive. Developing a rhythm can help speed things along and ensure accuracy over the length of the light.

8. Do the same for the back half of the light fixture. With so many ellipses in sequence it is advisable to do the final sketch using an ellipse template. While sketching ellipses is great practice, getting so many aligned can be difficult.

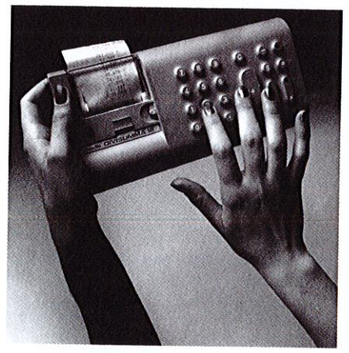
9. With the ellipses sketched, the ghost lines removed and some adjustments made to a few of the ellipses, the sketch is complete. Not an easy process using pen and paper or even with a tablet but with Rhino this model is built in minutes.

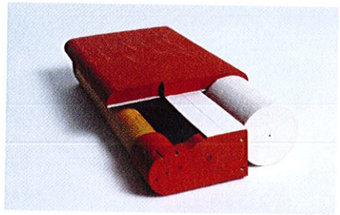
Tube/extrude

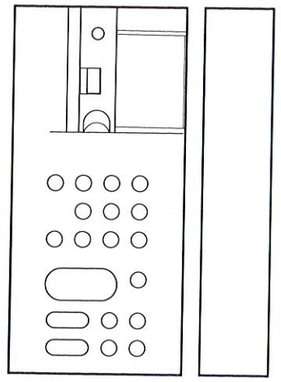
Mario Bellini's Divisumma 18 calculator

Mario Bellini, like many of his Italian contemporaries, trained as an architect but worked primarily as a designer of furniture and products. Among his initial clients was Olivetti, the Italian manufacturer of business machines, for whom he designed many products including the Divisumma 18 calculator. Bellini added a 'soft touch' long before such a concept was commonly employed, through the use of rubber, which served to integrate the controls in a more sensuous and sculptural way.

The 'skin' that forms the primary surface of the product, along with the colour and minimal layout, makes this calculator stand out from more traditional business products. Bellini's design created a membrane as opposed to a button, resulting in a more unified control panel. His experiments with 'stretched membranes' are also essential to understanding compound curvature.







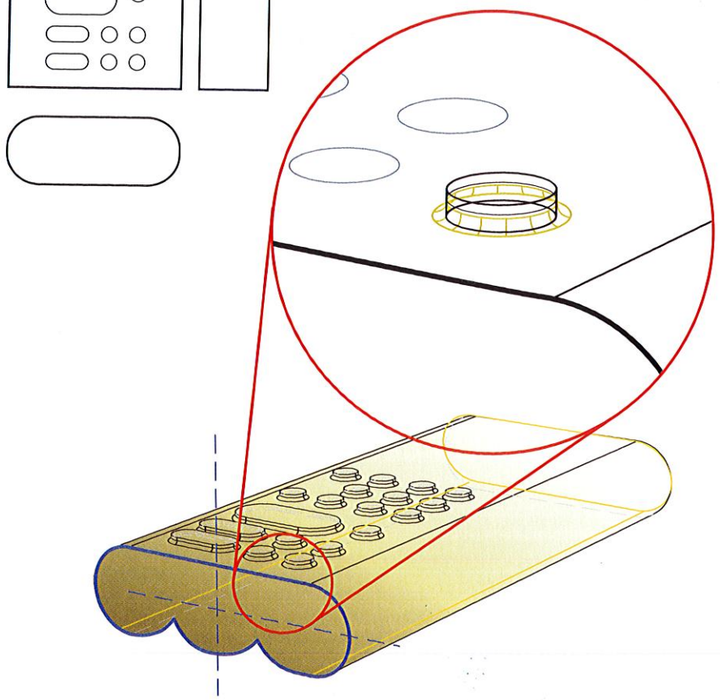
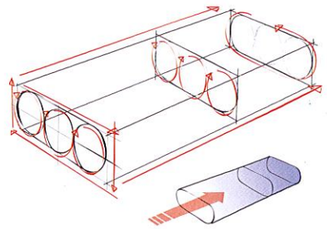
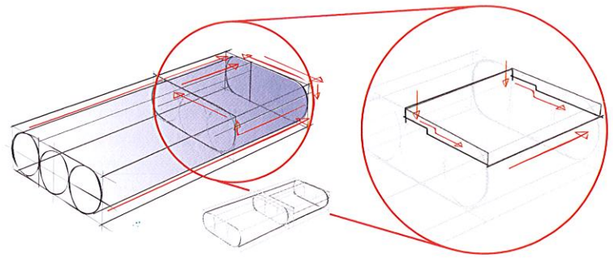


Fig. 19
(Above right) Orthographic front, side and top view sketches, recreated by the author.
(Above) Product shots and early form study model courtesy of Mario Bellini.

Fig. 20
Whether sketched or extruded in CAD, the vertical edges need to meet tangent. The fillet at the base of the buttons creates a fluid 'skin' or membrane feeling to the surface of the machine.

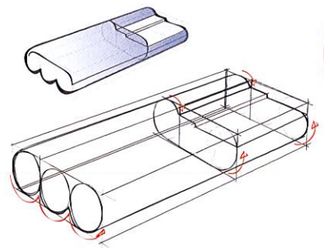


1. Sketch in a cubic form (box) the size of the product. Sketch three sets of ellipses for reference as illustrated above. These ellipses define the lozenge shape of the extrusion (see detail) while providing additional reference for the secondary detailing, which is a cut extrusion.

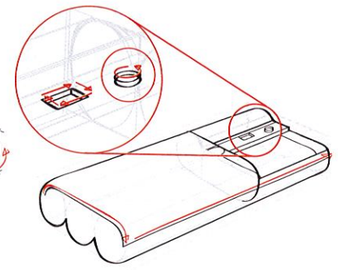


2. With the cubic form still visible sketch in the reference lines that will be used for the subtractive process of detailing the display. 'Sketching through' the cubic form can be difficult, which is why it's so important to sketch lightly and darken the lines later. At this stage a clearly defined boundary should be established.

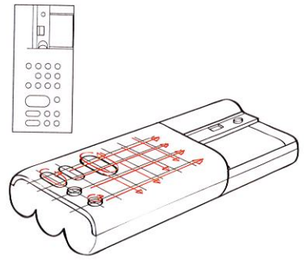
3. With the first set of reference lines placed and the boundary defined, begin cutting downwards into the surface of the extrusion to define the display panel. Note the presence of a step and sketch accordingly. This sketch has been darkened for clarity. In reality it would also have been sketched very lightly.



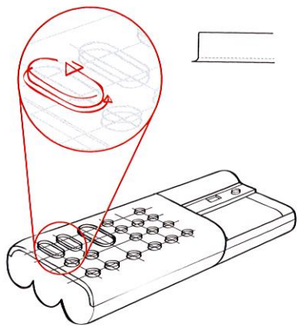
4. Cut through to reveal part of the tubular extrusion that forms the housing for the paper roll in the calculator (see detail in blue). Sketch over part of the original ellipses that defined the tubular form of the product as well as the cut extrusion at the base.



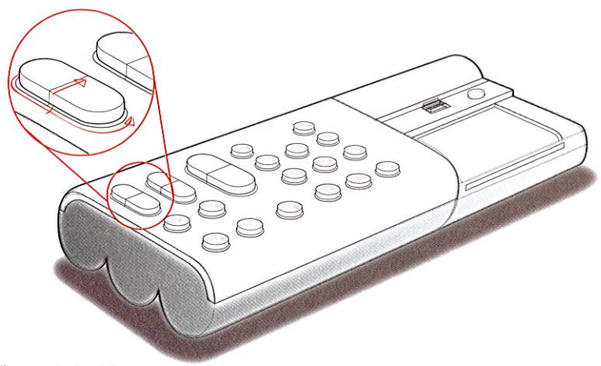
5. With the display panel cut away, begin the detailing process of the on/off switch and the small light. I've sketched in another control but as this cannot be seen from this perspective it won't be detailed. The cavity for the switch and the elliptical cylinder of the light are simple sketches.



6. Reference the orthographic front view in order to lay out guide lines for the buttons, which are rubberized for a 'soft touch' effect. Use the guide lines as major and minor axes to sketch rough ellipses that appear to sit on top of the surface of the product.



7. Sketch a nearly identical ellipse slightly above the first one to indicate height. To create the soft touch button sketch an additional ellipse which will be larger (offset) from the original sketch. This creates the reference geometry to sketch the filleted transition.



8. The remainder of the process involves line-weight definition. With a product as complex as this (the button placement, for example, needs very accurate spacing) it is best to use the original sketch as an underlay and go back in with tools (straight edge, ellipses templates, etc.) to refine the sketch. The sketch can also be scanned and the linework recreated in Illustrator or another vector-based software. In this case the lightest lines represent fillets or contours on the buttons or edges of the product while the darkest and boldest line weight is reserved for the outline.

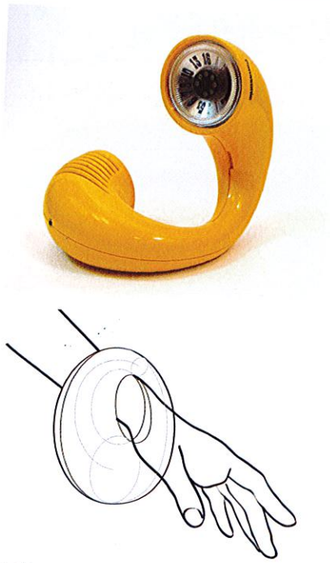


Fig. 21
The Toot-a-Loop radio could be closed to make a form that fitted around the consumer's wrist. The radio combined portability, fashion and mobility in a unique product.

Pipe/Loft

Matsushita Model R-72 Wrist Radio, Toot-a-Loop

The Toot-a-Loop R72 radio from Panasonic was the second in a series of small transistorized radios that emphasized both play and fashion. Its predecessor – the R70) – was spherical and originally designed as a commemorative product to be exhibited at the Japan World Exposition in Osaka, in 1970.

The R70's primary design cues came courtesy of the *Apollo 11* spacecraft (1969) while the R72's futuristic styling, although clearly 'space age', was also a statement of pop culture's desire for greater mobility. The ring shape allowed the end-user to carry the product wrapped around their wrist like a giant piece of jewellery – the tuner controls were accessed by twisting the radio. This innovative series sent a clear message to Japanese product designers of the day, who had previously focused exclusively on rational functionality, that playfulness and fun are also important factors in design.

The Toot-a-Loop radio is an excellent object to sketch in order to master complex curving form creation. The two symmetrical halves can be thought of as horns defined by a large radius on one end and a small radius on the other end. The path is not a simple circle but an ellipse. Note that the product's opening is off-centre. To sketch a product like this, designed before CAD software was commonly used, in perspective the designer must understand the various orthographic views and how the large circular interface (radio dial) connects to the smaller circular section where the product pivots. This is an articulating product that forms a large S when opened and is a slightly eccentric 3D loop when closed (hence its name). In the computer this form would be created through a sweep operation with the two sections and the central guide curve that connects them.

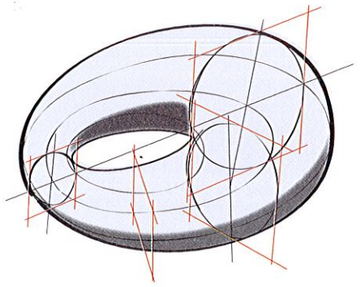


Fig. 22
This orthographic sketch was done to work out the guide curves precisely. Once one half of the object is modelled the second half can be mirrored.

Fig. 23
It is useful to think of a circular ring as a clock face, and sketch elliptical sections at o'clock positions.

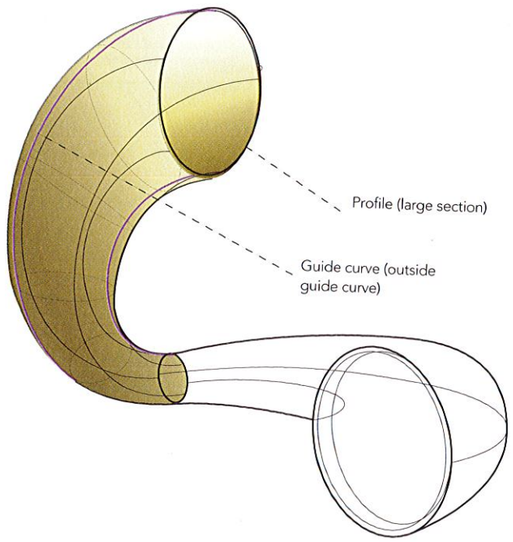
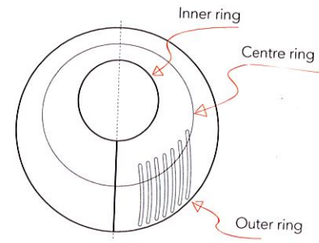
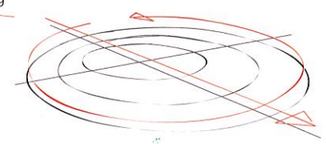


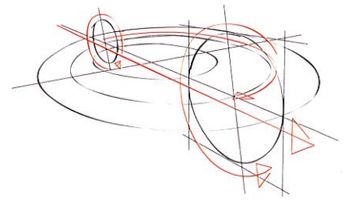
Fig. 24
This object was modelled in Rhino using a sweep operation that involved two sections as well as some guide curves.



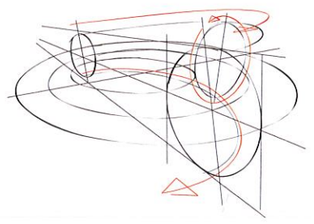
1. The radio is an articulating set of horns that swivel at the centre. Each horn is made of a series of diminishing circular sections aligned along the centre ring and touching the inner and outer rings. The first step is to establish a plane parallel to the ground to sketch the nested rings in perspective.



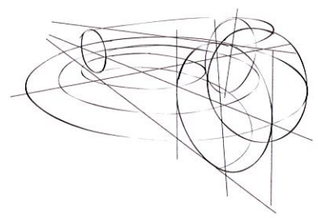
2. Rather than sketch the plane, I have sketched two axes to represent the plane and oriented the nested rings to pass approximately through the centre of the smallest ring. NB: the rings are not concentric (sharing the same centre) but eccentric. This creates the asymmetry of the product.



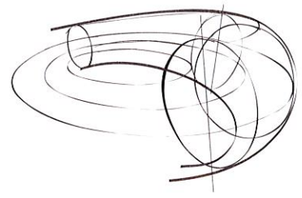
3. Referencing the centreline and all three rings, sketch two ellipses – one for the larger diameter and one for the smaller diameter. The major axes of both ellipses will lean towards the left vanishing point because they are below the horizon line. Additional elliptical sections are required to sketch the outlines accurately.



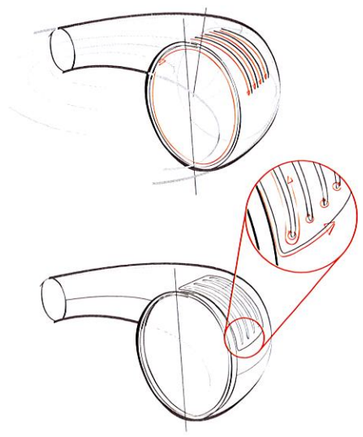
4. A third elliptical section can be sketched at the 3 o'clock position. Note that the major axis of this ring leans towards the right vanishing point because it is oriented 90 degrees away from the other two faces. One more sectional ellipse needs to be placed for accuracy.



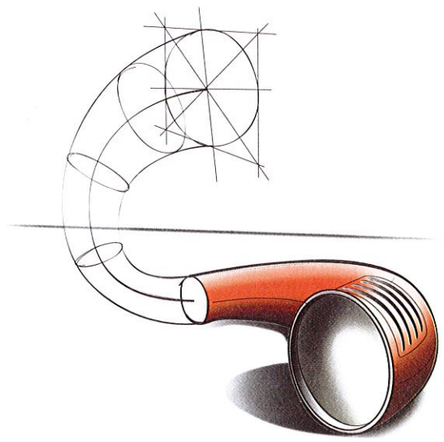
5. The fourth ellipse will be sketched near the 4:30 position. Note that the major axis of this ellipse leans in the same direction as the first two, and the minor axis is larger because it's almost parallel to the picture plane. An ellipse becomes more circular as its plane rotates parallel to the picture plane. The sketch can now be closed.



6. The outlines are sketched quickly to ensure a smooth arc. Be sure to touch the ellipses at the various tangent points. The outline connects the ellipses into a form that resembles a horn. The challenge in sketching and reading such forms is the lack of clear edges. The outline helps to hold the form together.



7. For secondary details like vent holes, parting lines and thickness, various methods can be used. Sketch light arcs (shown in red) that follow the contour of the body for the speaker vents. These are partial ellipses and can be sketched referencing what's already there rather than sketching a full ellipse. Double up the arcs and cap them.



8. Forms that are difficult to read due to a lack of clear edges can benefit greatly from the addition of colour, shade and a cast shadow. In this case the sketch was brought into Photoshop and colour was added along with highlights. The shadow was created as a path, feathered and filled with a black to no colour gradient. The edges of the shadow were lightened with a low-opacity eraser to add depth. The sketching process informs the rendering process, making it easier to know where to add the colour, shade and highlights. Finally the second half of the product has been lightly sketched in based on what is already there.

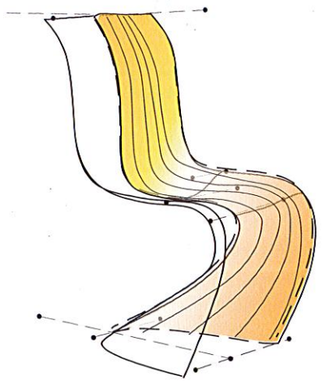
Tutorial

Panton chair

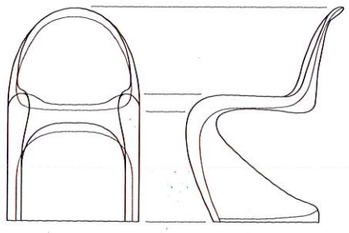
The Panton chair is justifiably famous as the first manufactured single-form injection-moulded chair. Long before the ubiquitous white plastic chair arrived, Panton was trying to solve a similar problem: how to use form and material to make a plastic (polypropylene) chair that was not only strong enough to support the required weight but was also stackable.

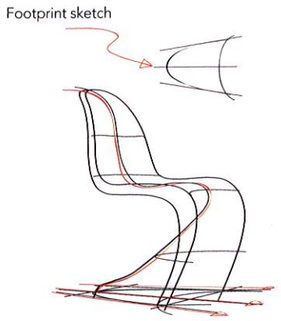
In some ways the Panton chair resembles an earlier radical experiment in furniture design: the Zig Zag chair by Gerrit Rietveld. But whereas Rietveld made his out of planar wood material mechanically fastened with screws, the Panton chair is far more expressive and conforms more closely to the contours of the human body.

Given the complexity of the Panton chair's form, building it in the computer should be done as a surface operation. Just as with sketching, the computer model is built through a series of sections that match the chair's side-view profile. With a centre-plane profile and an outside profile joined by a set of connecting guide rails, half the form can be created and then mirrored. This provides only the approximate shape of the chair (seat pan, back and concave leg). The final front-view profile must be cut into that surface. The wrap-around edge or profile that runs around the chair, thus providing much of its stability, is created through a series of sectional profiles sketched at strategic points on the chair and then lofted. (This is, of course, only one of many ways to build and sketch the chair.)

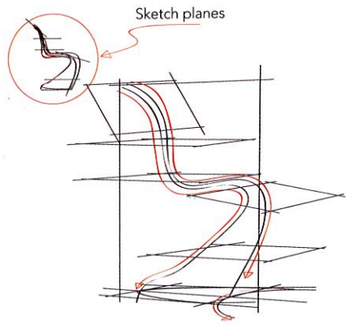


Panton chair by Verner Panton, courtesy of Vitra.

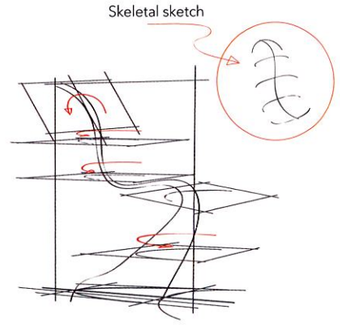




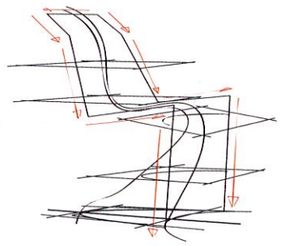
1. Darkened outlines are used to define the perimeter while sectional sketches help define interior contours. The bottom plane that defined the base of the chair has been left along with the plane that defines the rear profile. There's enough here to connect the dots to build the chair.



2. With the 'footprint' of the object sketched out on the bottom plane, side profiles can be sketched. Reference planes parallel to the bottom plane can be lightly sketched in to help situate the various sectional sketches accurately in space for interior contours. Angled planes can be added.



3. With practice reference planes are no longer necessary. Designers can picture the plane and accurately place the sketch symmetrically along the side profile like a skeletal spine (in red circle). Centring the sectional sketches is crucial. The endpoints become guides for the compound curve (outline) that closes the shape.

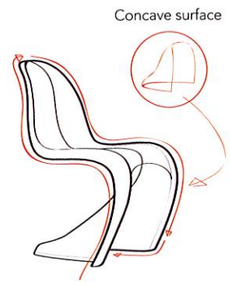


4. Another approach is to use the sectional sketches to help lightly 'box-in' the basic form. This way the chair can be better visualized. The skeletal box should touch the end points (vertices) of the sectional sketches. Think of this as a test run for sketching the actual compound curves.

5. Rather than trying to sketch one quick and continuous compound curve, sketch smaller key sections to serve as guides for a final continuous compound curve. Sketching this way allows you to focus on specific aspects of the form such as seat pan or back without having to see the whole design.

6. Continue to connect smaller curves with larger expressive curves that extend beyond the object to capture the compound curvature. With such a sculptural chair you might keep sketching lightly over the sections until the form is correct, then use this sketch as an underlay to redraw the final form.

7. The last step is to sketch the fold at the outer edges of the chair. This fold (or rolled-over surface) is a structural element that adds stiffness to the form, like a large fillet on a plastic container or bottle. The footprint sketch didn't include this extra fold as it might have confused matters. It is now added before the final bold outline is sketched.



8. The original sketch has been used here as an underlay for a new sketch. Unnecessary geometry has been removed. The bold outline merges the final compound curve to define the compound curved surfaces of seat, back, sides and bottom support. Light contour lines are added for clarity. The sketch is rendered for maximum readability.

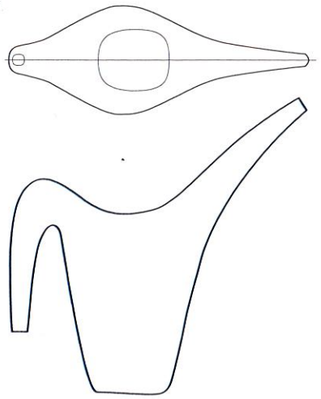
9. Compound curvature is difficult to truly read with lines only. Here the Panton chair has been quickly rendered in Photoshop to add a base colour along with highlights, shade and cast shadows. Shadows and a horizon line help to ground the chair while the crisp highlights and gradients communicate a gloss plastic finish.

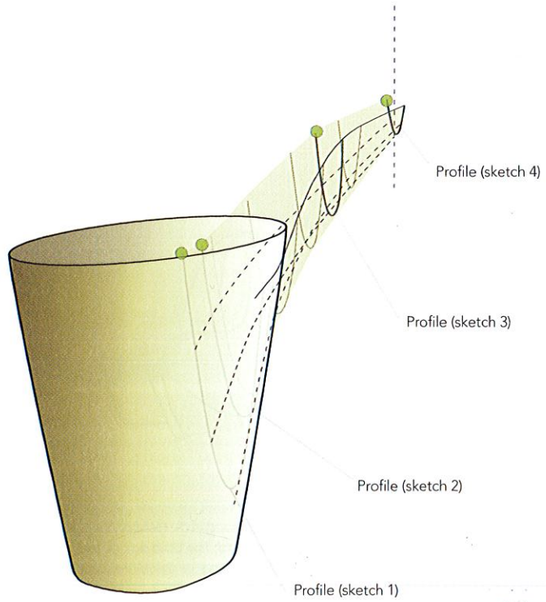
Tutorial

Vållö watering can

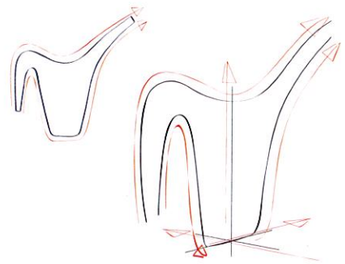
The Vållö watering can by Monika Mulder for IKEA is an ideal form for advanced sketching as it represents a series of compound curved surfaces that flow seamlessly into each other. This thin-walled plastic watering can is rigid enough to carry water while still stackable. According to Mulder, transporting 'air' is taboo at IKEA. Indeed, Mulder noted that she 'would never have thought of that shape if it were not for being forced to make it affordable in transport.' The result, as Phil Patton, automotive critic for the *New York Times*, says, it 'resembles a flower itself, blossoming upward. The cleverness of its single shape—proven in its stackability—is as impressive as the Verner Panton plastic chair or (even more to the point) William Sawaya's Calla chair for Heller. The upward sweep of the spout, like a heron or bittern in an Audubon print, or a coyote baying at the moon, contrasts with the plunging arc of the handle, shaped like the high heel of a woman's shoe.'

This quick and very approximate SolidWorks model shows one strategy for lofting the spout on the Vållö. Surface models are built oversized along non-critical dimensions and then trimmed with profile sketches to get the desired geometry. In the case of the Vållö, the profile (sketch 2) is an intersection curve to help ensure tangency between the spout and the body of the product. With CAD, as with sketching, there are always multiple ways to get any form built.

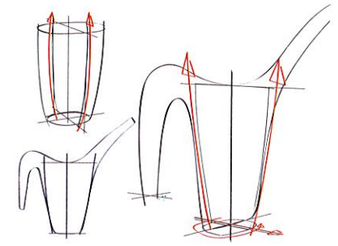




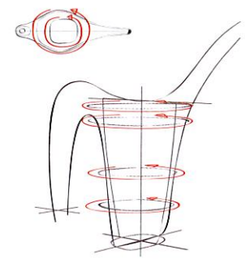
Understanding the subtle geometry of the Vållö begins with orthographic sketches which can be translated into perspective sketches or computer models. Here the front and side views have been juxtaposed. Above the front and side views have been quickly sketched for translation into a SolidWorks surface model.



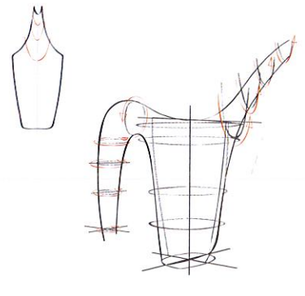
1. Establish a vertical centreline to help sketch the side profile. Sketch an axis for the base of the product. The sketch does not need to be complete, just enough to help place other critical geometry. In this example no planes will be created, only centrelines and axes, which will define the space of planes without the extra lines.



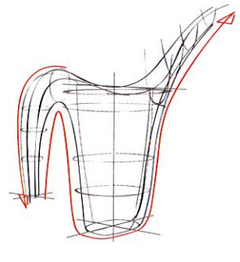
2. With the side profile in place, sketch a partial section to define the volume of the product. The axis and centreline are needed to place the geometry accurately. Sketch the base section of the product touching the various profile sketches already in place. Three profiles are now in place to help place additional sections.



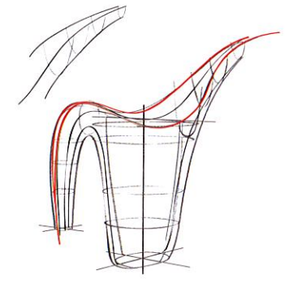
3. Sketch a top-view orthographic to be sure of the geometry. Working off of the centreline, the axis and the various profiles, add in a few more sections to help define the outline of the watering can body. The section that defines the base of the product is more rectilinear than the upper sections.



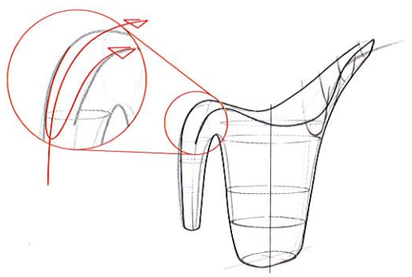
4. Referencing the earlier profile of the handle, quickly sketch in some elliptical sections to define the 3D volume of the handle. This will require imagining where the various horizontal planes are placed to determine the exact shape of the various ellipses. Do the same thing for the spout.



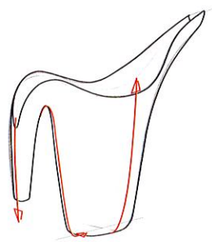
5. In order to accurately sketch the handle or spout, it is advisable to roughly sketch the overall outline of the product. This will provide much needed reference points for the more complex compound curves that define the top of the spout. The surface connecting the handle and body of the product is a good start.



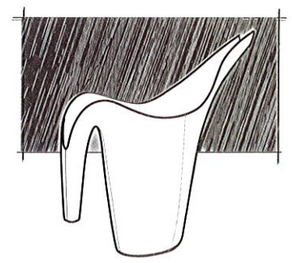
6. With both the outline and sectional sketches approximately in place along the profile, sketch in the first compound curve to define the upper edge of the spout continuing back to the handle. The uppermost sectional sketch that defines the body of the product can assist with the placement of the compound curve.



7. With all of the sectional geometry in place, sketch a new centreline down the back handle to help place the compound curve that defines the opening there. Centrelines for perspective sketches are essential as they help establish the symmetrical nature of the geometry. Note the back half of the sketch is smaller.



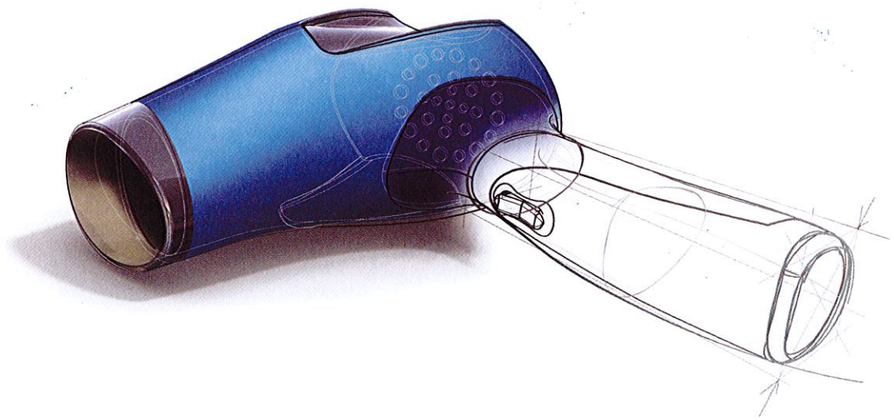
8. A sketch with so many sections should be retraced for clarity if the ghost lines are too dark. For a product with this number of compound curved surfaces, a few contour lines can really help to define the geometry. A light parting line is added at the back of the product along with one contour along the centre.



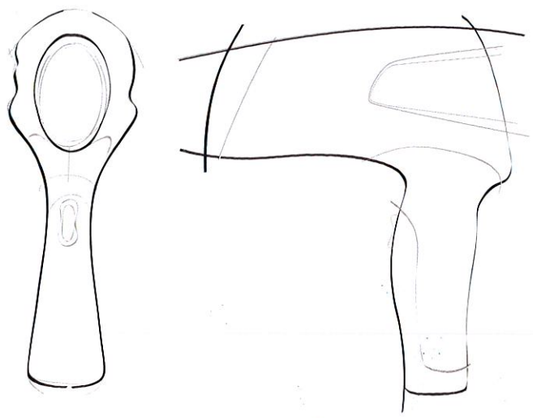
9. Assess the results and lighten (highlight) or darken (shade) where necessary. Here, the value of the core shadow has been intensified while the area closest to the light and directly opposite the shadow has been lightened. The back edge of the cylinder has been lightened to add greater contrast to the core shadow.

Tutorial

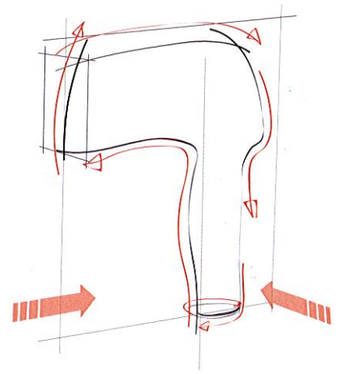
Sketching tools



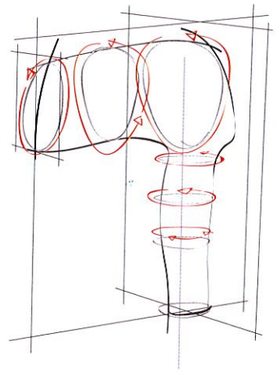
The blow dryer concept (above) began as a loose freehand sketch developed first orthographically and then perspectively. This process clarified greatly the strategy used in building the CAD model in SolidWorks. The most difficult part of that process is creating a smooth transition between the handle of the product and the body where the fan motor resides. This is similar to sketching/building many hand tools such as drills, sanders and sabre saws. Spending the time to work out the proportional details in orthographic and developing the concept perspectively through sections provides great insight into building the final model. In the above example the rendering has been manipulated in Photoshop to sync up with the wireframe drawing and a free-hand sketch using a Wacom tablet. This mash-up provides the tightness of a photorealistic rendering with the looseness of a sketch.



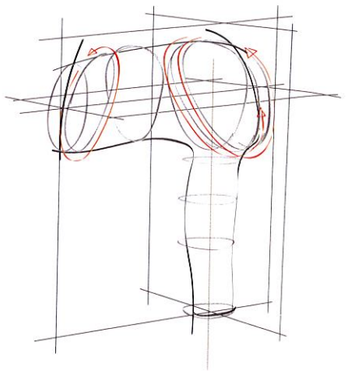
(Right) Rough orthographic front and side profile sketches.



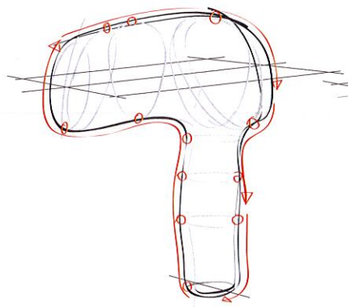
1. Quickly sketch the dominant side view in perspective (sketch planes if necessary). Sketch an arcing centreline to help position the opening which, in this case, is not circular but elliptical. Sketch a sectional reference at the base.



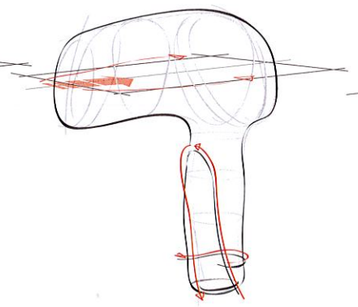
2. Sketch front, middle and back sections for the body of the product. Add a few horizontal sections for the handle. With only a few sketches in place the wireframe takes shape and the product's basic geometry is established.



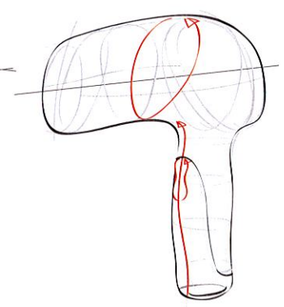
3. Sketch the sections that are tilted out of vertical or horizontal orientations: the front chrome collar and the back face of the product. Reference other sections to help position these sketches. The next step involves outlining the product.



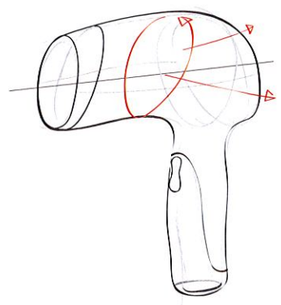
4. The outline should touch tangent to the various sketched sections (circled in red). A heavier line will help differentiate the outline from the sections. Modulating the outline (varying the thickness) will help increase its impact.



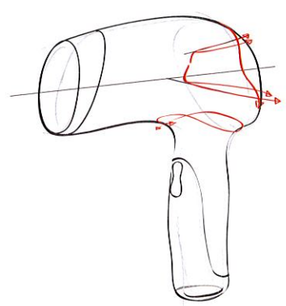
5. Now begin sketching secondary details like the overmoulded handle. Sketch on it as though it's three-dimensional and follow the contours as they wrap around the handle. Finally sketch arcs on the middle plane to suggest the outer edges.



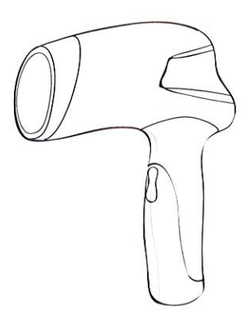
6. Sketch the parting line on the handle to help accurately place the power switch. Sketch a section at the correct angle to position the concavity on the product's upper housing. Sketch the peanut-shaped button directly over the parting line.



7. Sketch the lower and upper edges of the concavity by referencing the new section. Sketch these arcs as though they are on a 3D surface rather than a sheet of paper. Add the necessary detail to the power switch



8. Refer to the orthographic views before sketching in the back section to define the concave detail. Using a subtractive approach cut away the required surface. Sketch in a compound curve to achieve the transition between handle and body.



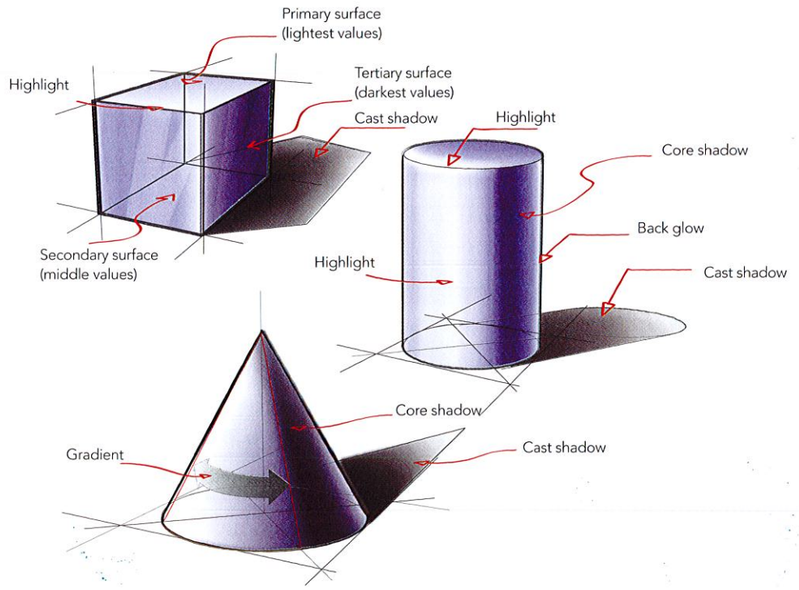
9. Use a template to tighten up the ellipses. Re-trace the sketch leaving out any construction lines to achieve a clean look or leave light construction lines and darken the outline, parting line, and any cut lines for vents or openings.

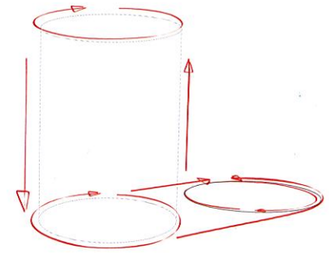
Tutorial

Fundamentals of rendering

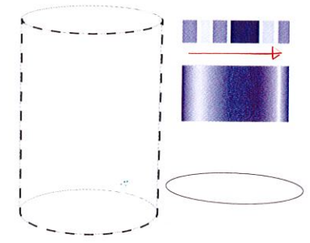
Rendering digitally is quickly becoming the norm for product designers. Proficiency comes with practice and having a clear goal in mind. Over time designers develop a personal 'workflow' that fits their needs. Designers familiar with marker rendering often simulate their traditional approach with digital tools while younger 'digital natives' often learn the software with little or no knowledge of the past. The main goal, as with sketching, is to develop fluency and speed. Rendering should fit into the larger design process as naturally as possible. The following short list will be helpful for rendering (in Photoshop in particular).

1. Renderings are only as good as the drawing being rendered. (Good sketches = good line art!)
2. Always work with layers (which can be deleted or easily moved around) and name them!
3. Move from light to dark creating value in direct relation to the object's form.
4. Work fast and never apply colour at full opacity.
5. Use gradients sparingly as they can overwhelm a form and appear gimmicky.
6. Use paths to control light, shade and shadow.
7. Learn the short cuts (hot keys) to speed up the workflow.
8. Learn to customize the workspace to your method of working.
9. Highlight, shade and shadow should come last.
10. Photograph a wide array of objects to study their surfaces and use those resources to practise rendering.

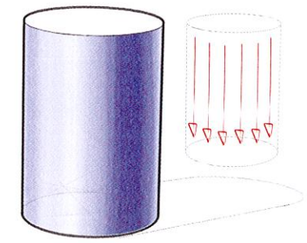




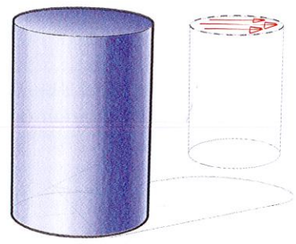
1. Sketch a cylinder using vector-based software like Adobe Illustrator or using a pen and paper and then scan it. Carefully sketch the shadow of the cylinder to help establish where the light source is coming from. This will determine everything that follows. Using the magic wand tool in Photoshop select the front surface only.



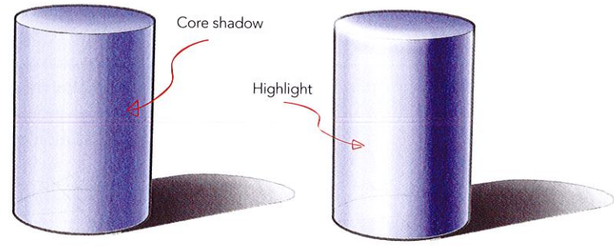
2. The selection will be highlighted with a pattern of 'marching ants', the term used to describe a dashed-line marquee. Next apply a multi-colour gradient to the selection. A colour gradient, like a texture gradient, is a perfectly smooth transition between two or more colours on a surface and will reinforce the effect of light.



3. Another approach is to apply a series of quick vertical brushstrokes using the airbrush tool set to a low opacity (20-30 per cent) and a large diameter. With the opacity low and diameter large, gradient effects can be achieved with repeated passes to build up darker values. The variation in value reinforces the illusion.

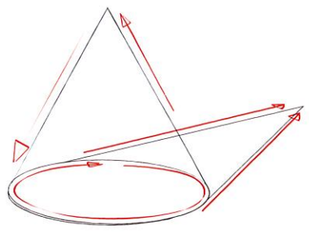


4. Using the magic wand, select the top surface only and apply either another gradient or a series of large-diameter and low-opacity airbrush strokes that move from left to right to build up the desired value. In this case the front of the cylinder top should be lighter and the back darker, given the location of the light.

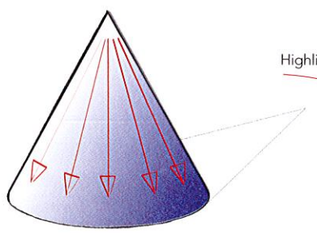


5. Using the magic wand again, select the shadow area. With a large diameter airbrush set to a low opacity (10 per cent) brush in the shadow. Begin with the area closest to the object and work outwards. Make large quick passes. If necessary use an eraser tool (10 per cent opacity) to soften the outer edges.

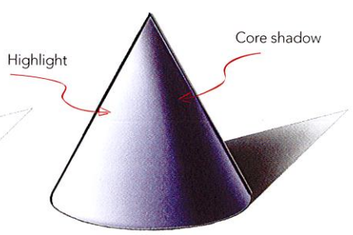
6. Assess the results and lighten (highlight) or darken (shade) where necessary. Here, the value of the core shadow has been intensified and the area closest to the light and directly opposite the shadow has been lightened (highlight). The back edge of the cylinder has been lightened to add greater contrast to the core shadow.



7. Sketch the cone either on paper with a pen and scan it or in the computer using a vector-based software program like Adobe Illustrator. Be sure to sketch the shadow because this sets up much of the dynamic for the remainder of the rendering process. The shadow is in direct line with the light source: move that and the shadow moves with it.



8. Just as the airbrushed strokes on the cylinder involved large vertical gestures, the airbrushed stokes on the cone should taper outwards in order to follow the direction of its surface. Even though the drawing is on a flat two-dimensional surface, the addition of colour can easily add the necessary value required for the eye to see the drawing as a



3D volume. The core shadow and highlights must also follow the taper of the cone in order to complete the illusion. All that remains is to add a shadow, which will help ground the object and reinforce the direction of the light source. Softening the shadow's tip helps give it depth.